MICROTOOLS FROM THE BLACK WARRIOR VALLEY: TECHNOLOGY, USE, AND CONTEXT

BY

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THESIS

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For my Grandfather,

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CHAPTER I

INTRODUCTION

In the tenth and eleventh centuries A.D. societies referred to as Mississippian developed in the interior river valleys of the Midwest and Southeast. Between A.D. 1000 and 1200, Mississippian communities in a number of regions developed networks of hierarchically ranked polities. Political hierarchies incorporated a complex form of hereditary ranking. Social institutions and their ideological constitution extended beyond the boundaries of local settlement. Maize agriculture provided the economic foundation upon which these societies depended (Steponaitis 1983, 1986a; Griffin 1985; Peebles 1978).

A great deal of archaeological research during the past decade has focused on Mississippian social and economic strategies, using chiefdom models of socio-political organization (Peebles and Kus 1977; Steponaitis

1978; Welch 1986). Although the development of Mississippian societies is ultimately rooted in historically specific situations, much has been learned of the material basis of the society and culture of these peoples through these more general considerations.

One category of items that became increasingly important in Mississippian society is that of shell beads. Both freshwater and marine shell beads and ornaments have a long history in the Eastern Woodlands, extending back at least to the Late Archaic (Winters 1968). There appears to have been considerable fluctuation through time in the frequency of shell bead production and use, as well as change in the technology of bead production. The mortuary record from Late Woodland and early Mississippian societies suggests that shell beads may have played an important role in social negotiations and interactions between individuals and groups during this time (Steponaitis 1986a; Welch, in press). It is also at this time that a microlithic tool technology is most prevalent in the archaeological record.

Mississippian microtools were first recognized at the site of Cahokia, the largest center of Mississippian development, located near present-day East St. Louis. Subsequently, similar tools have been found at a number of sites in the Cahokia region, at other settlements in the Mississippi Valley, and throughout the Southeast. Microwear studies have determined that the Cahokia tools were used primarily to drill shell, however bone and antler working is also evidenced (Yerkes 1983). Microtools, unfinished shell beads, and shell manufacturing debris have been found together in the same depositional contexts at a number of sites. These contexts include burials, refuse pits, and house middens at mound center sites, and domestic settlements (Morse 1975; Schnell et al. 1981; Yerkes 1984; Ensor 1981).

During the past five years various models of Mississippian domestic specialization have been put forth. These models have been based, in part, on the interpretation of microtools as "specialists'" tools (Prentice 1983, 1985; Yerkes 1984, 1985). Arguments have focused on *a priori* interpretations of the tool "type" as evidence for craft specialization and economic differentiation (Yerkes 1984, 1985). These studies work from an evolutionary framework rather than examining the actual organization of productive activities. In response to these arguments, problems have been identified with the logic and data interpretation that result when technology is equated with economy and preconceived notions of social development (Pauketat 1987; Muller 1986). Effects on artifact distribution patterns due to temporal variation, depositional factors, and site formation processes were also not considered prior to interpreting these data as evidence for economic specialization (Pauketat 1987).

Since their initial discovery in large numbers and at isolated areas at Cahokia, microtools have been linked with craft production activities involving manufacture of the thousands of shell beads commonly found amongst the mortuary remains of these peoples. The subsequent discovery of similar tools at other early Mississippian phase settlements in the American Bottom suggests that microtools were commonly used throughout the region. Microtools have been found in a number of household and refuse deposits on the American Bottom, suggesting that there was little or no labor allocated to craft production outside the control of the household (e.g. Tosi 1984:23).

This pattern suggests that shell-working on the American Bottom was perhaps not organized at a scale beyond the needs of individuals or households. On the other hand, the tendency for these tools to occur in greater numbers at paramount sites, such as Cahokia, suggests that prehaps there was a greater demand for the use of microtools at these sites.

The organization of production, social exchange, and the envaluation and use of items of material culture are processes central to understanding the social construction of Mississippian communities. However, models of specialization that have focused on a particular artifact "type," rather than on the social organization of production, have confused the issues of craft production and economic specialization. Craft production can become specialized in the development of complex societies through increasing hierarchical control over the specialized sectors of production, raw materials, and manufactured items. This must be demonstrated, however, through the integration of a number of lines of archaeological evidence, of which the technology of production is only one (e.g. Tosi 1984).

This study describes tools that are part of a microlithic technology recovered from surface collections and test excavations in the Black Warrior River Valley, in west-central Alabama. The Black Warrior Valley is the settlement region of the Moundville chiefdom. The Moundville site itself is second in size only to Cahokia. Technological and functional studies were undertaken in order to determine first, the structure of the manufacturing technology, and secondly, the uses to which the tools were put.

The chapters that follow do not address the issue of productive specialization. Rather, the aim is to describe and interpret a particular assemblage of stone tools using a method that integrates typology, technology, and tool use within a regional historical and social setting. The intent is to first identify the structure of the tool technology relative to a productive activity. The organization of production is then examined within the limits of the data base. The spatial distributions of the tools suggest that the technology is part of a domestic productive context. The implications of this observation are examined in the course of this study.

Chapter II presents a classification of the microtools and related artifact classes. The intent of the chapter is, in part, to describe the assemblage. The chronological context of the tool assemblage is also examined. Description of the assemblage is prefaced by a discussion of the archaeological identification and classification of microtools in the Southeast. Chapter III presents results of a technological analysis of the microtool assemblage. Core technology and features of microtool manufacture are examined and compared to the larger technological context of which the tools are a part. Tool use is examined in Chapter IV. The results of an optical microwear analysis are presented for a sample of 105 tools. Relationships between tool form, technology, and tool use are examined in order to evaluate the degree of functional specificity of the tool assemblage and technology. Locational attributes are examined as well. These data are then correlated with regional settlement pattern and site structure information.

In conclusion, Chapter V brings together the lines of evidence examined in this study relating to the organization of production involving a microlithic tool industry in the Moundville region. Comparisons are made between the Black Warrior Valley industry and analogous industries in order to evaluate the functional and technological similarities and differences between assemblages. Implications for the organization of production involving the use of microtools in view of other regional trends are also evaluated.

As a prelude, I begin with an overview of the late prehistory of the Moundville region, and the nature of the sample on which this study is based.

The Cultural Setting

There are several recent publications outlining the history of research in the Black Warrior River Valley and specifically at the site of Moundville (Bozeman 1982; Steponaitis 1983, 1986b; Scarry 1986, 1988; Welch 1986, in press; Peebles 1987; Powell 1988). The intent of this discussion is not to provide a similar review, but to present a synopsis of the culture history and related issues pertaining to the study region as it is presently known. A great deal of archaeological work has been carried out in the past decade and a half, including reanalysis of collections, excavation, and site survey and testing in both the Black Warrior and Tombigbee river valleys. This review of the data will draw from a number of studies and syntheses of the regional prehistory derived from the intensive research programs that have been carried out over the past several years. A reference map for Moundville and adjacent areas is provided in Figure 1.

The Moundville area is best-known archaeologically as the location of the Mississippian chiefdom centered at the Moundville site. In a span of only 200 years, between A.D. 1200 and 1400, the settlement at Moundville grew markedly in size, population, and complexity. By A.D. 1400 a total of 20 platform mounds had been constructed enclosing a rectangular plaza. At this time the site covered about 100 ha (Steponaitis 1983:4-6).

Subsistence economy was based on the intensification of field agriculture that was concentrated on Eastern Eight

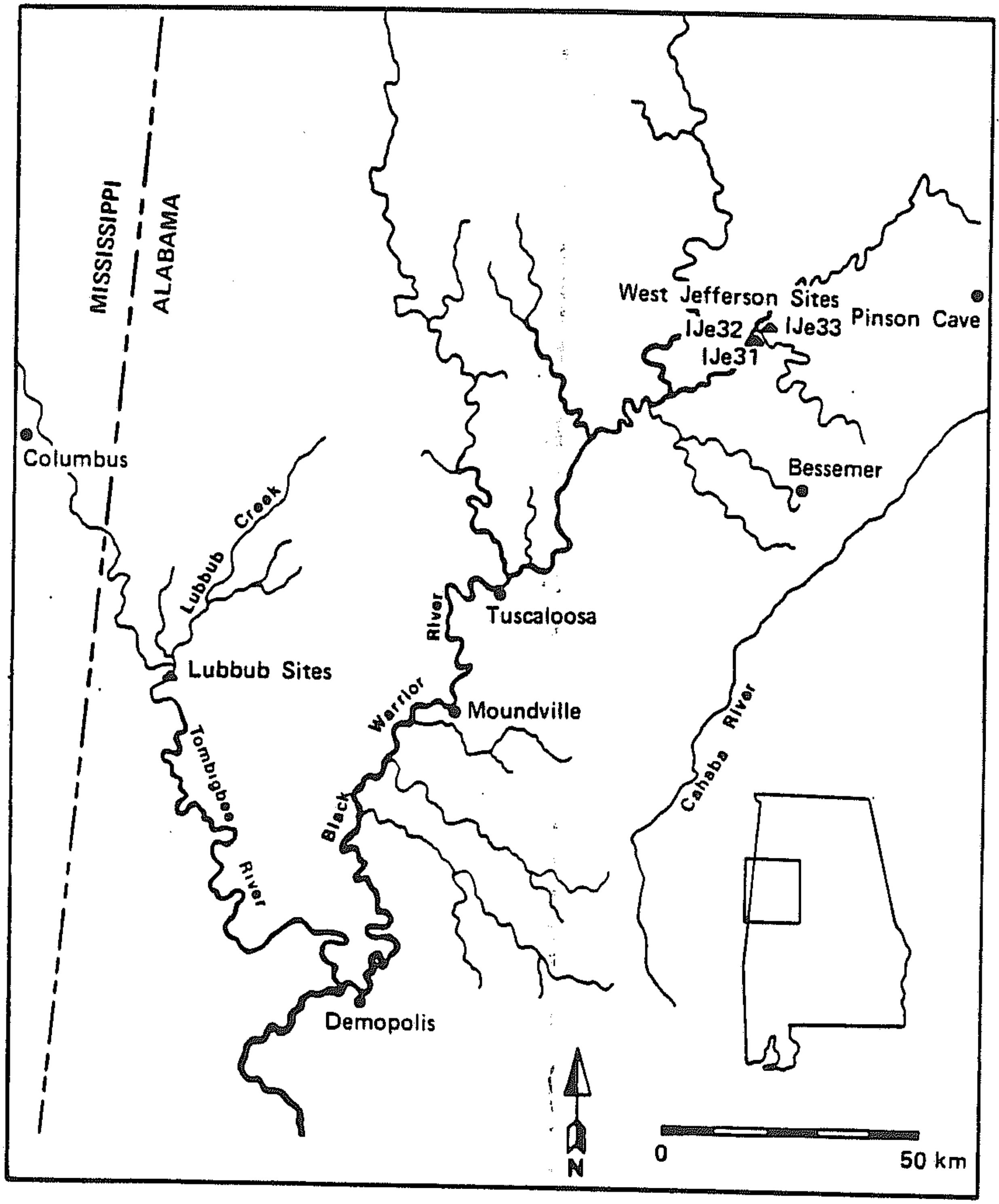


Figure 1. Regional map showing archaeological areas in west-central Alabama referred to in the text.

Row corn (Scarry 1986; Peebles 1987). A variety of wild animal and plant resources contributed to the subsistence base as well. There is little evidence of nutritional stress among the resident population at Moundville (Powell 1988; Peebles 1987).

A number of single-mound "centers" were established north and south of Moundville beginning sometime around A.D. 1050, and by the thirteenth century a three-level settlement hierarchy was present, with Moundville clearly the regional center. Around each of the outlying centers were scattered farmsteads and hamlets that housed the majority of the population (Bozeman 1982).

The internal organization of Moundville combined domestic and public space in the form of dwellings, storage facilities, a plaza, cemeteries, and possible areas of specialized production of ceramics, greenstone celts, and possibly marine shell objects (Welch 1986:133-172; Peebles 1987:17). Mortuary evidence suggests that social distinctions existed within a restricted segment of the society resident at Moundville. Preferential burial in mounds and cemeteries, and the presence of exotic burial goods suggests some form of ascriptive rank among the higher levels of the social hierarchy. However, for the majority of individuals, status, as expressed at death, appears to have been related to factors of age, gender, and personal achievement (Peebles 1987:13).

Recent studies of the political economy of the Moundville chiefdom have concluded that the pattern of production and consumption is most similar to models of "prestige goods" economies (Welch 1986; Peebles 1987). Within such systems, certain items, their consumption and perhaps production, are symbolically manipulated in social relations. Power and control are linked to the possession and manipulation of exotic and rare goods, the value and meaning of which serve to legitimize and perpetuate the social structure, and the power of the individual(s) controlling resources and/or products (Frankenstein and Rowlands 1978; Friedman and Rowlands 1978). The emergence of Moundville as a regional center appears to be correlated with periods of increasing conflict and fluctuation of exchange in the region. The abandonment of certain sites, and a decline in the frequency of imported goods at others, apparently was linked to the emergence of Moundville as the regional center controlling long-distance exchange (Peebles 1987; Steponaitis 1986b; Welch, in press).

Work that has been undertaken in both the Moundville region and the central Tombigee Valley provide a view of life prior to Moundville's political and economic hegemony. The Tombigbee Valley lies immediately to the west of the Black Warrior Valley (see Figure 1). In the following sections aspects of community, settlement, and social organization are discussed in a brief sketch of the period preceding the Moundville emergence in these two regions.

Community, Settlement, and Subsistence

The chronologies for the Black Warrior and Tombigbee regions are provided in Figure 2. These chronologies are based on ceramic seriations, paleomagnetic and thermoluminescent measures, and radiocarbon determinations (Jenkins 1982; Steponaitis 1983; Scarry 1986; Welch 1986; Peebles 1987).

This study is concerned specifically with the West Jefferson phase, which was initially recognized in the

PERIOD	CENTRAL TOMBIGBEE PHASES (Jenkins 1982; Peebles 1987; Welch, in press)	MOUNDVILLE AREA PHASES (Steponaitis 1983)	BESSEMER AREA PHASES Jenkins and Nielsen 1974; Ensor 1979; Walthall and Wimberly 1978; Welch, in press	DATE (A.D.)
Mississippian	Summerville IV	Alabama River		1700
				1550
	Summerville II/III	Moundville III		1400
		Moundville II		1250
	Summerville I	Moundville I	Bessemer	1050
Late Woodland	Miller III	West Jefferson	West Jefferson	900
				600

Figure 2. Late prehistoric chronology for the central Tombigbee and Black Warrior valleys.

Bessemer area west of Birmingham, Alabama (Jenkins and Nielsen 1974; O'Hear 1975; Ensor 1979). In the Tombigbee region, the last 200 years of the Late Woodland Miller III phase is contemporary with the West Jefferson phase in the Black Warrior Valley. The ceramic complex in the Black Warrior region consists primarily of grog-tempered plainwares classified as Baytown Plain, variety Roper. Shell-tempered Moundville I phase ceramic types occasionally occur in West Jefferson deposits, but rarely account for more than 2% of the assemblage (Steponaitis 1983:81).

Evidence from the Black Warrior Valley suggests that this region was not permanently occupied prior to the West Jefferson phase, although elsewhere in the interior of the Southeast settlements were occupied on a more or less permanent basis as early as A.D. 400 (Welch, in press; Steponaitis 1986a:381). West Jefferson settlements consisted of villages or hamlets generally less than 0.5 hectares and were concentrated southwest of the present city of Tuscaloosa (Peebles 1987:5). Although there has been no systematic survey of the valley south of Tuscaloosa, West Jefferson communities were presumably dispersed throughout the Moundville region. Residential base settlements were located along floodplain terraces and may have been temporarily abandoned during the flood season in late winter and early spring (Welch, in press). Smaller camps were occupied on a short-term seasonal basis. These sites were located on the higher river terraces and in the uplands (Peebles 1987; Welch, in press). A similar pattern of larger, nucleated villages and smaller seasonal camps is also observed for the Late Woodland Miller III phase in the Tombigbee Valley (Jenkins and Krause 1986).

Sometime between A.D. 1000 and 1200 a second level in the settlement hierarchy was established in the form of single mound-plaza settlements. Between A.D. 1050 and 1250 there were at least four of these settlements, including Moundville, in the Black Warrior Valley. Similar settlements were established north of Moundville at the Bessemer site, and to the west in the Lubbub area in the central Tombigbee region. Although investigation of these early Mississippian settlements is limited, the available evidence suggests that these sites were residences of individuals who had access to certain exotic materials

(Steponaitis 1986b; Peebles 1987).

Late Woodland subsistence practices combined hunting, gathering, and gardening. Maize, introduced some 200 years prior to the onset of the West Jefferson phase, and a variety of wild and domestic grasses were cultivated (Scarry 1986; Caddell et al. 1981; Steponaitis 1986a). Botanical evidence from the central Tombigbee area shows an increase in the abundance of corn during the Late Woodland. Data from the Moundville region also suggest that the shift toward field production of maize began in the West Jefferson phase (Scarry 1988). Although wild plants and animals continued to contribute to the subsistence base, corn agriculture was intensified during the later part of the Woodland period, perhaps as a result of increasing economic pressures (Welch, in press). An increase in the number of Late Woodland and early Mississippian sites and the health status of Summerville I mortuary populations point to increasing population and economic stress at this time (Cole et al. 1982:Table 14; Peebles 1987; Welch, in press:Table 5).

In summary, the period between roughly A.D. 900 and 1200 witnessed changes in social organization and economy, material culture, and settlement in both regions. Although the primary unit of domestic residential settlement appears to have remained unchanged, corn agriculture was intensified at the same time we see changes in settlement and social organization. New forms of architecture included rectangular wall-trench houses, above- ground storage facilities, and the construction of platform mounds. A second level in the settlement hierarchy, the single mound-plaza settlement, also emerges at this time. Other technological changes are seen in the domestic sphere with the adoption of shell-tempered wares and changes in cooking, storage, and serving vessels. There is also evidence of production and exchange of agricultural implements including chert hoes, and greenstone celts and axes. Microlithic blade-core technologies are another innovation that occurs along with an increase in shell craft production (Steponaitis 1986a). The introduction of the bow-and-arrow and other changes in lithic technology, to be addressed in more detail in the context of this study, also occurred at this time.

Social Organization

From the breakdown of Middle Woodland exchange networks (Steponaitis 1986a) until the establishment of a "prestige goods" economy after A.D. 1100, there is little evidence of social differentiation among the inhabitants of the Tombigbee and Black Warrior valleys. Most West Jefferson burials excavated in the Bessemer area (at Pinson Cave), and Miller III burials from the central Tombigbee Valley lack burial goods, except for shell beads and ornaments (Welch, in press). During the early part of the Miller III, shell beads manufactured from freshwater mussel shell were found with subadults, adult females, and, rarely, adult males. However, by A.D. 900 to 1050, marine shell beads appear to be more abundant compared to freshwater beads. Moreover, although marine shell beads were found with some subadults and females, there appears to be an increase in their occurrence with adult males (Welch, in press). Along with the emphasis on marine shell beads and pendants, there is evidence of other inter-community exchange relationships as seen by the appearance of imported copper, and greenstone celts/axes placed in the graves of adult males. These items appear to be objects of personal property and there is still little evidence of social differentiation visible in the mortuary record.

The apparent onset of exchange for both agricultural implements and other material goods is probably not unrelated to the rather sudden development of mound centers and ceremonial mound-plaza settlements. At this time (A.D. 1050-1200) there is also a peak in the frequencies of marine shell beads in mortuary contexts (Peebles 1987:Figures 6 and 7). Evidence of the development of social distinctions can be found in the burial of individuals in cemeteries with exotic goods, especially adult males (Welch, in press). These distinctions contrast with village-area burials that tend to lack burial goods.

The historical relationships between outlying mound sites and the settlement at Moundville are presently poorly understood. However, excavations at one of these centers, 1Tu50, has revealed a high proportion of nonlocal goods (Steponaitis 1986b). These materials include imported stone used for the production of agricultural tools and weapons. By the beginning of the thirteenth century A.D., 1Tu50 appears to have been abandoned (Steponaitis 1986b). It is around this time that Moundville emerges as a major regional center, whose apparent control of nonlocal goods and production appears to have had a major impact on the region as a whole.

Summary

I have presented an outline of the picture of Mississippian emergence in the Moundville region, however the details have yet to be brought into focus. Relationships between agricultural production and other forms of domestic production await archaeological investigation at both the mound settlements and smaller farmsteads or hamlets. Only through systematic examination of all types of community settlements will their interconnections become more clearly understood.

It is interesting to note that, prior to Moundville I times, shell beads and shell ornaments were important among adults, both male and female, and children. Freshwater shell beads are found with males and females, adults and subadults among Late Woodland and early Mississippian populations in both the Tombigbee and Black Warrior valleys. At some point, however, marine shell became increasingly valued as a material for body ornamentation and other ritual and symbolic activities. The increasing abundance and restriction of marine shell beads with certain individuals during early Mississippian times (after A.D. 1050) is most likely related to the changing social use of this material.

The Moundville Survey and the Microtool Sample

The lithic materials examined in this study were collected in 1978 and 1979 during surface survey of sites in the Moundville area conducted by the University of Michigan Museum of Anthropology (UMMA). A map of the study area is given in Figure 3. The Moundville Project, directed by Christopher Peebles, combined the efforts of several co-investigators in an integrated research project in the Moundville region.

As part of this project, the Moundville survey, directed by Paul Welch, visited known Late Woodland and Mississippian sites in the Black Warrior Valley between Tuscaloosa and Akron, Alabama. The survey covered

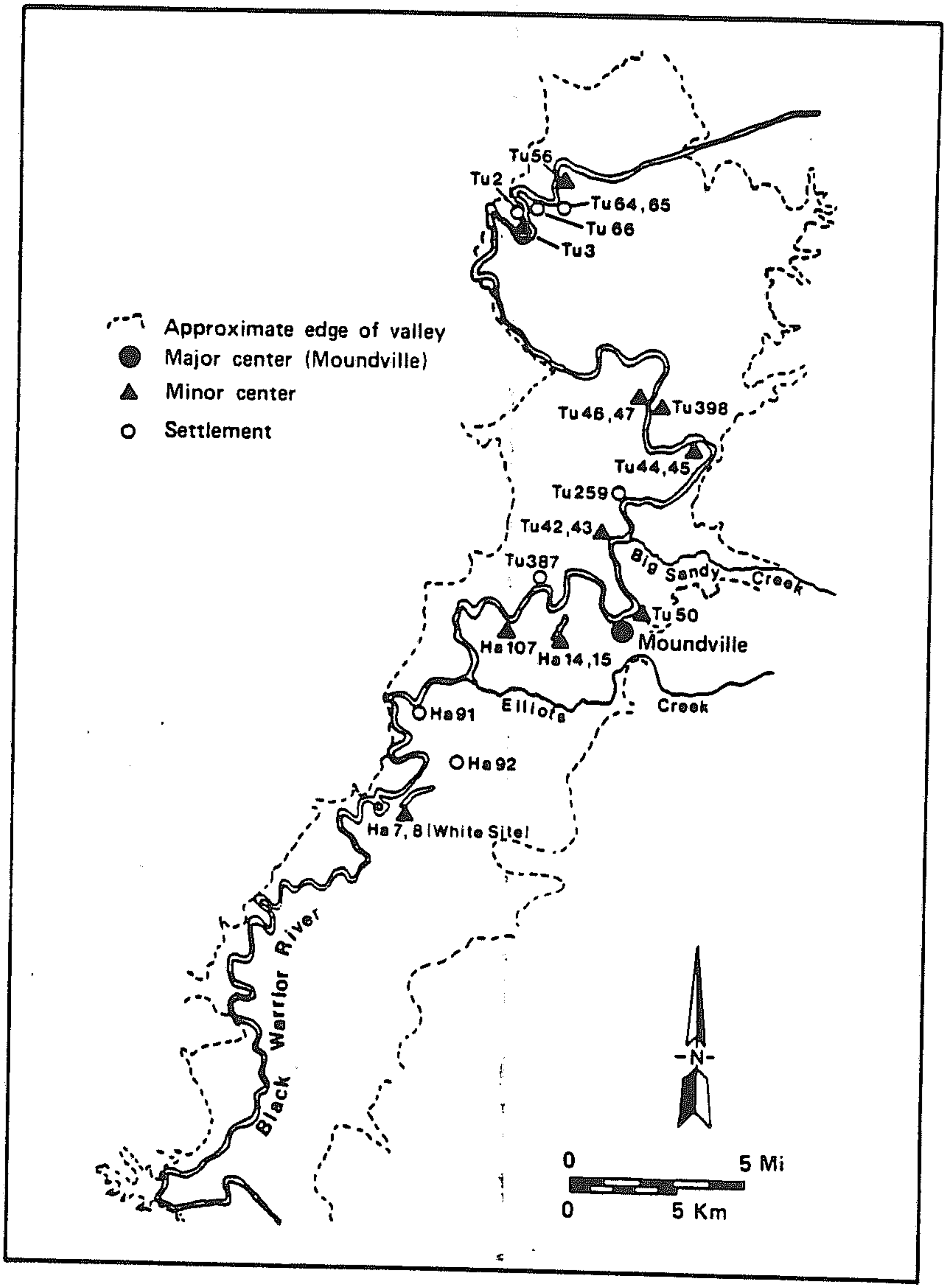


Figure 3. West Jefferson and Moundville phase sites referred to in the text surveyed during the UMMA Moundville Survey, 1978-79 (after Bozeman 1982).

approximately 25 kilometers north and south of Moundville (Welch 1981; Bozeman 1982). The intent of the survey was not to discover new sites but to clarify the chronology, size, and organization of known Moundville phase settlements. The survey methods were designed to maximize spatial control and comparability between sites. Sites of sufficient size and artifact density were gridded into 20 x 20 m units and all surface material collected. Sites were not collected unless surface visibility was at least 60 to 70% (Paul Welch, personal communication).

While the survey produced representative, controlled artifact collections from a number of West Jefferson and Moundville phase settlements, the data are limited by the lack of systematic coverage in the floodplain and the uplands. Although the distribution of mound sites is most likely accurately represented both to the north and south of Moundville, nonmound sites and smaller farmsteads are underrepresented in the sample. This bias is greatest downstream from Moundville where logistical and physiographic constraints have limited archaeological investigation (Paul Welch, personal communication).

Among the items recovered by the Moundville survey are a variety of chipped stone artifacts that collectively may be called microtools. Prominent among these tools are a number of items whose overall morphology suggests they were used as drills. Of a total of 105 used tools examined in this study, 76% are from gridded surface collections, 10% are from mound test excavations, and 14% are from test excavations conducted at the White site (1Ha8) (Welch 1986). Microtools from the White site were found in mixed West Jefferson and Moundville phase deposits, and in an undisturbed West Jefferson phase pit. Microtool manufacturing debitage, including blade cores, blades, and unfinished tools, were recovered primarily from site surfaces. One core found during excavations at 1Tu50, a West Jefferson and Moundville I site, is included as well.

In a recent review article, Steponaitis (1986a) noted that the apparent connection between microtool technologies and shell beads during the period of Mississippian emergence and consolidation was perhaps not coincidental. Morse (1974) also emphasized the importance of the technology in terms of Late Woodland and early

Mississippian interaction. On the other hand, other researchers have focused on the implications of the tools and the technology from an evolutionary perspective. These arguments interpret the presence of the technology as evidence that certain individuals and communities were involved in craft specialization involving shell-working on a part-time basis (Prentice 1983, 1985; Yerkes 1984, 1985). These interpretations have derived from a particular theoretical point of view, rather than the inherent variability of the individual artifacts. While technological evidence alone can not address the issue of economic specialization, links between exchange relationships, production, and shell beads during the initial period of Mississippian development is apparent. Tool design, use, and a production context are all factors that together structure stone tool technologies. These connections are the focus of this study.

CHAPTER II

THE BLACK WARRIOR VALLEY MICROLITHIC ASSEMBLAGE: CLASSIFICATION AND CHRONOLOGY

Small tools, generally referred to as gravers, perforators, and drills, have been recognized in a variety of Late Woodland and early Mississippian archaeological contexts throughout the Southeast. Because of historical associations, formal similarities in design, and functions, these tools are often classified as microtools, or microliths. While in certain regions microtools were manufactured on blades, in other situations, similar tools were manufactured on flakes and other pieces of debitage. Because of this divergence in technological style, classification of these tools can be somewhat ambiguous. This is related, in part, to the initial link established by archaeologists working at Cahokia between the tools, a blade-core technology, and shell craft production (Mason and Perino 1961; Yerkes 1983).

The existence of variability in tool form suggests that microtool manufacturing strategies were not always consistent. For example, while the Cahokia assemblage represents a structured blade-tool production technology, microtools manufactured at certain outlying sites in the American Bottom were stylistically different. Yerkes (1987:166) comments that shell drills from the Labras Lake site would not have automatically been classified as microdrills using the formal criteria defined by Mason and Perino (1961) who link the tools to a blade industry. It is apparent that the organization of microtool production must be evaluated on a site-by-site basis, as well as in a regional framework. Factors affecting the organization of a specific stone working technology would be expected to vary through time and in different regions, given the specific socio-economic uses to which the tools were put.

The intent of this chapter is to first, describe the Black Warrior microlithic assemblage, and secondly to evaluate the chronology of the tools. Typological description is conducted with the goal of clarifying the morphological variability seen in the finished tools and manufacturing debris. This approach is designed to facilitate comparisons with other related assemblages in order to evaluate variation in manufacturing methods and techniques. Description of the Black Warrior assemblage is preceded by a brief overview of the archaeological classification of microtools in the Southeast. The intent of this discussion is to summarize the extent of formal variability in microtool morphology and technology, the aim being to highlight the interpretive and typological implications of this variability. Artifact class descriptions are prefaced with a discussion of the classification methods used in the context of this study, and the variables measured in order to characterize the tools and manufacturing byproducts. The chronology of the assemblage is discussed following the class descriptions. The chapter concludes by evaluating the typological and chronological implications of the Black Warrior Valley microtool assemblage.

Microtool Classification in the Southeast

Artifacts classified as microtools from the late Middle Woodland onward in the Southeast vary in manufacturing techniques, degree of retouch, raw material, and the morphology of the bit and tool haft. As the type's name suggests, the small size of the tools is one of the distinguishing features of the artifact class. As a tool tradition, late prehistoric microlithic industries are characterized by three previously documented trends: (a) they generally occur in Late Woodland and early Mississippian contexts, (b) there are similarities and differences between and within settlements as to the relative frequency of microlithic tools within the total assemblage, and (c) they are linked, although not exclusively, to shell-working.

Initially described as "spicules of chert more or less square in cross-section," the Cahokia microlithic assemblage was later recognized as comprising "true microblades, tiny implements made from microblades, and usually exhausted cores from which the blades had been drawn" (Mason and Perino 1961). During the course of the

FAI-270 excavations microtools, blades, and cores were found at a number of outlying Mississippian sites on the American Bottom. These sites include both small domestic settlements and larger mound center sites (Yerkes 1984; Milner et al. 1984). The Cahokia microlithic industry has since become synonymous with analogous industries that were identified at two other Mississippi Valley settlements, Zebree in Arkansas (Morse and Morse 1980, 1983) and the Carson Mound site in Mississippi (Johnson 1987). Both the Zebree and Carson industries are technologically and historically connected to the Cahokia industry.

The Mississippi Valley microlithic industries can be described as a technological tool tradition that was focused on a common method of stone working and a specific raw material. Microtools were most frequently used during the tenth and eleventh centuries A.D. at large mound center sites such as Cahokia and Mitchell on the American Bottom, and at Zebree in Arkansas. Use-wear studies of microtools from Cahokia and other outlying sites have suggested that the tools were used primarily to drill shell. However, bone and hide polishes were also identified (Yerkes 1983, 1984, 1987). Since the initial identification of microtools at Cahokia, there has been an explicit typological association of these tools with a developed blade-core technology and shell working. Moreover, the industry as a whole has been interpreted as a trait related to developing social complexity during the Mississippian emergence (Yerkes 1983, 1984, 1985). One implication of this narrow association with a specific technological, social, and cultural context is that microtools from smaller sites are considered either as "problematical" (Faulkner 1968), or more recently, as "specialists'" tools (Prentice 1985).

Flake and blade microtools, as a component of local flake-tool technologies, are documented at a number of sites in the Southeast as early as 1000 B.C. and as late as A.D. 1500 (Kline 1985; Dickens 1976). Microtools vary in the degree and kind of secondary retouch required in their manufacture, depending on the intended function of the tool. Raw materials used are local, and formal similarities and differences can be related to (a) raw material characteristics and (b) tool use within the local communities where they are found.

Microtools have been reported from a number of sites in Tennessee. These tools are generally made on flakes rather than specially produced blades. One such tool assemblage comes from the Owl Hollow site (Kline 1985). The Owl Hollow assemblage consists of 28 tools that are morphologically and functionally similar. These tools are described as part of a microlith complex representing an opportunistic manufacturing technique (Kline 1985:88). The tools are manufactured on selected pieces of flake debitage, rather than a flake or blade preform. The implements are interpreted as scraping/graving and drilling tools related to the manufacture of bone needles (Kline 1985). Although the term microtool is not used, Dickens (1976:135-138) describes a unique flake-tool assemblage from the late Mississippian Pisgah phase at the Warren Wilson site. Included in this tool assemblage are a variety of small, cutting and perforating implements. Microtools made on blade-like flakes and other small flakes were also found in Late Woodland deposits at the Mason site. These tools are described as microtools, and are referred to as a problematical tool category (Faulkner 1968:99;Plate XII,G). Other microtool finds are reported from Late Woodland levels at the Westmoreland-Barber site (Faulkner and Graham:1966:83-84), and from Feature 69, an early Late Woodland midden on the Moccasin Bend site in Hamilton County, Tennessee (Graham 1964:31; Faulkner 1968:100).

In Alabama and Mississippi, microtools are found manufactured on flakes as well as blades. Described as microperforators, gravers, and drills, these tools are found at large Late Woodland villages as well as smaller, seasonal settlements, and at early Mississippian mound center sites (Rafferty and Starr 1986; Futato 1977, 1983, 1987; Ensor 1979,1981). In the Tombigbee and Tennessee River drainages, microtools made on flakes, blade-shaped flakes, and reworked triangular points have been found in late Middle Woodland, Late Woodland Miller III, and early Mississippian deposits (Futato 1977, 1983, 1987; Atkinson et.al. 1980; Rafferty and Starr 1986; Allan 1983; Jenkins et al. 1975). Futato (1983), uses the term "microlith" in a general sense to describe small tools made on both flakes and blades from Woodland and early Mississippian contexts in the Cedar Creek drainage. At the Lubbub archaeological locality, in the central Tombigbee River Valley, a microlithic industry composed of tools, blades, and cores is found in late Miller III and early Mississippian Summerville I contexts (Ensor 1979, 1981; Allan 1983; Walthall 1980:154).

In Georgia, microtools are reported from three early Mississippian sites. At the Gregg Shoals and Clyde Gulley sites, located along the Savannah River in northeast Georgia, quartz blade-tools and cores were found in Etowah phase deposits, an early Mississippian component in the South Appalachian Province (Tippitt and Marquardt 1984). At the site of Cemochechobee, an early Mississippian mound site, microtools were found in fill deposits in Mound B (Schnell et al. 1981).

In summary, small cutting, graving, and perforating tools, collectively described as microtools, are found in a number of archaeological contexts throughout the Southeast. Variability exisits in both tool technology and use. Microtools, as such, are found predominantly in Late Woodland and early Mississippian deposits. The tool class includes the hundreds of blade-tools from early

Mississippian deposits at large mound center sites such as Cahokia and Zebree in the Mississippi Valley. In the Southeast, microtools have been found at the mound center sites of Cemochechobee, Carson Mound, and the Lubbub Archaeological locality in the Tombigbee River Valley. Microtools made on both flakes and blades are also found to occur in lithic assemblages from farmstead and village contexts on the American Bottom, in the Moundville region, and throughout the Southeast. Functional studies have concluded that microtools from Cahokia and other American Bottom sites were used primarily to perforate shell. Other uses, including bone and hide working, are also evidenced.

The following classification of the Black Warrior microlithic assemblage is designed to present the full range of morphological and technological variability of this particular tool type in the Moundville region. The classification is designed to be functionally neutral since an evaluation of tool use is presented in Chapter IV.

The Black Warrior Valley Industry

The Black Warrior Valley microtools are primarily bifacially retouched and are manufactured predominantly, although not exclusively, on blades. Blade-core industries are technologically distinct and include finished and unfinished tools, as well as core and blade debitage. One hundred five whole and broken retouched microtools, 82 unfinished tool fragments, 745 unretouched blades, 55 blade cores, and 8 blade-core platform removal flakes from 15 sites in the Black Warrior Valley are included in this study. These data are provided in Tables A.1 through A.7 in Appendix A.

Microtools from sites in the Moundville region are generally less than 3.0 cm in maximum length. The mean length:width ratio is 2.5, and the mean width:thickness ratio is 2.0. Both size and form identify these tools as falling within the traditionally defined microtool class that includes small hafted bit-tools. On morphological grounds alone, the tools fall into the microdrill and graver functional categories described for the Mississippi Valley and Lubbub industries. Excluding small fragments, 72% of the tools are manufactured on blades or blade-shaped flakes. Of the remaining 28%, 11 tools are made on flakes, and 14 are manufactured on triangular bifaces.

Classification Methods

The following classification is based on morphological and technological attributes. Microtools have generally been described as drills or gravers, and occasionally scrapers, based on the bit-edge configuration. Because of the close link between tool design and intended function, there is a close correspondence between tool form and function. However, since the different microtool types, such as gravers and drills, do not form mutually exclusive formal classes, I have used the term "bit-tool" to refer to the implements classified in this study. This term is functionally neutral, yet it is descriptive of the small bit-like, retouched ends characteristic of the implements.

The typology is based on a three-tiered, class-type-subtype hierarchy. Class designations refer to the primary categories or components of the industry, including both tools and manufacturing debris. Variability in artifact form within classes, where it exists, is described using the type-subtype nomenclature. Artifact fragments too small to be unambiguously identified, tool types represented by only a few examples, and certain technological tool distinctions are treated as artifact groups and, as such, are excluded from the formal classification. The typology can be illustrated by the dendritic key shown in Figure 4. Similar dendritic keys have been used to build ceramic typologies focusing on local stylistic and technological variability (Steponaitis 1983). This typology implies a tree-type classification and, as such, is characterized by the following: (a) a hierarchy of importance among attributes that determines the order in which attributes are considered when assigning specimens to types, and (b) the classification criteria shift, depending on which "branch" of the tree is being followed in the process of classification (Whallon 1972; Steponaitis 1983:51).

The primary attribute differentiating bit-tool types is the nature of the blank used as the tool preform. Bit-tools made on flakes form one type or branch and bit-tools made on blades another. Once the appropriate type is

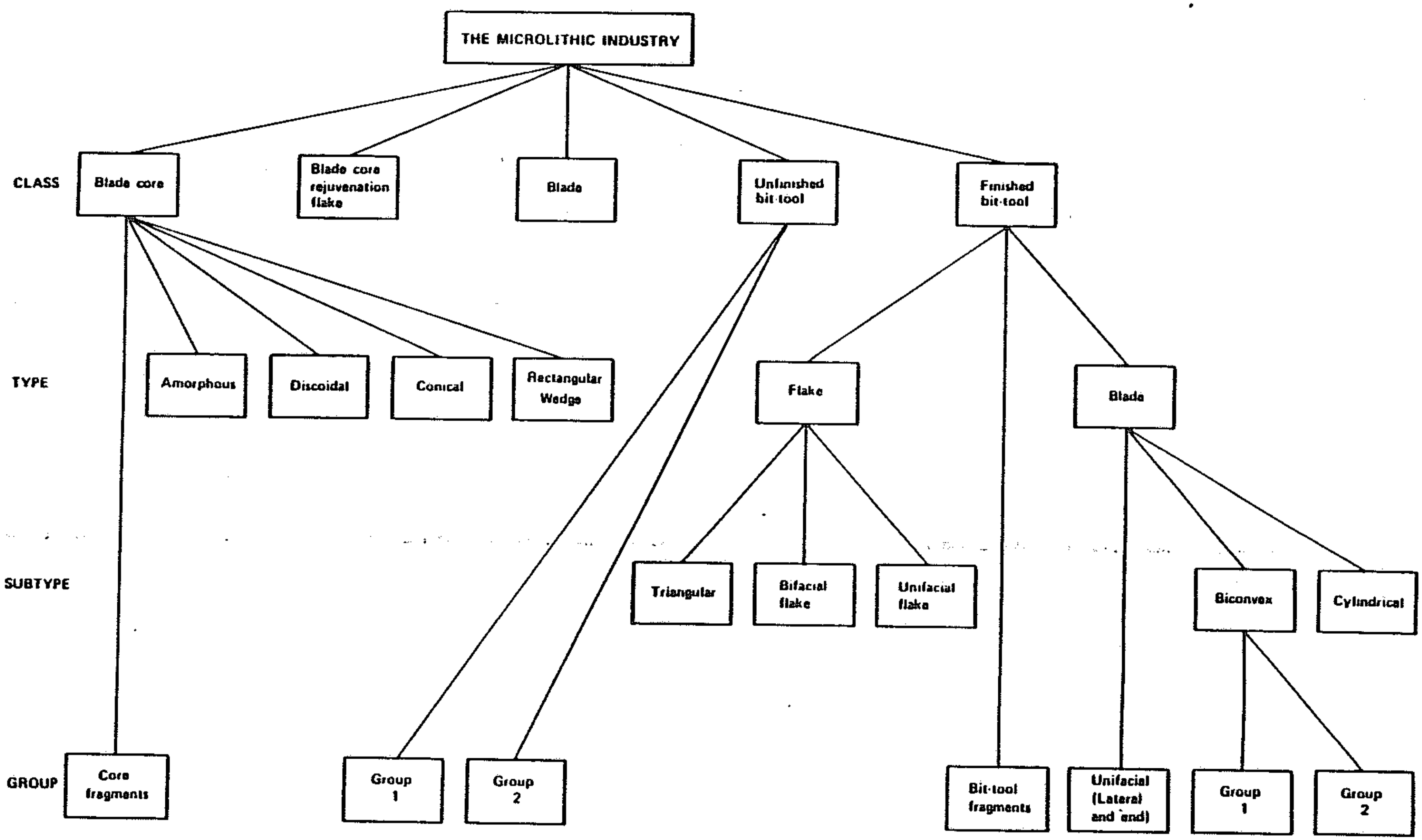


Figure 4. Dendritic key for the Black Warrior valley microlithic assemblage.

determined, then other technological and morphological attributes can be considered in the formation of microtool subtypes for both flake and blade microtools. Both unifacial and bifacial tools are present in the sample. After the pattern of surface and edge retouch is determined, variability in the shape of the tool haft and bit is considered. In addition to morphological-technological variation, tool bit shape is also affected by use. This aspect of variation will be examined when tool function is considered in Chapter IV. Technological relationships between microtool types and subtypes are considered in Chapter III. Blade core types are defined by the nature of blade removals (single versus multiple) and the resulting core morphology.

Variables of Core, Blade, and Bit-Tool Morphology

Variables used to describe the morphology of the cores, blades, and tools can be grouped into two categories: descriptive and technological. Descriptive variables recorded include three categories of information: (a) provenience, (b) raw material and conditions of thermal treatment or burning, and (c) overall dimensions (maximum length, width, thickness, cross-section, and breakage condition). Dimensions characterizing the haft and bit components of the tools were also measured in addition to overall size. Linear measurements used to define the size of the tools, blades, and cores are shown in Figure 5. Core thickness, not shown on the diagram, is defined as the maximum thickness measured along a plane perpendicular to the length-width axis. Bit-tool thickness is measured along a plane perpendicular to the maximum width of the tool.

Core technological variables were selected to describe features of the core platforms and the blade removal face. Core platform measurements include: (a) the number of platforms per core, (b) the location of the platform with respect to the core preform, (c) the presence or absence of platform preparation, and (d) the angle formed by the intersection of the blade removal face and platform surface. Variables characterizing the blade removal face are: (a) length, and (b) the number of blade removals along a single face. The geometric shape of the exhausted core was also recorded. Blade technological variables include: (a) cross-section, (b) the presence/absence and

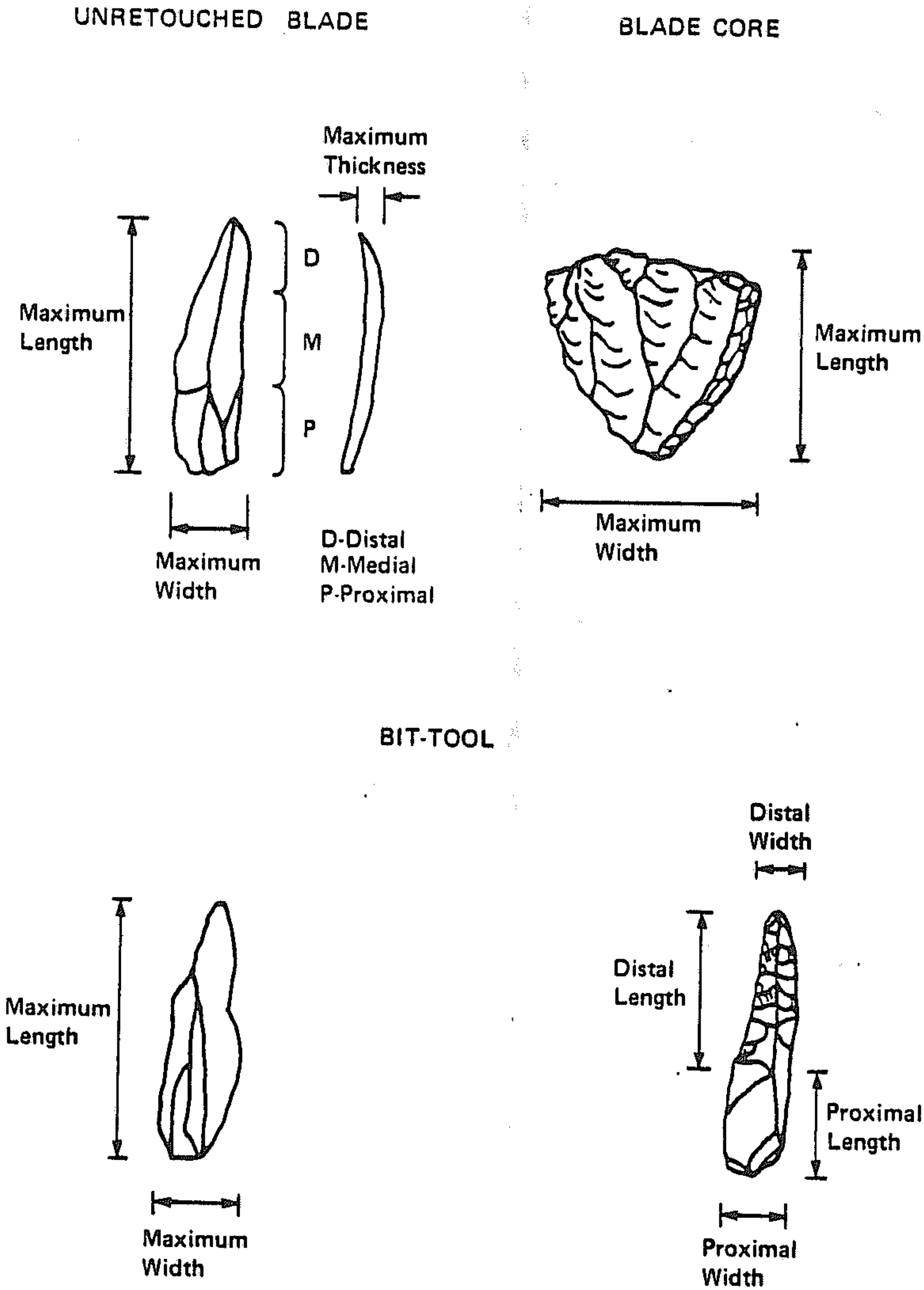


Figure 5. Descriptive variables.

location of cortex, and (c) the presence of dorsal flake scars. Microtool technological variables include: (a) the presence/absence of cortex, (b) tool haft and bit cross-section, and (c) the character of retouch. Discussion of the values for these variables is included in two different contexts in this study. The first deals with the regional classification of the individual artifacts. The second discussion focuses on the technological implications of the morphological variability and is presented in Chapter III.

In the sections that follow the artifact classes are described. Sample size, class definition, and sample descriptions are provided. As a prelude to this discussion, I begin with a description of the raw material from which the tools are manufactured.

<u>Raw Material</u>

Unlike the Mississippi Valley industries that were based on tabular Crescent Quarry cherts, the Alabama industries are based on the local Tuscaloosa gravel cherts deriving from Devonian and Mississippian formations. Local

Tuscaloosa cherts were the primary source of stone used by the prehistoric inhabitants of this region, especially in the Late Woodland and Mississippian periods.

Both the quantity of raw material available and its accessibility along stream channel terraces and exposed gravel bars would have made acquisition of this resource relatively easy. In situ limestone deposits and bedded cherts do not occur in west-central Alabama. The closest bedded cherts are the Bangor and Fort Payne deposits that outcrop in the northern part of the state and in portions of southern Tennessee, northeastern Mississippi, and northern Georgia.

The Tuscaloosa Formation consists of redeposited stream gravels that include a variety of rounded chert cobbles, sandstones, quartz, and quartzite. Quartz is predominant in gravel deposits in the eastern part of the state, while cherts are predominant in west-central and northwestern Alabama (Futato 1980). The Formation occurs in the basal portion of the Upper Cretaceous sedimentary deposits in the northern part of the Coastal Plain Province. Deposits extend in a belt 80 to 120 kilometers wide swinging from the east westward through Tuscaloosa County (Adams et al. 1926).

The quality of the gravel cherts is variable, as is the size of the individual cobbles (Futato 1980). Tuscaloosa cherts are generally fossil-free cryptocrystalline materials ranging in color from white to pale yellow and brownish-yellow. These materials when unaltered by thermal treatment are referred to in the archaeological literature as yellow chert or jasper. When heat-treated the cherts change color to varying shades of yellow-orange to pink and red depending on the temperature and intensity of heating (Futato 1980; Ensor 1980). Heat-treated gravel cherts in this region are frequently referred to as red jasper.

The use of thermal treatment of the local gravel cherts has both regional and temporal continuity in the Tombigbee and Black Warrior drainages (Futato 1980, 1983; Ensor 1980; Gillespie 1977). During the Late Woodland and Mississippian periods core-flake industries were based completely on heat-treated Tuscaloosa cherts. Sites surveyed in the Black Warrior Valley are covered with heat-treated gravel-chert debris, cores, and tools. There is no apparent association between the application of heat-treating and the manufacture of certain tool types. Although there are occasional implements made on non-treated materials, these appear to be exceptions rather than the norm. Having described the raw material basis of the industry, let us turn to a description of the individual artifact classes represented in the Black Warrior Valley sample.

Blade Cores

A total of 422 cores were collected during survey of the Black Warrior Valley sites, 81% of which were made on heat-treated Tuscaloosa gravel cherts. The cores are remnants from flake, bipolar, and microblade industries. Blade cores represent 15% of the total number of cores in the assemblage.

A total of 55 blade cores, 34 of which were whole, were identified in this study. Blade cores in the Black Warrior sample represent a continuum from initial core reduction to core exhaustion, including aborted and broken cores. The Black Warrior cores can be divided into two groups based on the occurrence of multiple (two or more), or single blade removals. The final shape of the multiple blade cores is determined by a combination of technological features including: (a) the amount of preparation and orientation of the platform with respect to the core preform, (b) the number of platforms per core, and (c) the number of blade removals per platform.

The 34 whole cores can be divided into five core types based on the final shape or geometry of the remnant core. Core fragments were excluded from the typology of whole cores and are described as a separate group. The frequency distributions of the core types are provided in Table 1. Blade core dimensions and characteristics are summarized for the five types in Tables 2 and 3.

Conical Cores. Seven conical cores were identified in the blade core class (Figure 6). Conical cores form a distinct core remnant because of the cone shape resulting from attempted multiple blade removals around the perimeter of the platform. The cone apex is created by convergence of the distal ends of the blade removal scars. As the core becomes more completely prepared and reduced, the cone

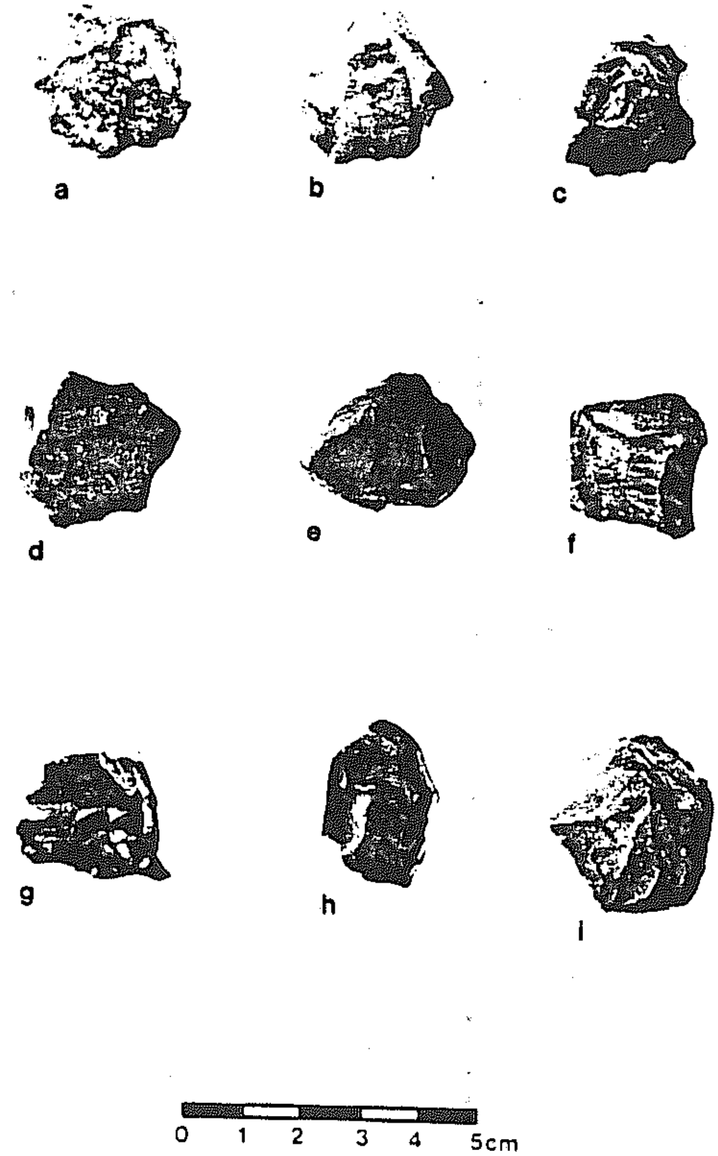


Figure 6. Conical and rectangular/wedge cores; a - e, conical; f - i, rectangular/wedge. a. Ha92-16-34, b. Tu66-40-1, c. Tu42-51-11, d. Ha92-45-9, e. Tu259-9-18, f. TuM2-1-2, g. Ha92-11-27, h. Tu66-16-2, i. TuM7-5-6.

Table 1. Core Type Frequency Distributions

Type	n	%
MULTIPLE:		
Conical	7	12.7
Rectangular/Wedge	3	5.5
Discoidal	6	10.9
SINGLE:		
Amorphous	18	32.7
FRAGMENT	21	38.2
TOTAL	55	100.0

shape becomes more defined.

Conical cores in the Black Warrior sample range from completely exhausted core nuclei to cores with minimal blade removals and unprepared platforms. These cores appear to have been manufactured by splitting already fractured cobbles, creating a roughly triangular preform shape. The platforms on all of the conical cores are non-cortical fracture surfaces.

Table 2. Blade Core Metrics

Type	n	Length (mm) Mean	S.D.	C.V.	Width (mm) Mean	S.D.	C.V.	Thickness (mm) Mean	S.D.	C.V.
Amorphous	18	34.3	7.1	21	25.3	4.1	16	18.0	3.8	21
Conical	7	28.5	2.3	28	25.1	2.3	9	14.1	2.8	26
Discoidal	5	38.5	7.4	19	25.6	4.8	19	18.2	4.5	25
Rectangular	2	27.3	4.7	17	23.8	0.6	2	16.3	1.8	11
Wedge	1	28.7	-	-	21.1	-	-	17.8	-	-

Table 3. Blade Core Technological Characteristics

Type	n	Blade Removal Face Length (mm) Mean	S.D.	C.V.	Platform Angle Mean	S.D.	C.V.
Amorphous	18	25.7	7.9	31	85.4	4.7	6
Conical	7	20.9	3.5	17	84.7	6.5	8
Discoidal	5	23.9	4.3	18	84.0	4.9	6
Rectangular	2	22.0	2.9	13	90.0	-	-
Wedge	1	22.1	-	-	90.0	-	-
Fragment	16	-	-	-	83.0	6.2	9
Platform removal	8	-	-	-	86.1	7.7	9

exhausted core platforms all show multiple facets removed to create a flat surface and to prepare the platform edge after successive blade removals. The faces for removing blades were also prepared, as evidenced on the more exhausted cores. Platform angles range between 73 and 90 degrees. Between three and five blade removals are evidenced on the exhausted cores.

Rectangular/Wedge Cores. Three cores in the sample are rectangular to wedge-shaped, the form depending on characteristics of the cobble preform and the presence of more than one platform (Figure 6). The small sample of cores in this type is likely a result of complete core reduction and breakage. Many of the core fragments appear to be remnants that would fall into this core type based on platform and blade removal features. Cores in this category are manufactured on blocky, rectangular-shaped core preforms. Two or more blades were removed from a common platform down one face of the core creating a rectangular shape. Platforms were flaked to create a flat, uniform surface, and acute angles were re-established by removing a burin-like transverse spall across the platform. The single wedge-shaped core has two platforms intersecting at right angles. Platform angles for this core type are in the ninety degree range resulting from complete core reduction.

Discoidal Cores. A total of six discoidal cores were identified in the sample (Figure 7). Tabular-shaped cobble fragments or flakes were used as core preforms. Both flakes and blade-shaped flakes were removed from the perimeter and on both faces of the core preform creating a bifacial or discoidal shape. Flakes and blades removed from cores in this category tend to be longer than those removed from conical or rectangular-wedge cores. Overlap in the production of both flakes and blades is indicated for this core type. However, some of the flake removals appear to isolate guiding ridges to facilitate blade removal. Platform angles range betwen 78 and 90 degrees.

Amorphous Cores. In contrast to the shaped, multiple blade core types that together comprise one-fourth of the blade core sample, are amorphous-shaped cores (Figure 8). A total of 18 amorphous cores were identified. Cores in this category were manufactured from cobble fragments of variable shape lacking a consistent pattern of platform

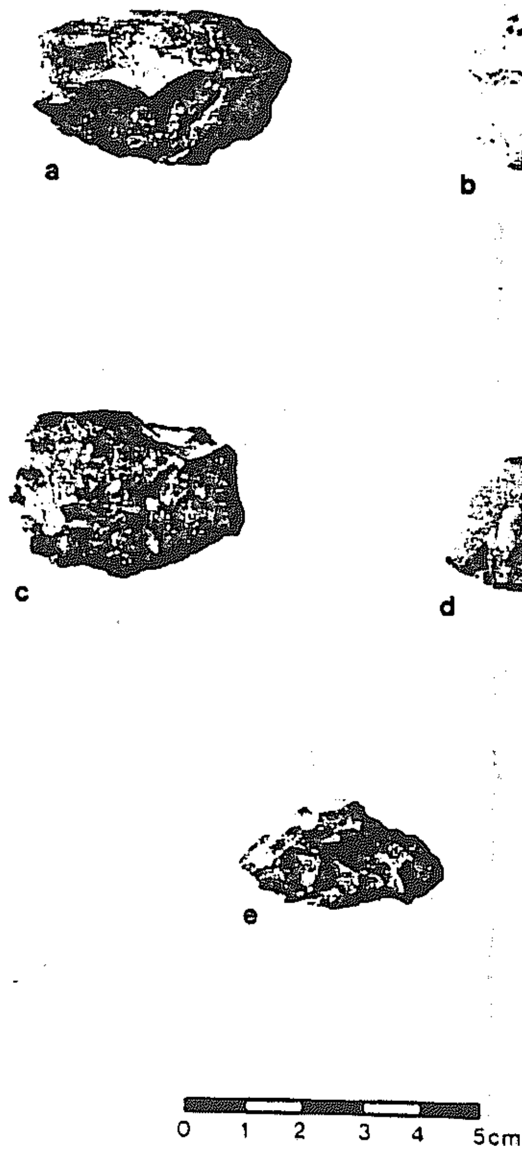


Figure 7. Discoidal cores. a. Tu66-70-1, b. Tu259-16-4, c. Tu259-14-29, d. Tu66-17-2, e. Ha92-2-26.

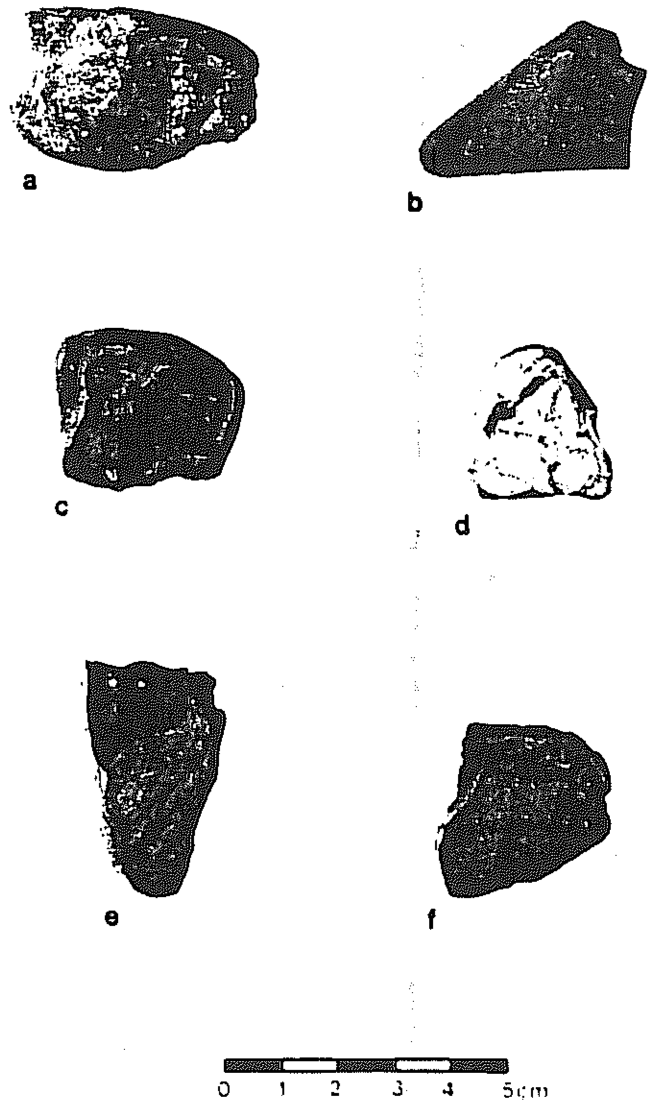


Figure 8. Amorphous-shaped cores. a. Ha15-21-11, b. Ha92-5-8, c. Tu66-51-1, d. Tu42-66-2, e. Ha92-22-17, f. Ha92-17-11.

orientation or blade removal. Amorphous cores have a single platform located on a naturally flat surface on the core preform. Both non-cortical fracture planes and cortical surfaces were used as platforms. Generally blades were removed from the longest flat cobble face, often using a non-cortical fracture surface. In some cases a platform was created by removing a single transverse flake to create a flat surface. Only one or two blades were removed.from these cores. Platform angles range between 78 and 90 degrees and have the lowest measure of platform angle variation compared to the other shaped core types.

Core Fragments. Nearly half of the cores in the assmeblage are fragments, mainly proximal, although one distal fragment is represented (Figure 9). The nature of the platform and blade scar facets indicate that the majority are fragments of multiple removal cores. Platform angles range between 72 and 98 degrees.

Core Rejuvenation Flakes

Eight platform removal flakes were identified in the sample (Figure 10). These flakes are recognizable as fragments of core platforms along with the upper portions

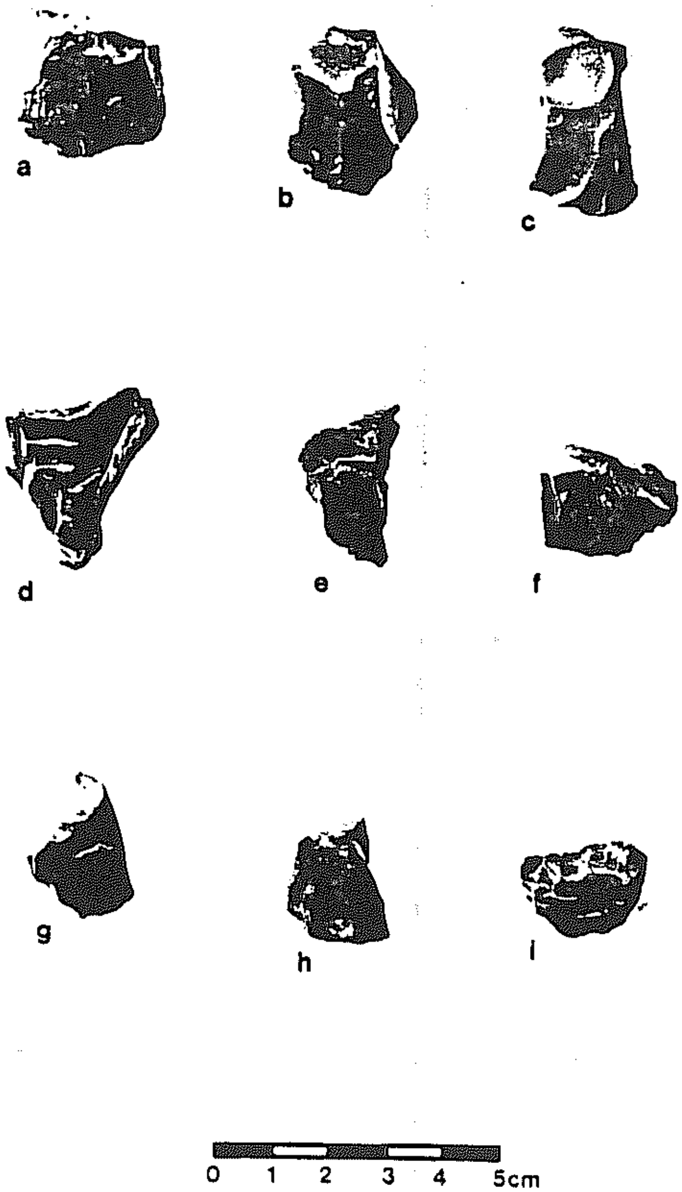


Figure 9. Blade core fragments. a. Ha92-32-22, b. Ha92-3-14, c. Tu42-49-12, d. Tu66-31-2, e. Ha15-8-5, f. Tu66-68-1, g. 'Tu66-69-2, h. Tu2-35-7, i. Ha92-37-15.

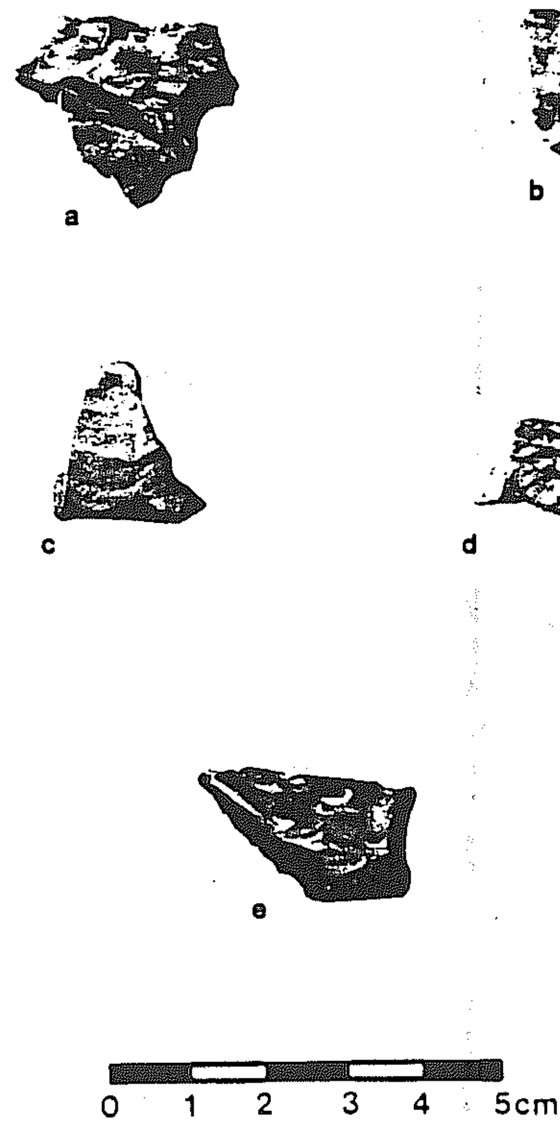


Figure 10. Blade core platform rejuvenation flakes. a. Tu66-42-4, b. Tu56-29-2, c. Tu262-CBC, d. Ha15-8-7, e. Tu66-45-2.

of the dorsal face of the core exterior. Crabtree (1968) notes that core recovery is important either when there is a shortage of material, or when the time required to prepare a new core is considered. Both of these factors may have been in operation when the task of heat-treating the material is considered.

Unretouched Blades

A total of 745 blades and blade fragments were recovered from sites in the Moundville region (Figure 11). The primary use of the blades appears to have been to serve as preforms from which the bit-tools were manufactured. The frequencies of breakage conditions are provided below in Table 4. A sample of 462 complete blades was used to describe the metric attributes summarized in Table 5.

A blade is generally recognized as a specialized flake that is linear in shape, having parallel to sub-parallel edges, its length being twice that of the width (Crabtree 1972). By definition blades are not random flakes since they must be struck from a prepared core that is designed to produce them.

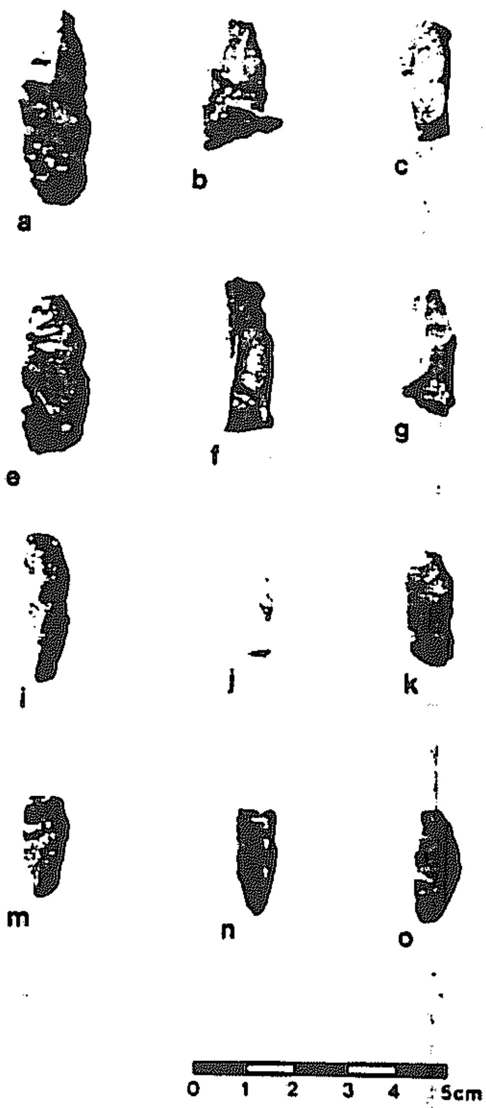


Figure 11. Blades. a. Tu66-12-9, b. Ha92-21-22, c. Tu66-65-18, d. Tu66-14-1, e. Tu259-5-36, f. Ha92-32-25, g. Tu-259-5-36, h. Tu66-49-1, i. Tu58-CBC, j. Tu259-2-16, k. Ha92-2-34, l. Tu66-14-1, m. Tu66-39-1, n. Tu66-35-1, o. Tu66-44-1, p. Tu259-2-16.

Table 4. Breakage Condition for the Blade Sample

Condition	n	%
Complete	462	62
Distal	9	1
Medial	37	5
Proximal	44	6
Medial-distal	88	12
Medial-proximal	100	13
Lateral	5	.7
TOTAL	745	100.0

Table 5. Blade Descriptive Statistics[1]

Variable	n	Mean	S.D.	Range	C.V.
Length (mm)					
l/w > 2.0	321	19.6	3.7	12.2 - 38.3	18
l/w < 2.0	141	17.7	3.2	11.9 - 27.6	18
Width (mm)					
l/w > 2.0		8.4	1.6	2.2 - 13.5	19
l/w < 2.0		9.9	1.9	6.3 - 18.8	19
Thickness (mm)					
l/w > 2.0		3.0	1.1	0.1 - 9.5	36
l/w < 2.0		2.9	1.0	1.1 - 6.2	35
Width: Thickness					
l/w > 2.0		3.0	0.9	0.8 - 6.5	30
l/w < 2.0		3.7	1.0	1.8 - 8.4	28
Length: Width					
l/w > 2.0		2.4	0.4	2.0 - 7.1	18
l/w < 2.0		1.8	0.2	1.1 - 2.0	10

1 For each variable, statistics are presented separately for blades with length/width ratios of > 2.0 and those with ratios of < 2.0.

The Black Warrior blades are not finished products. Rather, these items were used primarily as tool blanks for manufacturing bit-tools. Consequently, items included in the sample are discarded blades, blade fragments, and debitage resulting from this manufacturing process. While, for classification purposes, I have followed the traditional, formal blade criteria to a degree, other distinctive production features were used in defining the Black Warrior Valley blade sample as well. Thus, the full range of variation characteristic of the manufacturing trajectory is represented.

Similar approaches in the definition of blade assemblages can be found in the work of other researchers who have studied blade industries in the Arctic and among the prehistoric Chumash in California (Aigner 1970; Arnold 1983). The approach I have used follows the logic expressed in Aigner's definition of blades in terms of their production features. In this way,

> all of the variation, including poorly manufactured blades which clearly were not suitable as tool blanks, is included since the aim is to define a total system of stone tool production with its real patterns of manufacture and real end-products, not idealized categories of blades, or microblades preconceived by the archaeologist [Aigner 1970:61].

Microblades in the Southeast are described as such because they are generally less than three centimeters in maximum length. Mean blade lengths for the major Southeastern microlithic industries, including Cahokia, are listed in Table 6. Only the subset of blades in the Black Warrior assemblage with a length:width ratio greater than or equal to 2.0 is listed in Table 6. This is done to allow comparisons with other industries that are defined by this feature. Frequency distributions for maximum blade length and width are shown in Figure 12. Blades in the sample are primarily triangular in cross-section (74%).

In contrast to trapezoidal blades designed for cutting tasks, triangular blades are a more suitable preform design for tools such as drills and gravers. By design, these tools require a relatively sturdy symmetrical axis and a convergent or tapering end. While the blades in the sample are primarily waste blades, they are nonetheless fairly consistent in size. The majority have a single dorsal ridge extending along either the entire length, or part of the length of the blade. Variability in size and features of the blade also affected the degree of retouch required

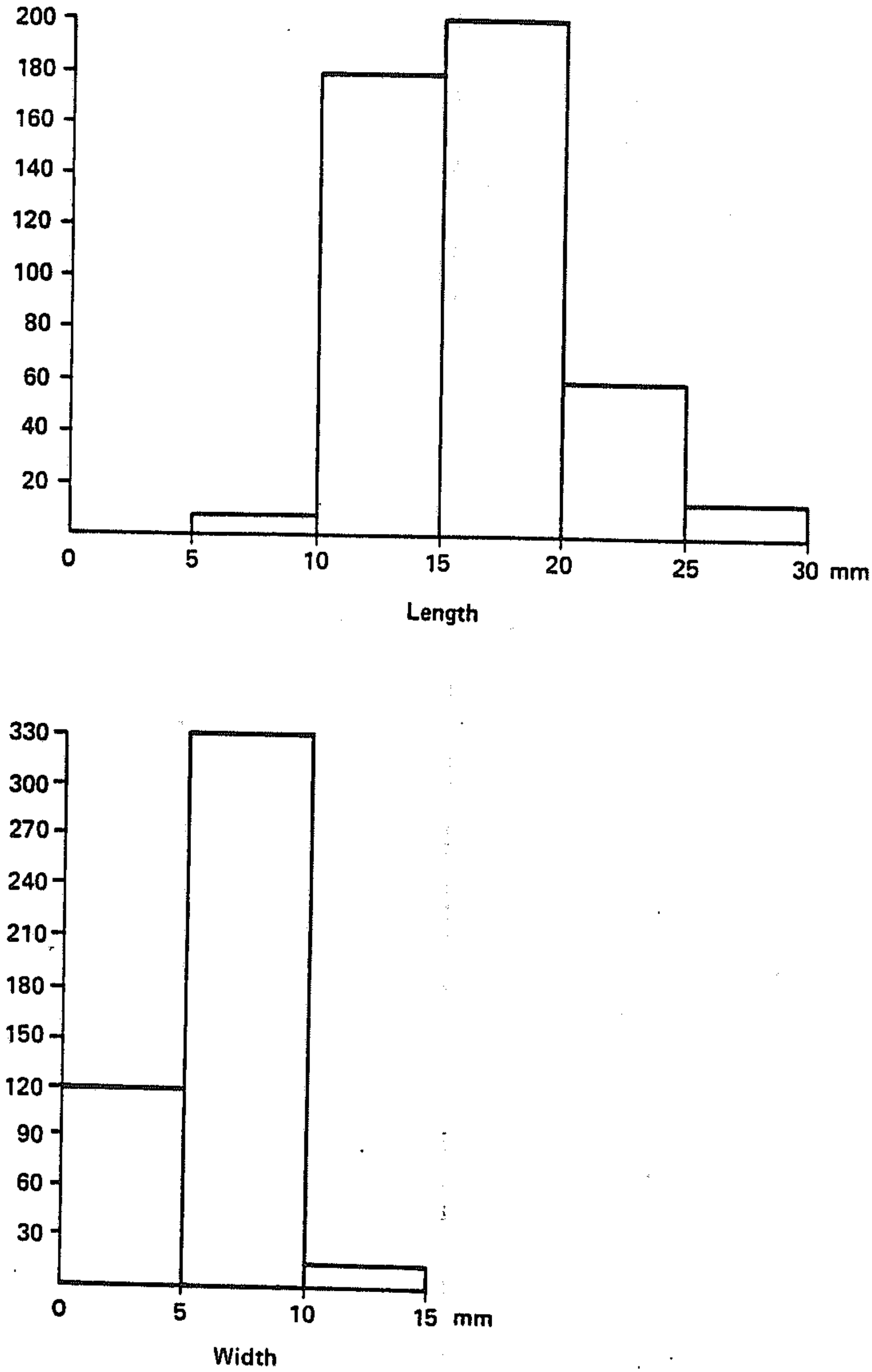


Figure 12. Distributions of maximum length and maximum width for the Black Warrior Valley blade sample (complete blades only, n=462).

to manufacture a suitable bit-tool. These features will be discussed in greater detail in Chapter III.

Table 6. Comparisons of Blade Length for Major Microlithic Industries (mm)

Industry	Raw Material	n	Mean	S.D.
Poverty Point (Webb and Gibson 1981)	local gravel	30	33.8	8.2
Cahokia (Yerkes 1983; Mason and Perino 1961)	Crescent Quarry tabular chert	64	25.3	7.2
Zebree (Morse and Morse 1980)	Crescent Quarry tabular chert	66	19.4	7.1
Carson Mound (Johnson 1987)	Crescent Quarry tabular chert	38	28.1	8.1
Lubbub Area (Ensor 1981)	Tuscaloosa gravel chert	14	27.1	5.0
Black Warrior Valley	Tuscaloosa gravel chert	321	19.6	3.7

Unfinished Bit-tools

One of the distinctive features of the Black Warrior and Lubbub micro-tool assemblages is that the blade bit-tools are primarily bifacially shaped. And, as one would expect, broken, and aborted biface bit-tool preforms occur in both industries. This characteristic is less common among microlithic industries that were based on tabular cherts. The Cahokia, Zebree, and Carson Mound industries are predominantly unifacial. The physical difference in raw material is likely to be one reason for differences in manufacturing techniques.

A total of 82 unfinished bit-tool fragments were identified in the Black Warrior assemblage (Figure 13). Two distinct groups can be recognized by differences in flaking patterns and dimensions of width and thickness. Group 1 preform fragments are larger and have undergone initial primary flaking. This group has a mean width:thickness ratio of 1.7. Group 2 preform fragments are smaller and have undergone both primary and secondary flaking. The mean width:thickness ratio for the second group is 2.1.

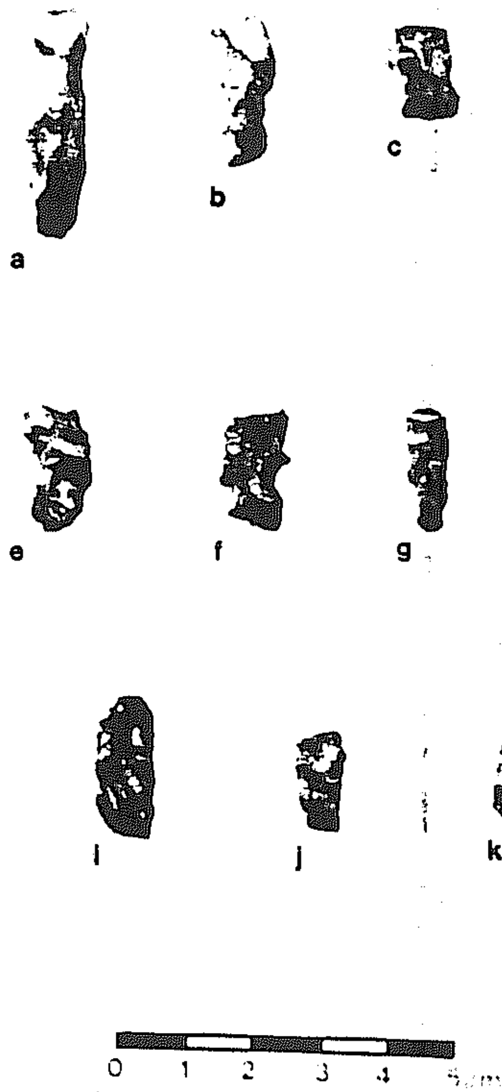


Figure 13. Unfinished Bit-tool fragments; a - f, group-1; g - k, group-2. a. Ha92-32-16, b. Tu66-15-33, c. Tu66-14-3, d. Ha92-37-11, e. Tu66-22-2, f. Tu59-1-6, g. Tu259-12-25, h. Tu66-41-42, i. Tu66-25-10, j. Tu56-22-13, k. Ha15-22-5.

Used Bit-tools

The Black Warrior microlithic assemblage includes 105 small bit-tools and tool fragments. The small size of the implements is a defining feature of the tool class. Size, form, and manufacturing methods together identify the majority of the objects classified in this study as microtools. Microtool bits are both bifacial and unifacial. The majority of the tools are manufactured on blade preforms.

Unbroken, used tools account for 36% of the bit-tool sample. Frequencies of the breakage conditions for the tool class as a whole are provided in Table 7. Metric dimensions for the bit-tool class as a whole are provided in Table 8.

Table 7. Frequencies of Breakage Conditions for the Bit-Tool Class

Condition	n	%
Complete	38	36
Distal	3	3
Medial	6	6
Proximal	5	5
Medial/distal	20	19
Medial/proximal	33	31
TOTAL	105	100

Table 8. Bit-tool Metric Dimensions, Morphological Types Combined (Complete Only)

Variable	N	Mean (mm)	S.D. (mm)	Range (mm)	C.V.
Length	39	20.89	4.34	13.90-34.40	20.7
Width	39	8.80	2.01	6.00-14.70	22.9
Thickness	39	4.48	1.04	1.70-8.00	23.3
Weight	39	0.74	0.29	0.30-1.40	40.0
Bit Length	33	8.86	3.23	2.70-17.7	36.5
Bit Width	36	4.34	1.33	2.50-8.50	30.6
Bit Thickness	37	3.15	0.78	1.50-5.10	24.8
Haft Length	33	12.16	4.31	3.30-24.1	35.5
Haft Width	36	8.92	2.09	4.50-14.70	23.4
Haft Thickness	36	4.31	1.01	2.90-8.00	23.5
Width:Thickness	39	2.06	0.67	1.17-4.20	32.8
Length:Width	39	2.51	0.83	1.17-4.58	33.2
Bit Width:Thickness	36	1.40	0.33	0.75-2.42	24.1
Bit Length:Width	33	2.07	0.66	1.08-3.70	31.8
Haft Width:Thickness	36	2.15	0.67	1.21-4.20	31.3
Haft Length:Width	33	1.48	0.72	0.24-3.53	48.5

Blade Bit-tools

Blade bit-tools are the largest technological category; 63 of the 105 bit-tools are manufactured on blades. Blade bits include items that are traditionally classified as microdrills and represent the finished tools in a distinct core-blade technology. The reduction process involved three stages: (a) thermal pre-treatment of local Tuscaloosa gravel chert; (b) preparation of cobble cores for the removal of microblade preforms; and (c) bifacial and unifacial surface and/or edge retouch.

Two blade bit-tool subtypes are defined, both of which are characterized by bifacial retouch. These subtypes include a biconvex type and a cylindrical type. Unifacially retouched blades form a separate group of blade-bit tools. Although the unifacial tools are morphologically distinct, the small sample size warrants description of these tools as a group, rather than a formal subtype. Descriptive statistics for the blade bit-tools are presented in Table 9.

Cylindrical Blade Bits. Twenty cylindrical blade bits are represented in the sample (Figure 14). As the name

Table 9. Blade Bit-tool Metric Dimensions For Complete Tools

Variable	N	Mean (mm)	S.D. (mm)	Range (mm)	C.V.
Length	22	22.46	4.28	16.20-34.00	19.0
Width	22	8.13	1.56	6.00-11.00	19.2
Thickness	22	4.77	1.00	3.10-8.00	21.0
Weight	22	0.74	0.26	0.40-1.40	35.5
Bit Length	19	9.15	2.97	5.70-15.30	32.5
Bit Width	20	4.09	0.93	3.00-5.90	22.9
Bit Thickness	20	3.22	0.71	2.00-5.10	22.2
Haft Length	19	13.80	3.69	8.80-24.10	26.7
Haft Width	20	8.19	1.73	4.50-11.0	21.1
Haft Thickness	20	4.50	1.11	3.00-8.00	24.8
Width:Thickness	22	1.77	0.50	1.17-2.87	28.6
Length:Width	22	2.86	0.80	1.69-4.58	28.2
Bit Width:Thickness	20	1.27	0.17	1.00-1.75	13.6
Bit Length:Width	19	2.24	0.68	1.46-3.70	30.5
Haft Width:Thickness	20	1.89	0.54	1.21-2.87	28.9
Haft Length:Width	19	1.79	0.67	1.00-3.53	37.7

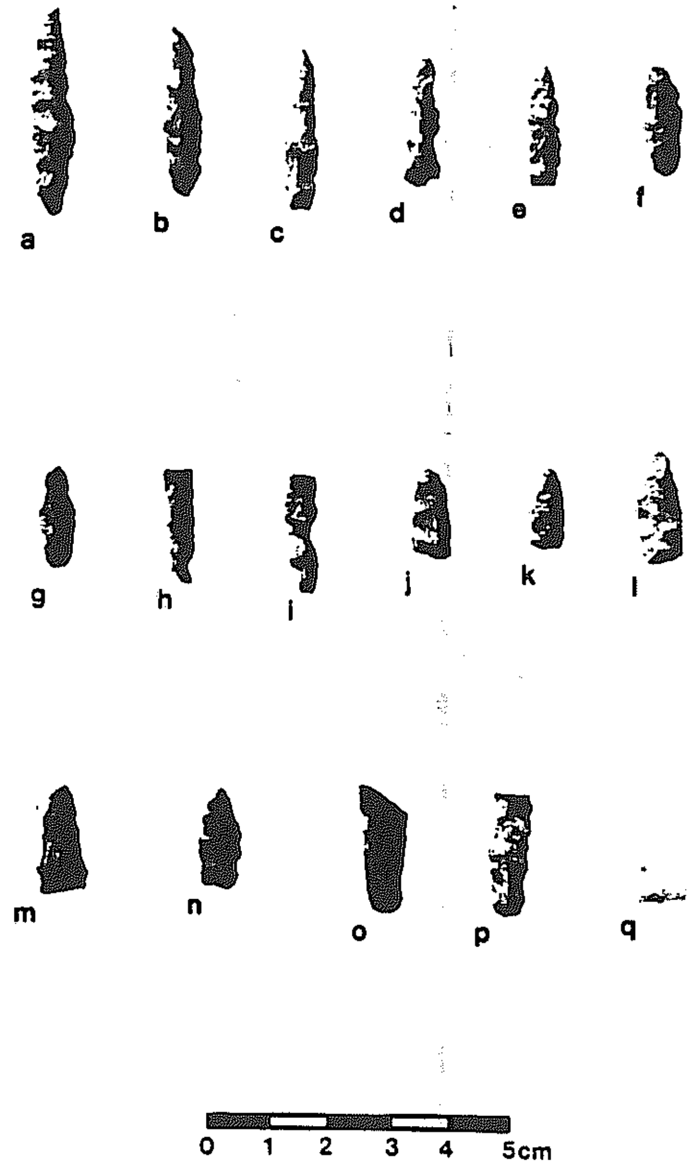


Figure 14. Cylindrical bit-tools. a. Ha92-22-14, b. Tu66-21-6, c. Ha8-27-1, d. Tu48-CBC, e. Ha7-46-5, f. Tu65-1-28, g. Tu46-8-11, h. Tu66-14-20, i. Tu398-3-1, j. Tu259-13-28, k. Tu259-8-27, l. Ha8-233-1, m. Ha92-11-21, n. Tu66-31-13, o. Ha7-50-7, p. Tu259-12-24, q. (quartz), Tu62-1-1.

implies, tools of this form are cylindrical along the entire tool axis. These tools are bifacially shaped creating a tool with a completely cylindrical cross-section. A mean width:thickness ratio of 1.4 with a coefficient of variation of 18% describes the fairly uniform cylindrical shape of this implement.

Cylindrical tools have larger bits than the other bit-tools. The mean length of cylindrical bits is 12.1 mm. One of these tools is double-bitted (Figure 14:f). Another tool is unique in that it has an almost completely cylindrical cross-section (Figure 14:h). Descriptive statistics for cylindrical bit-tools are provided in Table 10. With the exception of one quartz tool and one tool made from unheated gravel chert, all of the tools are manufactured from heat-treated Tuscaloosa gravel chert.

Biconvex Blade Bits. Biconvex blade bit-tools are the most common bit-tool form in the sample (Figures 15 and 16). There are 40 biconvex bit-tools in the microtool class. Attributes defining this subtype include a tool haft that is biconvex in cross-section, and a small triangular-to-cylindrical bit.

Table 10. Cylindrical Bit-tool Metric Dimensions (complete only)

Variable	N	Mean (mm)	S.D. (mm)	Range (mm)	C.V.
Length	7	23.67	6.34	17.00-34.40	26.8
Width	7	6.74	0.61	6.00-7.70	9.1
Thickness	7	4.78	0.42	4.00-5.10	8.9
Weight	7	0.71	0.16	0.50-1.00	23.4
Bit Length	5	12.12	2.77	8.80-15.30	22.9
Bit Width	5	5.06	0.74	4.20-5.90	14.6
Bit Thickness	5	4.06	0.77	3.20-5.10	19.0
Haft Length	5	13.98	5.91	8.80-24.10	42.2
Haft Width	5	6.86	0.71	6.00-7.70	10.4
Haft Thickness	5	4.24	0.82	3.00-5.10	19.4
Width:Thickness	7	1.42	0.25	1.17-1.92	18.1
Length:Width	7	3.50	0.82	2.65-4.58	23.6
Bit Width:Thickness	5	1.25	0.11	1.09-1.40	9.5
Bit Length:Width	5	2.49	0.91	1.49-3.47	36.7
Haft Width:Thickness	5	1.66	0.31	1.27-2.00	18.9
Haft Length:Width	5	2.01	0.71	1.46-3.21	35.4

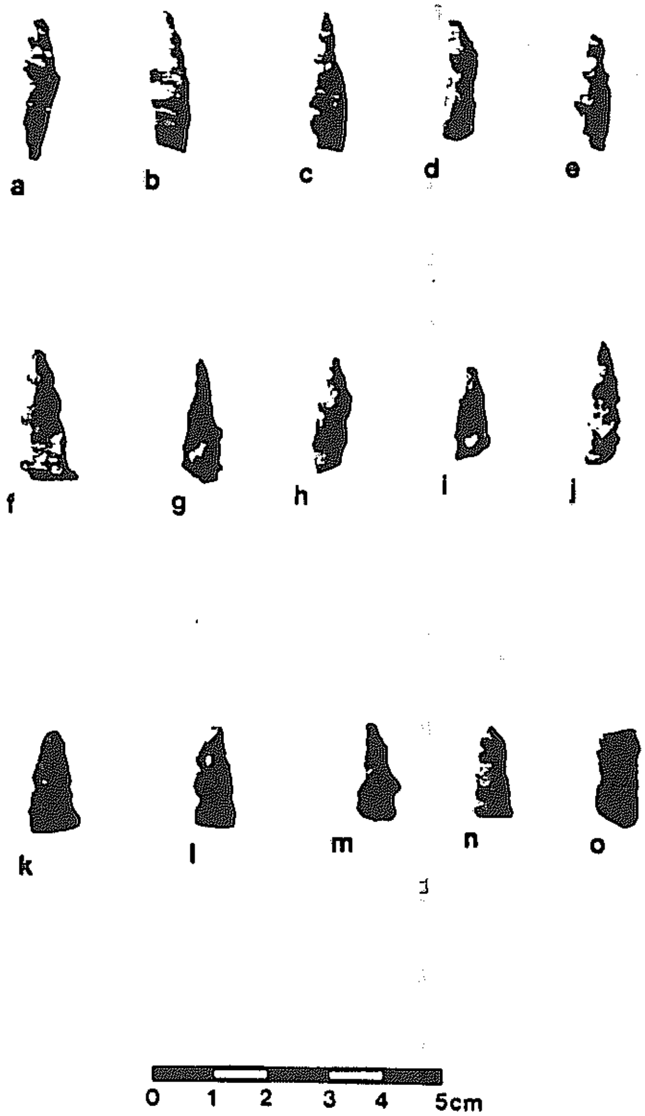


Figure 15. Biconvex bit-tools, group-1. a. Ha92-32-19, b. Tu2-15-5, c. Tu66-68-6, d. Tu259-5-21, e. Tu66-45-16, f. Tu66-15-3, g. Ha8-91-2, h. Ha8-256-2, i. Tu2-13-3, j. Ha92-36-12, k. Tu66-47-11, l. Tu66-30-19, m. Tu66-38-13, n. Tu66-30-18, o. Tu66-69-33.

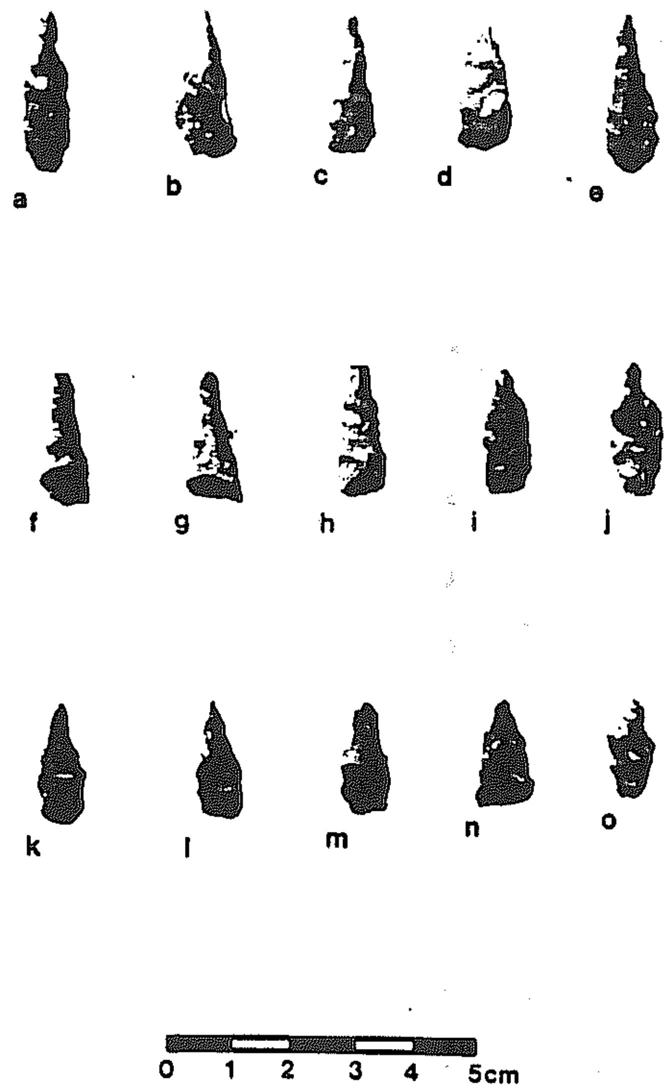


Figure 16. Biconvex bit-tools, group-2. a. Ha107-11-4, b. Ha8-189-1, c. Tu66-17-6, d. Tu259-12-27, e. Ha8-267-1, f. Tu58-CBC-6, g. Tu66-44-22, h. Ha8-75-1, i. Tu66-14-21, j. Tu66-42-9, k. Tu66-43-13, l. Tu66-13-5, m. Ha7-49-10, n. Tu346-7-4, o. Ha92-43-13.

Variation in the extent of secondary retouch required to manufacture these tools can be used to define two morphologically distinct groups. The primary attribute distinguishing between the two groups is the degree of secondary retouch. This variability is, in turn, related to the size and shape of the blade preform and prominence of a dorsal blade ridge. Group 1 biconvex bits (n = 16), were made on narrower blades having a prominent dorsal ridge (see Figure 15). Because of these features, minimal retouch was required to create the desired tool form. On the other hand, Group 2 biconvex bits (n = 24), were made on wider blades with a less-prominent dorsal ridge (see Figure 16). More extensive surface shaping and retouch was used in making these tools. Group 1 biconvex tools have both triangular and cylindrical bits, whereas the tools in Group 2 are primarily cylindrical in cross-section.

Descriptive statistics for biconvex bit-tools, and biconvex groups 1 and 2 are given in Tables 11, 12, and 13. A scatter plot of width versus thickness can be used to visually differentiate between the two biconvex bit-tool groups as shown in Figure 17. Two of the implements in this subtype were manufactured on unheated gravel cherts,

Table 11. Biconvex Bit-tool Metric Dimensions (complete only)

Variable	N	Mean (mm)	S.D. (mm)	Range (mm)	C.V.
Length	15	21.90	3.03	16.20-26.80	13.8
Width	15	8.78	1.44	6.60-11.00	16.4
Thickness	15	4.76	1.19	3.10-8.00	25.0
Weight	15	0.76	0.30	0.40-1.40	40.0
Bit Length	14	8.10	2.30	5.70-13.50	28.4
Bit Width	15	3.77	0.77	3.00-5.30	20.4
Bit Thickness	15	2.94	0.43	2.00-4.00	14.7
Haft Length	14	13.74	2.85	10.30-18.50	20.8
Haft Width	15	8.63	1.75	4.50-11.00	20.3
Haft Thickness	15	4.59	1.21	3.10-8.00	26.4
Width:Thickness	15	1.93	0.51	1.30-2.87	26.9
Length:Width	15	2.56	0.62	1.69-3.69	24.2
Bit Width:Thickness	15	1.28	0.19	1.00-1.75	14.9
Bit Length:Width	14	2.15	0.59	1.46-3.70	27.6
Haft Width:Thickness	15	1.97	0.59	1.21-2.87	30.1
Haft Length:Width	14	1.72	0.67	1.00-3.53	39.2

Table 12. Biconvex Bit-tool Metric Dimensions, Group 1 (complete only)

Variable	N	Mean (mm)	S.D. (mm)	Range (mm)	C.V.
Length	6	23.43	1.57	21.20-25.10	6.7
Width	6	8.23	1.86	6.60-10.80	22.6
Thickness	6	5.36	1.39	4.30-8.00	25.9
Weight	6	0.91	0.32	0.60-1.40	35.4
Bit Length	5	9.94	2.42	7.20-13.50	24.4
Bit Width	6	4.08	0.99	3.00-5.30	24.4
Bit Thickness	6	3.08	0.51	2.50-4.00	16.8
Haft Length	5	13.62	2.54	10.80-16.20	18.6
Haft Width	6	7.85	2.38	4.50-10.80	30.3
Haft Thickness	6	4.93	1.59	3.70-8.00	32.4
Width:Thickness	6	1.55	0.21	1.30-1.89	14.1
Length:Width	6	2.95	0.60	2.19-3.69	20.6
Bit Width:Thickness	6	1.32	0.24	1.00-1.75	18.5
Bit Length:Width	5	2.40	0.77	1.80-3.70	32.2
Haft Width:Thickness	6	1.65	0.60	1.21-2.84	36.5
Haft Length:Width	5	2.07	0.95	1.00-3.53	45.8

Table 13. Biconvex Bit-Tool Metric Dimensions, Group 2 (complete only)

Variable	N	Mean (mm)	S.D. (mm)	Range (mm)	C.V.
Length	9	20.88	3.41	16.20-26.80	16.3
Width	9	9.15	1.05	7.70-11.00	11.4
Thickness	9	4.36	0.91	3.10-6.00	20.8
Weight	9	0.65	0.25	0.40-1.10	38.9
Bit Length	9	7.07	1.54	5.70-10.60	20.8
Bit WIdth	9	3.56	0.54	3.00-4.70	15.3
Bit Thickness	9	2.84	0.36	2.00-3.20	12.9
Haft Length	9	13.81	3.16	10.30-18.50	22.9
Haft Width	9	9.15	1.05	7.70-11.00	11.4
Haft Thickness	9	4.36	0.91	3.10-6.00	20.8
Width:Thickness	9	2.18	0.51	1.42-2.87	23.5
Length:Width	9	2.31	0.50	1.69-3.48	22.0
Bit Width:Thickness	9	1.26	0.15	1.06-1.50	12.6
Bit Length:Width	9	2.01	0.46	1.46-2.94	23.0
Haft Width:Thickness	9	2.18	0.51	1.42-2.87	23.5
Haft Length:Width	9	1.52	0.41	1.11-2.40	27.0

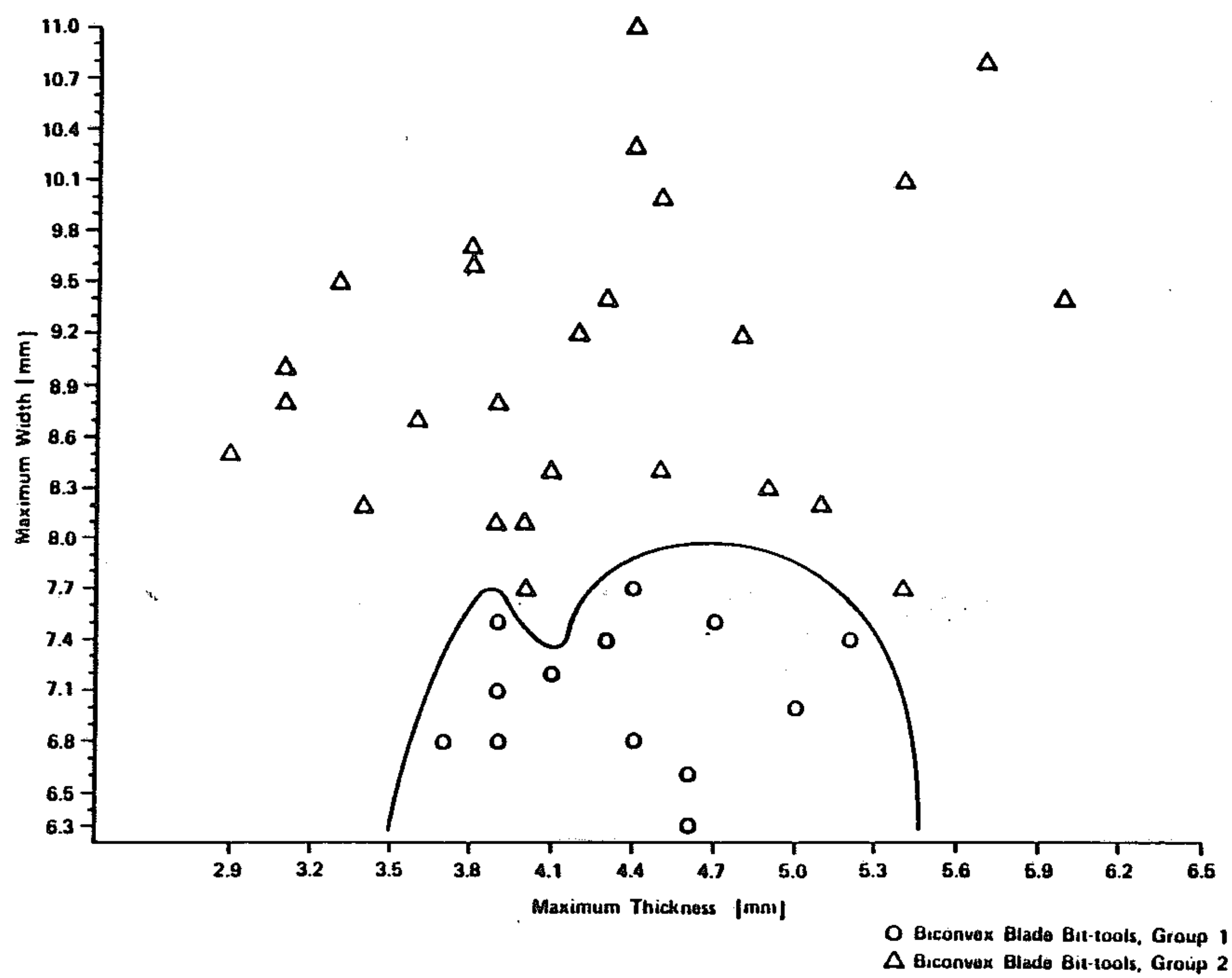


Figure 17. Scatter plot of maximum width versus maximum thickness for biconvex blade bit-tools, groups 1 and 2.

while the rest are made from the local heated cherts.

Unifacial Blade Bits

Four bit-tools characterized by unifacial edge retouch have been included in the microtool class (Figure 18). Except for either lateral or end retouch, these tool are otherwise unaltered. Two implements are characterized by steep lateral retouch along the entire length of both edges, converging into a rounded tip (Figure 18:a and b). The lateral edges show signs of heavy use and are blunted. These tools are square in cross-section. One is manufactured from quartz and the other from heat-treated Tuscaloosa chert. The other two tools in this group show fine unifacial edge retouch at the distal end of the tool, forming an acute tip (Figure 18:c and d). Both are triangular in cross-section and are manufactured from heat-treated Tuscaloosa chert.

Flake Bit-tools

Flake bit-tools occur less frequently than blade bits. A total of 39 bit-tools manufactured on flakes are included in the micro-tool sample. Flake bits include tools

Figure 18. Unifacial blade and flake bit-tools. a - d, blade bit-tools; e - h, flake bit-tools. a. HaM6-19, b. Ha92-40-6, c. Tu46-14-5, d. Ha8-270-2, e. Tu259-5-20, f. Tu66-49-23, g. Tu259-14-26, h. Ha8-91-1.

traditionally classified as micro-tools in the Southeast, but are made on non-blade preforms. Although not manufactured on blades, these tools are morphologically similar to the blade bit-tools. Two bifacial flake bit subtypes are differentiated on the basis of tool form. A third subtype is defined by unifacial lateral and end retouch.

Triangular Bifacial Bits

Triangular bit-tools are a distinct subtype within the flake bit-tool type. These tools are characterized by a bifacially shaped triangular tool haft and a tapering, bifacially retouched, narrow, bit-like projection (Figure 19). While these tools may have been intentionally manufactured as such, the formal similarities to Late Woodland and Mississippian triangular arrow points suggests that certain tools in this subtype are reworked arrow points. Fourteen triangular bit-tools are included in the micro-tool class. Descriptive statistics are provided in Table 14.

Throughout the Eastern Woodlands, small triangular arrow points are one of the most common chipped stone tools occurring on Late Woodland and Mississippian sites.

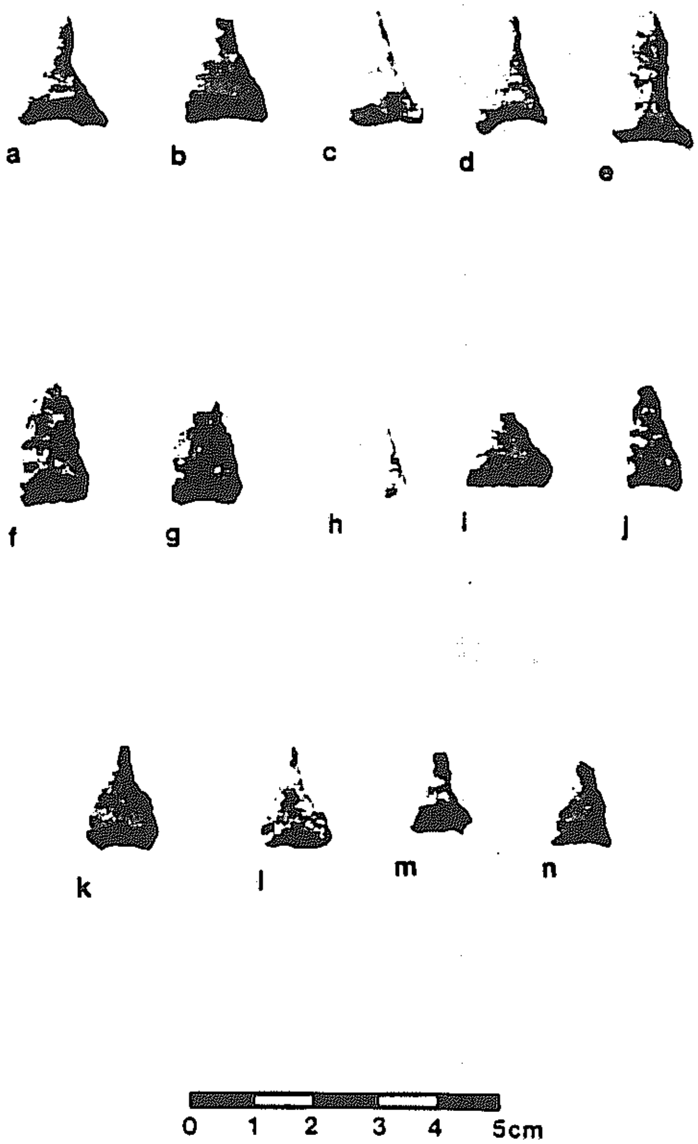


Figure 19. Triangular bit-tools. a. Tu66-31-11, b. Ha8-189-2, c. Tu66-16-33, d. Tu66-51-5, e. Ha8-118-1, f. Tu346-17-1, g. Tu66-45-22, h. Tu66-43-18, i. Ha7-33-3, j. Ha92-25-3, k. Tu346-10-1, l. Tu66-1-6, m. Tu259-8-28, n. Ha92-13-9.

Table 14. Triangular Bit-tool Metric Dimensions (complete only)

Variable	N	Mean (mm)	S.D. (mm)	Range (mm)	C.V.
Length	4	18.90	1.94	17.20-21.00	10.2
Width	14	12.01	1.65	9.30-14.70	13.6
Thickness	14	4.33	1.32	2.90-7.70	30.5
Weight	4	0.82	0.33	0.50-1.20	40.0
Bit Length	11	9.19	3.94	2.60-17.70	42.8
Bit Width	12	4.17	1.43	2.60-7.00	34.4
Bit Thickness	12	2.86	0.93	2.00-4.90	32.5
Haft Length	12	7.79	2.44	3.30-11.90	31.3
Haft Width	12	12.27	1.70	9.30-14.70	13.8
Haft Thickness	12	3.96	0.86	2.90-6.00	21.7
Width:Thickness	14	2.89	0.79	1.55-4.20	26.5
Length:Width	4	1.48	0.23	1.17-1.71	15.6
Bit Width:Thickness	12	1.48	0.37	1.04-2.09	25.0
Bit Length:Width	11	2.18	0.68	0.78-2.93	31.5
Haft Width:Thickness	12	3.19	0.67	1.96-4.20	21.0
Haft Length:Width	12	0.63	0.19	0.24-1.00	30.0

Although considerable variability is common among these forms, two major types have been defined in the Southeast. These are the Hamilton type (Kneberg 1956; Bell 1960; Cambron and Hulse 1964) and the Madison type (Scully 1951; Kneberg 1956; Bell 1960; Cambron and Hulse 1964). Hamilton points are associated with Late Woodland Hamilton and Mason cultures in east-central Tennessee (Lewis and Kneberg 1970; Faulkner 1968). Hamilton points tend to be larger than Madison points and are characterized by incurvate blade and base edges. The Madison type is a smaller triangular point with relatively straight blade edges and a straight or slightly incurvate base. Madison points are known as the typical triangular Mississippian point.

In the central Tombigbee Valley, small triangular points first occur in Miller III assemblages but occur most frequently in late Miller III and early Mississippian phases (Ensor 1981). At the Lubbub Archaeological Locality, in the Tombigbee drainage, Madison points were common and tended to occur in Mississippian Summerville phase contexts (Allan 1983). At the West Jefferson Steam Plant Site, the Late Woodland West Jefferson phase type-site in the Black Warrior Valley, Madison points were the most common West

Jefferson chipped stone artifact class (Jenkins and Nielsen 1974). Both Hamilton and Madison points occur on the sites in the Moundville region; however, formal analysis of these tools has not been conducted. Considerable variation in size, workmanship, and shape of the blade edges characterizes the assemblage.

Reworked or recycled projectile points are common in chipped stone assemblages throughout the prehistoric cultural sequence in the Eastern Woodlands. Hafted scrapers and drills are common tools in Archaic and Woodland assemblages. While in some cases the practice of recycling a biface into a drill is clear from the beveled edge that results from reworking a wide blade into a narrow blade, in other cases the degree of reworking versus intentional manufacture is less clear. In the case of reworked triangular points, the intent of manufacture from a technological point of view is more ambiguous than for the larger stemmed bifaces that were manufactured in earlier periods. Whether purposely manufactured for use as a perforating tool or recycled on a triangular arrow point, the end result is the same. However, in light of the developed flake tool technology characteristic of Late Woodland and Mississippian lithic technology, the presence of reworked bifacial arrow points is interesting. One interpretation put forth is that these tools indicate recycling of arrows, both the point and shaft, for an alternative use in drilling or perforating (Rafferty and Starr 1986).

Other tool forms manufactured on bifacial triangular preforms during the Late Woodland and Mississippian periods are not well documented, although they tend to be small perforating tools. In the Gainesville Lake area, Ensor (1981:130) shows a group of tools listed as biface perforators, two of which appear to be triangular in shape. Allan (1983:154) notes that two Madison points from the Lubbub excavations have reworked distal ends. Futato (1977,1983) cites cases of intentional manufacture of triangular bit-tools on flakes from the Bellefonte site and in the Cedar Creek drainage. In the Tombigbee Valley in eastern Mississippi, Rafferty and Starr (1986) also report triangular perforating tools from a Late Woodland Miller III site. All of the tools in this category are manufactured from heat-treated Tuscaloosa gravels.

Other Bifacial Flake Bit-tools

This subtype category includes seven bifacial flake bit-tools, one of which is manufactured on a bifacial thinning flake (Figure 20:a). These tools are similar in form to biconvex blade bits except the flake tools tend to be smaller and wider.

Five of the flake tools are very similar in size and shape (Figure 20:b,c,d,f, and h). These tools have a roughly triangular form and range between 14 mm and 17 mm in length. The mean length of 15.7 mm is below the minimum of 16.2 mm for the blade bit-tool length. Tools in this category are bifacially shaped creating a biconvex haft and cylindrical bit. Two have remnant platforms on the edge near the base of the tool. Lacking a central dorsal ridge and the thickness seen in the blade bit-tools, bifacial flaking was used to create the necessary tool form.

One tool in the sample was manufactured on a bifacial flake (Figure 20:a). This tool is morphologically similar to tools in the biconvex blade bit subtype. Although this particular tool was manufactured on unheated gravel chert, the remaining tools

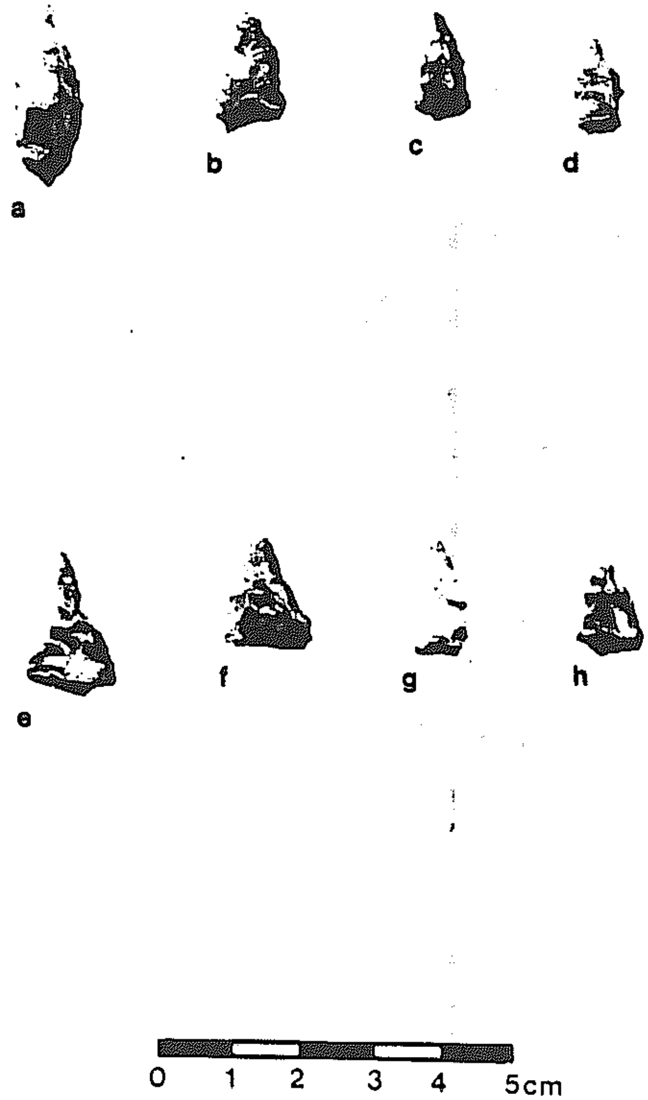


Figure 20. Bifacial flake bit-tools. a. Ha8-123-2, b. Ha92-16-33, c. Tu66-44-21, d. Ha92-4-9, e. Tu66-16, f. Tu46-14-2, g. Ha92-31-15, h. Tu66-49-19.

were manufactured from heat-treated cherts. Descriptive statistics are provided in Table 15.

Unifacial Flake Bits

There were a total of five unifacial flake bit-tools identified in the sample (Figure 18). These tools are often referred to as flake-gravers. They were included in the micro-tool class due to their overall small size and the likelihood that the tools were hafted. These tools are characterized by unifacial alternating retouch used to isolate a projection or bit on one end of the flake. Two tools were retouched on the sides and end. One tool was manufactured on a heat spall (Figure 18:h). All are manufactured from heat-treated Tuscaloosa chert. Descriptive statistics for unifacial and other bifacial bit-tools are provided in Table 15.

Bit-Tool Fragments

There are 10 bit-tool fragments that were excluded from the above categories because the fragments were so small that it was difficult to place them in a more formal type (Figure 21). All of the items in this group are

Table 15. Flake Bit-tool Metric Dimensions (complete only)

Variable	N	Mean (mm)	S.D. (mm)	Range (mm)	C.V.
Length	7	17.12	2.73	13.90-22.00	15.9
Width	9	9.53	1.58	7.40-12.60	16.6
Thickness	9	3.94	0.78	2.80-4.90	19.9
Weight	7	0.62	0.23	0.40-1.10	37.5
Bit Length	7	7.60	3.50	2.70-12.00	46.1
Bit Width	8	4.40	1.94	2.50-8.50	44.1
Bit Thickness	8	2.77	0.60	1.50-3.50	21.8
Haft Length	7	9.05	3.19	5.20-14.60	35.2
Haft Width	8	9.15	1.17	7.40-10.90	12.8
Haft Thickness	8	3.82	0.77	2.80-4.90	20.0
Width:Thickness	9	2.48	0.56	1.93-3.70	22.6
Length:Width	7	1.83	0.29	1.43-2.27	15.9
Bit Width:Thickness	8	1.60	0.54	0.75-2.42	33.7
Bit Length:Width	7	1.83	0.65	1.08-2.69	35.5
Haft Width:Thickness	8	2.45	0.43	1.93-3.03	17.6
Haft Length:Width	7	1.03	0.38	0.57-1.71	37.3

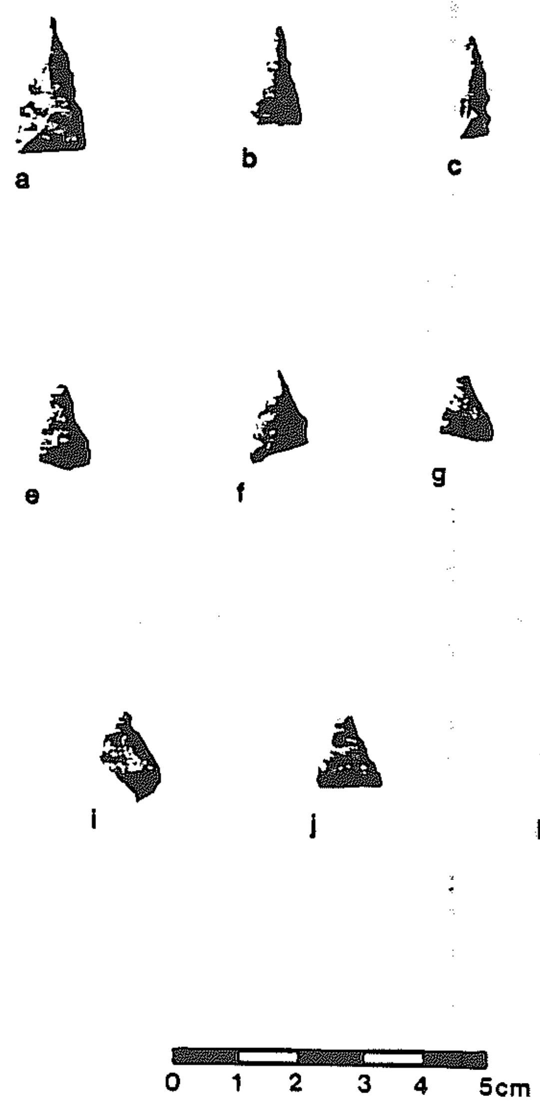


Figure 21. Bit-tool fragments. a. Tu66-45-15, b. Tu66-41-34, c. Tu58-CBC-T14, d. Tu66-65-16, e. Tu2-19-1, f. Tu66-16-29, g. Ha92-1-10, h. Tu66-24-4, i. Tu66-65-2, j. Tu346-7, k. Tu2-11-1.

distal bit fragments. It is likely that most are fragments of other flake bit tools rather than blade bit fragments. All of the fragments have small cylindrical-to-triangular bit projections and are bifacially retouched.

The Chronological Evidence

Evidence bearing on the cultural context of the Black Warrior microtools comes from excavations at two outlying single-mound sites and from surface distributions of tools from other outlying sites. There are no absolute dates for the industry. Chronological assessment is based solely on associations between the tools and ceramics, using the Moundville ceramic chronology (Steponaitis 1983). Based on both the excavated and surface contexts, the patterns observed suggest that the industry was most common during the West Jefferson phase, and possibly continued into the subsequent Moundville I phase.

Before reviewing the evidence, it is useful to discuss the nature of the data and the methods that were used to examine the surface collections for cultural-chronological patterning. Since microtools from surface-collected contexts comprise 72% of the 105 tools included in this study, any attempt to assess the cultural context of these tools must be regarded as tentative at best. However, since systematic collections were made using a 20 x 20 m grid, horizontal control of the surface materials does permit one to examine the co-occurrence, or lack thereof, between microtools and ceramic components.

Previous research conducted by Steponaitis (1983) and Bozeman (1982) has provided a foundation from which to explore the spatial, temporal, and configurational aspects of the site surfaces and cultural components. With the development of a finer-scale ceramic chronology for the Moundville phase (Steponaitis 1983), Bozeman was able to place the outlying Moundville phase sites into a cultural-historical framework (Bozeman 1982). He also investigated the distribution and variety of sites. This work forms the basis for assessing the cultural component of the microlithic industry as it is presently known from surface collections and test excavations in the Black Warrior Valley.

The most frequently occurring ceramics on sites in the Moundville region are West Jefferson and Moundville phase plainwares. Characteristic West Jefferson ceramics are grog-tempered wares classified as Baytown Plain, variety Roper. The most prevalent Moundville phase ceramics are the undecorated shell-tempered wares classified as Mississippian Plain, variety Warrior and Bell Plain, variety Hale (Steponaitis 1983). While overlap between grog and shell-tempered wares has been documented in certain areas between A.D. 900 and 1050, after A.D. 1050 ceramic manufacture became completely based on the use of shell temper (O'Hear 1975; Welch, in press; Steponaitis 1983).

These two ceramic components are represented on nearly every outlying site. In order to evaluate relative chronological patterns in the surface data, collection grid squares were used as the unit of analysis, and the relative frequencies of grog and shell-tempered wares and bit-tools were plotted for each grid unit. This enabled comparisons to be made between the ceramic and microlithic distributions for each site, as well as providing a means for calculating the size and density of the grog and shell-tempered ceramic cultural components. Settlement size and density varies for both the West Jefferson and Moundville phase occupations in the Black Warrior Valley. The majority of the settlements, however, are small farmsteads and hamlets between 0.2 and 0.5 ha. Larger sites are likely the result of overlapping occupation of a particular floodplain ridge. In most cases the settlements of different components overlapped, especially the high-density areas. At a few sites, however, there is a more complete separation in the surface scatters of grog and shell-tempered ceramics. Both the size and density of the Moundville and West Jefferson components and the degree of spatial overlap were considered when examining the distributions of bit-tools between and within the sites surveyed.

The Survey Evidence

Looking at the region as a whole, bit-tools were recovered from 8 of 15 sites systematically collected. Of the 76 tools found on those sites, 91% come from 4 sites, specifically 1Tu2, 1Tu66, 1Tu259, and 1Ha92 (see Figure 3). Three of these sites, 1Tu66, 1Tu259, and 1Ha92, were the largest aggregate settlements in the Black Warrior Valley between A.D. 900 and 1050. Grog-tempered ceramics cover an area between 0.8 and 2.6 hectares at each of these three sites. In addition to the tools, 72% of the unretouched blades, 65% of the blade cores, and 59% of the unfinished bit-tool fragments were also found at these three sites.

Bit-tools were not found on any of the single-component small Moundville phase farmstead sites such as 1Ha91 or 1Tu389-393. Additionally, bit-tools were not found at the outlying Moundville phase settlements, 1Tu42 and 1Ha15. Although the negative evidence for these sites alone does not preclude the possibility that these tools were used during the Moundville phase occupations, analogous industries from other Mississippian settlements are not common after A.D. 1200 (Milner et al. 1984; Yerkes 1984). At the large West Jefferson sites where bit-tools have been found, shell-tempered wares account for less than 5% of the ceramic assemblages. Moreover, the shell-tempered ceramics that do occur are predominantly Moundville III wares dating the occupation to after A.D. 1400 (Bozeman 1982; Steponaitis 1983). Thus, it appears that the bit-tools at these sites are most likely part of West Jefferson phase lithic assemblages.

In sum, the regional distributional trends indicated by the surface patterns suggest that the microlithic industry was most prevalent in the Black Warrior Valley between A.D. 900 and 1050, corresponding to the West Jefferson phase of the Moundville chronology. The primary evidence is the clustering of tools and debris from their manufacture at the three major West Jefferson phase settlements in the valley. Further support for this trend comes from the on-site distributions of tools and ceramics at 1Tu66, 1Tu259, and 1Ha92.

Using the 20 x 20 m grid squares at 1Tu66, 1Tu259, and 1Ha92 as the unit of analysis, contingency tables were constructed to examine the frequency of co-occurrence of bit-tools and either shell or grog-tempered wares (Table 16). Results of this exercise indicate that out of a total of 132 collection units there were no cases of bit-tools occurring in units with only Moundville phase ceramics. In contrast, a total of 17 tools from the three combined sites were recovered from units where only West Jefferson ceramics were found. While these data are not conclusive, they do suggest the tendency for bit-tools to co-occur with

West Jefferson phase ceramics rather than Moundville phase wares. When distributional information from all systematically collected sites is combined, there are no cases observed where bit-tools occur in units with only Moundville phase ceramics. In contrast, bit-tools occur in 4% of a total of 90 units where only West Jefferson phase ceramics are present.

Table 16. Contingency Table for Ceramic Types and Bit-tool Counts for 20 x 20 m Grid Units at 1Tu66, 1Ha92, and 1Tu259

Ceramic Temper Types per Grid Unit	1Tu66 #units-#tools	1Ha92 #units-#tools	1Tu259 #units-#tools	Total
Grog-tempered only	26 - 6	11 - 5	5 - 6	42 - 17
Shell-tempered only	- - -	- - -	- - -	- - -
Grog and shell mixed	41 - 56	31 - 17	18 - 16	90 - 89
Total	67 - 62	42 - 22	23 - 22	/ 132 - 106

Excavations at the White Site and 1Tu50

Bit-tools and a single conical blade core have been recovered during excavations conducted at two single-mound sites, the White site (Welch 1986), and 1Tu50 (Steponaitis 1986b). Test excavations at the White site revealed a large West Jefferson component and a Moundville III occupation in the village area of the site (1Ha8) (Welch 1986). Fifteen bit-tools and 11 unfinished tool fragments were recovered during the excavations. Bit-tools were found in two contexts: (a) a mixed West Jefferson/Moundville III midden, and (b) a West Jefferson phase pit. Unfortunately mixing between the shallow subsurface midden deposits made it impossible to assign the majority of the tools to either the Moundville or West Jefferson phase. However, the presence of a single cylindrical bit-tool in an apparently undisturbed West Jefferson pit suggests a clearer association of these tools with the West Jefferson settlement. Both the ceramic and botanical remains from the feature fill suggest a Late Woodland, possibly late West Jefferson, affiliation for the pit and its contents (Paul Welch, personal communication). Again, the tendency for microtools to not occur after A.D.

1200 suggests that the White site tools are of West Jefferson origin.

At 1Tu50, a single conical blade core was recovered during excavation of a house structure. Both West Jefferson and Moundville occupations occur at the site and the ceramics recovered date the site to no later than the Moundville I phase (A.D. 1050-1250) (Bozeman 1982; Steponaitis 1986b).

Chronological Evidence from Other Regions

While admittedly the temporal evidence is not without problems, certain chronological trends are evident for the microlithic industry in the Black Warrior Valley. On the basis of a blade bit-tool from a West Jefferson feature at the White site, and a blade core found at 1Tu50, it is clear that the industry was part of the technological repertoire of West Jefferson, and possibly Moundville I, communities. The survey data also support an early date for the industry in the Moundville chronology. The concentration of over half of the bit-tool sample at 1Tu66, a large West Jefferson settlement, is probably not coincidental. The same is true for the assemblages at 1Tu259 and 1Ha92. The on-site distributions of the tools also tend to be coterminous with the distribution of West Jefferson ceramics. In view of the spatial trends outlined above, and the absence of bit-tools from single-component Moundville phase sites, it is likely that the industry was most prevalent during the period between A.D. 900 and 1200.

Analogous industries and microtool finds in other regions also tend to occur in Late Woodland and early Mississippian contexts. At Cahokia, microtools and manufacturing debris were found to co-occur with Old Village ceramics that date to the early part of the Cahokia ceramic chronology, between A.D. 900 and 1200 (Mason and Perino 1961; Fowler and Hall 1975; Yerkes 1983). During the FAI 270 Mitigation Project in the American Bottoms, microlithic artifacts were found at a number of outlying sites in the uplands and floodplain (Porter 1974; Harn 1971; Milner and Williams 1981; Prentice 1983). Milner et al. (1984) report that the majority of microtools recovered from the FAI-270 excavations were affiliated with the Lohmann ceramic phase, which is dated between A.D. 980 and 1145 with a mean date of A.D. 1050 (Milner et al.

1984:168). Microtools tend to occur less frequently in the subsequent phases of the sequence and drop out of the archaeological record in this region sometime between A.D. 1200 and 1300 (Milner et al. 1984).

At the Zebree site, microtools, blades, and cores have been radiocarbon dated to between A.D. 800 and 1050 (Morse and Morse 1980, 1983:201). At the Carson Mound site, located in the lower Mississippi Valley, the microlithic materials are from surface collections. The similarity of the industry to both the Cahokia and Zebree industries has prompted the identification of the Carson Mound microliths with the early Mississippian occupation of the site (Johnson 1987).

Looking to regions outside of the Mississippi Valley proper, isolated occurrences of microtools reported from Tennessee, Georgia, Mississippi, and Alabama occur in deposits ranging in time from the late Middle Woodland through the Mississippian period. At the Owl Hollow site microtools occur in a Middle Woodland context dated to between A.D. 200 and 600 (Kline 1985). Microtools are also reported from Late Woodland Hamilton and Mason cultural phases, also in Tennessee (Faulkner 1968; Faulkner and Graham 1966; Graham 1964).

At Cemochechobee, microtools were found in early Mississippian Roods phase deposits from Mound B. Carbon-14 dates for these deposits range between A.D. 700 and 1090 (Schnell et al. 1981:248, Table A.1).

In Alabama and northern Mississippi, microtools have been recovered from a number of Late Woodland sites (Futato 1977, 1983, 1987; Rafferty and Starr 1986). At the Bellefonte site, in northern Alabama, microtools and blades were found in Middle and Late Woodland deposits (Futato 1977). Futato (1983:254) reports that there are three possible periods of relatively intense microtool use documented from sites along Cedar Creek in the Bear Creek drainage. These are the Late Archaic Perry phase, the Middle Woodland Lick Creek phase, and the early Mississippian McKelvey II phase (A.D. 700 - 1000). In the Tombigbee Valley, the Lubbub microlithic industry is most prevalent during the Late Woodland Miller III phase and may extend into the early Mississippian Summerville I phase (A.D. 1000 and 1200) (Ensor 1981, 1985).

In summary, microtools and related blade industries are found in both Late Woodland and early Mississippian deposits. At mound center sites microlithic blade-tools are found in early Mississippian deposits. At nonmound villages, microtools are found in Late Woodland and emergent Mississippian contexts. The microlithic industry from the Moundville region can be tentatively affiliated with West Jefferson and Moundville I communities. This is consistent with data from the Mississippi Valley suggesting that the technology was most prevalent between A.D. 900 and 1200. This period coincides with the Mississippian emergence in the Black Warrior Valley.

Discussion

This chapter has described the Black Warrior Valley microtool assemblage as including both flake and blade bit-tools. A microlithic industry is also documented in the form of cores and core rejuvenation flakes, blades, and unfinished tools. I have also examined the cultural context of the assemblage. Excavations at the White site and 1Tu50, in conjunction with site survey data, have indicated that the tool industry was a feature of West

Jefferson stone-working technology, and that it may have continued into Moundville I times as well.

As a tool class, the majority of the implements are small bit-tools manufactured on blade tool blanks. The primary tool types in the Black Warrior industry are biconvex and cylindrical blade bit-tools. These are part of a technological industry, a common method or style of tool manufacture. The industry was based on local chert resources and was focused on manufacturing a specific tool form. The Black Warrior Valley industry is stylistically and technologically similar to the Lubbub industry in the central Tombigbee Valley.

Morphological variability is related to variation in manufacturing methods and techniques linked to the type of tool preform (flake versus blade), and intended tool use. Drilling/perforating, and engraving functions are implied by the morphology of the tool bits. Certain tools in this group are functionally equivalent to blade tools, but lack the formal consistency in manufacture and design. The different tool uses will be further explored relative to morphological and technological variability in Chapter IV.

CHAPTER III

MICROTOOL TECHNOLOGY

> Culture is intellectual, rational, and abstract; it cannot be material, but material can be cultural and "material culture" embraces those segments of learning which provide a person with plans, methods, and reasons for producing things which can be seen and touched.
> [Glassie 1968:2]

Whether one is studying material culture from an ethnographic or archaeological context, the aim is to understand relationships between humans and their material world; to understand history through human action (Conkey 1984:11; Hodder 1986:79). As expressed in the quotation from Glassie above, culture is not itself material, but material can be cultural. The "culture" of the Black Warrior Valley microlithic industry is the subject of this chapter.

Crabtree (1972:2) defined prehistoric lithic technology as the science of systematic knowledge of forming stone into functioning implements. This knowledge consists of a variety of methods and techniques of stone working, the method being in the mind of the artisan, the technique in the hands. Methods involve culture-bound knowledge that is learned and passed on. Methods involve the designs, the styles, the traditions that create material objects within a given culture.

Unlike the ethnographic situation, the archaeologist is still left, after an assemblage or group of tools is classified, with the question of how to infer meanings from stone tools, as part of a specific cultural, social, and historical setting. An ethnographic example from New Guinea illustrates this point. The Duna refer to both cores and flakes by the same word, are. These material forms are conceptually, linguistically, and technologically undifferentiated. Both are used to carve wood, strip fibers, drill shells, and shave ocher into powder to make paint. Some of the smaller flakes, are kou, are distinguished linguistically and technologically in the sense that they are hafted onto handles and used for more specific tasks. Although these tools are distinguished linguistically and, to an extent, technologically and functionally, White and Thomas (1972) maintain that the Duna do not conceptualize these differences. This example illustrates the point that meaning is culturally defined and not inherent in the material objects, in this case the different stone tools used by the Duna.

Returning to west-central Alabama, it is not possible to determine whether West Jefferson and Mississippian stonesmiths distinguished categorically and/or linguistically between a blade bit-tool, a flake graver, or a transverse retouched cobble. On the other hand, stone tools, as objects of material culture, encompass a continuum of formal variation that the archaeologist can measure and describe. In addition, observed variation in tool technology can express an active interaction between an artisan and a technological tradition within a particular social and natural environment (Clay 1976). It is the <u>combination</u> of tool design, production, and use that create a technological pattern or style in a given social setting and this can be observed archaeologically. Thus, the interpretation of prehistoric stone tool technology must come from the links that can be established between a particular stone tool technology and a particular social context of tool use.

In this chapter I present a reconstruction of the technological practices used to manufacture the bit-tools described in Chapter II. While artifact types as such are the "objects" of archaeological classification and analysis, it is the technological structure or pattern that is interpretable within a wider cultural setting. The theoretical basis underlying technological studies of stone tools has been outlined through previous research (Sheets 1975; Collins 1975). Technological analysis is generally defined as a method to integrate the organization of prehistoric technology with the broader cultural milieu of which it is a part (e.g., Sheets 1975; Clay 1976; Greber et al. 1981; Johnson and Morrow 1987). It is argued here that understanding the use of microtools depends, in turn, on understanding the social context of productive activities in which they occur. In order to more fully understand the meaning of this pattern in tool design and use, however, it is first necessary to have a more detailed understanding of the variability and structure of the industry as a technological pattern.

I begin this chapter with a summary of the technological practices evidenced in Late Woodland lithic assemblages from the Black Warrior and adjacent Tombigbee river valleys. The intent of this summary is to provide a general picture of the structure of the regional chipped stone industries, of which the microtools are a part. Next, the structure of the microlithic assemblage will be described. The model presented encompasses procedures and products that form a reduction continuum. Assemblage variability is evaluated in relation to technological, material, functional, and cultural constraints. Potential constraints affecting the structure of lithic manufacturing strategies include: (a) raw material and source, (b) skill, (c) reduction methods, (d) functional intent, and (e) consumer/user demand (Sheets 1975; Arnold 1987; Hester and Shafer 1987).

The above lines of evidence are brought together in the course of this chapter to describe as well as interpret the structure of the microlithic assemblage. Interpretation derives from an understanding of the cultural and technological context of which the tools are a part. Description of the technological basis of the industry will provide a framework from which to examine relationships between technological activities, tool function, and production context--topics that will be addressed in Chapter IV.

Technological Context

Lithic data from sites in the central Tombigbee and Black Warrior river valleys indicate that a common stone-working technology was shared by Late Woodland and Mississippian communities in this region of the Southeast. Chipped stone technology was based on a common, locally procured resource that was heat-treated and used to produce a diverse range of cobble and flake tools.

The data base for the central Tombigbee region is more extensive than for the Black Warrior Valley as a result of the numerous site investigations in the Tennessee and Tombigbee drainages. Material summarized here is taken from two areas: (a) the Gainesville Reservoir area in west-central Alabama (Ensor 1979, 1980, 1981; Allan 1983), and (b) sites investigated in the upper Tombigbee Valley in northeastern Mississippi (Rafferty and Starr 1986) and the Bear Creek watershed in northern Alabama (Futato 1977, 1983, 1987). Data from the Black Warrior Valley are taken from the UMMA survey, and other small scale surveys and excavations in the Black Warrior drainage (Jenkins and Nielson 1974; Gillespie 1977).

Both the Tombigbee and Black Warrior River valleys cut across the Tuscaloosa Formation, the geologic source of the secondary stream-deposited cherts extensively exploited in Late Woodland and Mississippian times. The gravel cherts are variable in quality and size. Texture varies from coarse to fine and inclusions and impurities are variable within individual cobbles (Futato 1980). Accessibility along stream channel terraces and gravel bars would have made procurement relatively easy. Increasing exploitation of the gravel cherts beginning during the Middle Woodland period is no doubt related to the quantity and general availability of this local lithic resource. Nonlocal cherts are rare in Late Woodland assemblages; in every regional site report examined, Tuscaloosa gravel chert was the predominant Late Woodland chipped stone resource.

Late Woodland lithic industries included a wide range of unifacial tools. Bifacial tools requiring primary and secondary reduction were restricted to a few implements, primarily triangular projectile points and microtools. A core-blade technology was used for the production of microtool blade preforms in both the central Tombigbee and Black Warrior valleys. Manufacturing practices involved a trajectory initiated by thermal alteration of the chert gravels followed by: (a) manual and/or bipolar primary percussion to split the chert cobbles and cobble fragments, (b) preparation of core preforms, and (c) the use of primary and/or secondary percussion and pressure flaking techniques, depending on the desired tool and edge form.

Common tool forms are small flake and cobble edge-tools that required minimal primary percussion and pressure retouching. Both Gillespie (1977) and Rafferty and Starr (1986) emphasize the importance of the tool edge for interpreting Late Woodland lithic assemblages. Use-wear studies conducted on Late Woodland and Mississippian assemblages in the Cahokia region have determined that informal edge-tools were a major component of local household industries in the American Bottom (Yerkes 1987). The majority of edge-tools from sites in Alabama and Mississippi were manufactured on cobble fragments as opposed to flakes. Cobble fragment edges were modified into a variety of linear and point forms. Occasionally, as illustrated by the group of tools in Figure 22, cobble fragments were shaped, or selected for a shape, that complemented the functional design of the tool edge. Flakes, heat spalls, and cobble fragments were also utilized in tasks requiring a sharp edge and only minimal retouch.

The use of cobbles and cobble fragments for the production of informal tools represents one of two production techniques characteristic of these lithic industries. A second technique involved the use of cobble cores for the production of triangular projectile points and microtools (Rafferty and Starr 1986; Futato 1987; Ensor 1981). Triangular projectile points are the most common tool manufactured from flake preforms and the majority of

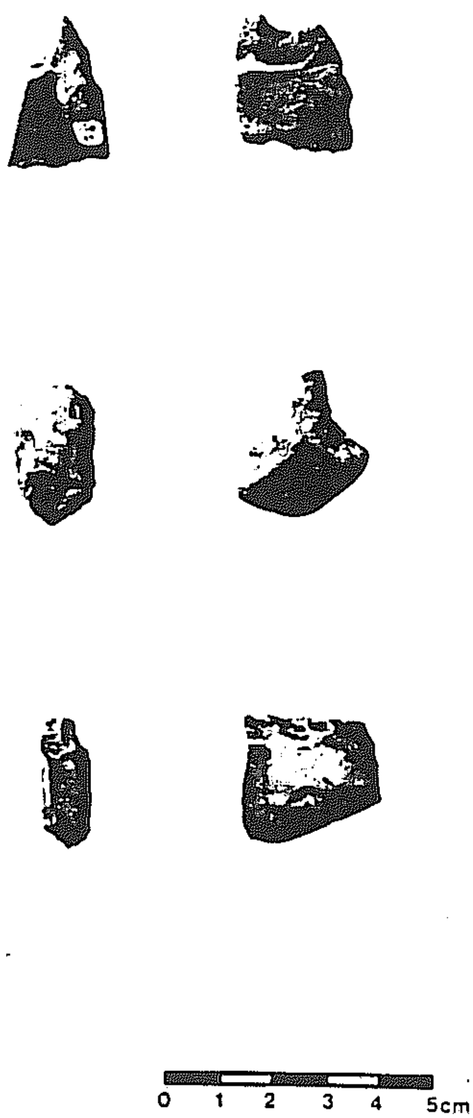


Figure 22. Cobble tools from late prehistoric lithic assemblages from the Black Warrior Valley.

the amorphous primary and secondary flake cores found on Late Woodland sites are most likely related to the production of these implements. A core-blade industry for the production of bit-tools appears to be restricted to certain households in the Summerville region in the Tombigbee Valley, and the Moundville region. Bit-tools more commonly found in other areas of the Southeast are manufactured on flakes and other non-blade preforms.

Heat-treating practices were used as a consistent strategy and, in all cases examined, this pattern diverges from that of preceding periods. In contrast to earlier uses of thermal heating to facilitate bifacial tool production, heat-treated stones encompass a much broader range of the chipped stone repertoire in Late Woodland and Mississippian times (Futato 1980, 1983; Ensor 1980). The widespread use of this technique suggests that Late Woodland stonesmiths were effectively transforming and expanding the local resource base. This new resource was a more homogeneous and viable material for meeting a variety of technological and functional demands.

Ensor (1980) has argued that heat-treating was a strategy for thermally reducing small chert cobbles. This interpretation is based on: 1) large quantites of fire cracked chert from certain Miller III sites in the central Tombigbee Valley, 2) the lack of cores from these same deposits, and 3) a general size reduction in objective tool pieces in Late Woodland and Mississippian lithic technology, presumably related to the introduction of the bow and arrow (Ensor 1980). While heat-treatment may have facilitated the reduction process of small chert cobbles to a degree, data from other Late Woodland contexts do not support this interpretation. For example, tools made on heat spalls, rather than core or cobble tools, occur infrequently and not systematically, as would be expected if tool preforms were regularly selected from among fire-cracked chert fragments (e.g. Rafferty and Starr 1986:112). In addition, heat-treated cores are an integral part of the industrial structure of Late Woodland lithic assemblages, as are other reduction techniques including both manual and bipolar percussion (Ensor 1980; Futato 1980; Gillespie 1977; Rafferty and Starr 1986). This is not to deny that heat-treating was used as a reduction technique.

The data do suggest that technological and functional constraints may have played a role in heat-treating strategies. When heated at temperatures ranging between 300 and 500 degrees Celsius, Tuscaloosa cherts develop a highly lustrous sheen and the flaking qualities of the stone, in terms of both control and predictability of flake removals, is enhanced (Ensor 1980). As pointed out by Rafferty and Starr (1986), both of these features would facilitate fine pressure flaking used to manufacture small edge-tools, bifacial triangular points, and microliths. Core-blade techniques would also benefit from increased control in flake removals. In contrast to larger, heavy-duty implements that tend to be made on unheated stones, small secondary pressure flaked tools and small edge-tools used in a variety of scraping, planing, cutting and perforating tasks tend to be made on heated stones (Rafferty and Starr 1986; Gillespie 1977). Rafferty and Starr (1986) and Gillespie (1977) emphasize attributes of tool edge sharpness and enhanced pressure flaking qualities of the heated stones, both of which appear to be important features of Late Woodland chipped stone technology.

The nature of the raw material both facilitated and constrained the cobble-flake tool industry in this region. Edge-tool design was not constrained by material size and shape. Rather, the material was successfully used to manufacture a variety of edge-tools. Variability in the quality of the material was controlled by thermal alteration that created a more workable material for both technological and functional objectives. Although the cherts were both abundant and accessible, evidence in the central Tombigbee and Black Warrior valleys suggests that almost every piece of available stone was used by Late Woodland stonesmiths (Rafferty and Starr 1986; Gillespie 1977). Because of the enhanced qualities of the heated stone and the time expenditure of heating the material, the resource was perhaps used in a more conservative fashion (Gillespie 1977). The large quantities of fire-cracked chert and debitage on Late Woodland sites, often in large pits, suggests that processing and tool production took place within settlements (Rafferty and Starr 1986; Gillespie 1977).

The general impression of the chipped stone industry is one of extensive utilization and molding of local lithic materials to meet a variety of domestic tasks. The industry is primarily composed of informal cobble edge-tools designed for perforating, graving, scraping, planing, and cutting tasks. Manufacturing practices required, for the most part, a minimal level of skill in the use of primary percussion and pressure flaking techniques for the production of tools used in a variety of activities. On the other hand, cobble core preparation and the systematic production of blade bit-tools may have required a greater level of stone-working expertise beyond the requirements of cobble-flake tool production. Blade tools are also rare in lithic assemblages throughout the region compared to other flake and cobble tools. The introduction of the bow may also have affected the structure of Late Woodland lithic technology. Triangular points reworked into perforating tools suggests recycling of both the stone tool and arrow shaft (Rafferty and Starr 1986).

A major constraint on any technology is the nature of the size, shape, and amount of a given raw material (e.g. Johnson 1987). The similarities between lithic assemblages in this region is no doubt related, in part, to the use of the same raw material. Material constraints were overcome by adopting techniques of thermal alteration. Cobble fragments were used as tool preforms as well as for flake and blade cores. In some cases the natural cobble form was incorporated into the tool design, the focus being on the working edge of the tool. Thus, while in some cases overall tool morphology was related to the shape of the material, in other cases the shape was altered to fit the intended tool design.

In summary, the Late Woodland stone-working industry in the Black Warrior-Tombigbee region can be characterized by the following features: (a) extensive exploitation of locally available gravel cherts, (b) systematic thermal processing of these stones that served to transform and expand the local resource base into a more viable and homogeneous material, (c) the use of bipolar and manual percussion and pressure flaking techniques to produce a range of formal and informal cobble and flake tools, (d) a flake and bifacial core industry aimed primarily at producing triangular projectile points and bit-tools, (e) a blade-core industry for the production of bit-tools, and (f) the use of unretouched flakes, blades, cores, cobble fragments, and reworked projectile points.

Bit-tool Production

Bit-tools classified as microtools were manufactured either from flakes or blades. Morphological variability in the Black Warrior sample can be related to technological and functional factors including: (a) core technology (blade versus flake), (b) formal design of the tool haft, and (c) the degree and nature of retouch required given the intended tool function, and morphological features of the tool blank (e.g., flake versus blade, presence/absence of a dorsal ridge). The most consistent attributes are width and thickness of the tool bits. Mean distal width ranges between 3.6 mm and 5.1 mm. Mean bit thickness ranges between 2.8 mm and 4.1 mm. The coefficient of variation for both measures is between 13.0 and 24.0. Consistency in these variables is related in part to shaping of the tool bit that occurs through continual use.

Flake bit-tool manufacturing strategies were embedded in local flake and cobble tool production strategies, but blade bit-tool production was based on a blade-core technology. The occurrence of similar blade-core industries in other regions suggests that, perhaps, both functional and cultural constraints influenced the structure of Late Woodland and early Mississippian blade tool industries. In the following sections, the manufacturing trajectories for flake and blade bit-tool production will be described. I begin with bit-tools manufactured on flakes.

Flake Bit-Tools

Flake bit-tools in the Black Warrior assemblage were manufactured on a variety of pieces of stone including: (a) flake fragments, (b) biface thinning flakes, (c) a heat spall, (d) biface fragments, and (e) reworked triangular projectile points. These tools are often described as microperforators, gravers, or drills (Futato 1977, 1983, 1987). Tool design was not contingent on a preferred flake type; rather, the working edge was the primary tool attribute. While the majority of the tools were manufactured on heated stones, occasionally unheated gravel chert and quartz were used.

Tool bits vary in shape and size. The range of morphological variability is illustrated in Figure 23. Certain flake tools are similar in form to blade bit-tools. Tool bits are sharp and acute, as well as rounded and blunt. A restricted function in perforating/drilling and graving tasks is suggested by the morphology of the tool bits.

Tools were shaped by pressure flaking the edges to form the desired edge configuration. The intended tool function and the form of the tool blank determined the degree and nature of retouch. Certain tools required only minimal unifacial edge shaping, while others were bifacially retouched. Triangular bit-tools were manufactured on flakes, bifaces, and reworked arrow points.

The Blade Bit-Tool Industry

In contrast to flake bit-tools, blade bit-tool production involved a conceptual link between a tool design, a manufacturing method, and function. The overall tool form and not just the working edge was considered in the functional design of the tool. Blades were produced in a systematic fashion for the specific production of bit-

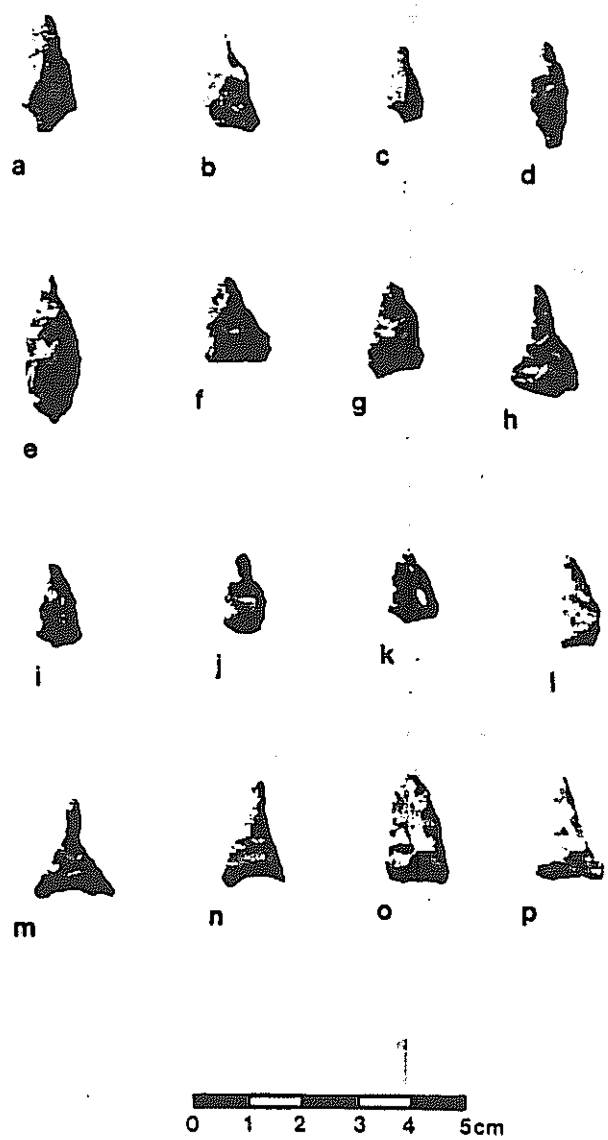


Figure 23. Flake bit-tools. a. Tu259-5-20, b. Tu66-49-23, c. Tu259-14-26, d. Ha8-91-1, e. Ha8-123-2, f. Tu46-14-2, g. Ha92-16-33, h. Tu66-16, i. Tu66-44-21, j. Ha92-4-9, k. Tu66-49-19, l. Ha92-31-15, m. Tu66-31-11, n. Tu66-51-5, o. Tu346-17-1, p. Tu66-16-33.

tools. The method used for the production of suitable blades involved a blade-core technology based on the local heat-treated gravel cherts. The structure of the Black Warrior cobble blade-core industry is diagrammed in Figure 24. The industry is culturally distinct in the region in that it occurs only in late Miller III and West Jefferson phases in the Tombigbee and Black Warrior valleys. The core technology and bit-tool manufacturing techniques are described below for the Black Warrior Valley industry.

Core Technology

Techniques that allow for the production of blade-shaped flakes require the design of a core in a way that prevents the spreading of a flake during conchoidal fracture. This is accomplished by setting up a prepared ridge that determines the width of the flake and acts as a guide in the removal of the flake along the core axis (Crabtree 1968). The result is a product whose dimensions of length, width, thickness, and curvature can be controlled by the artisan, depending on the intended tool or product design.

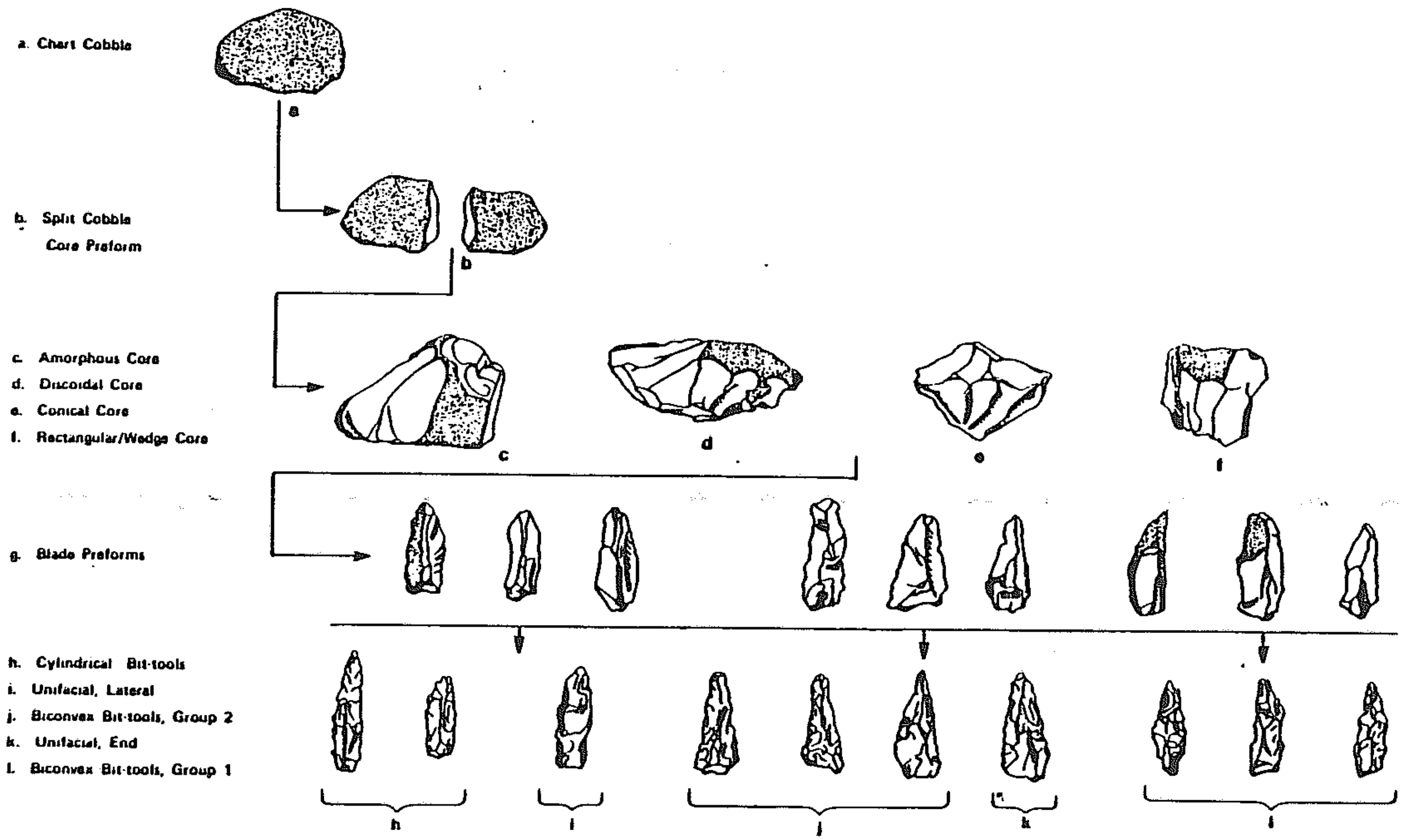


Figure 24. Blade bit-tool manufacturing trajectory for the Moundville area microlithic assemblage.

Core preparation varies depending on characteristics of the raw material and type of blade desired. However, setting up a platform at the correct angle, and the preparation of a ridge are steps common to blade-core industries in general. Because of the necessary preparation required by a blade industry, remnant cores can be distinguished from amorphous flake cores that required relatively minimal platform preparation. Thus, the industry can be defined by the sum of its remains in blades, tools, remnant cores, and platform rejuvenation flakes.

The size and shape of the raw material constrained the adaptation of a blade-core industry to the local gravel cherts. Due to the size and rounded shape of the cobbles, there were limitations on the number of consecutive blades that could be removed from a single core. Also, the rounded shape of the cobbles required the preparation of a non-cortical, straight blade removal face. This constraint was overcome in one of two ways: (a) by using a fracture plane as the blade removal face or, (b) by using a non-cortical flake or cobble fragment as the core preform. In addition, straight ridged blades are more difficult to remove on gravel cherts since rounded cobbles constrain the removal of blades with straight dorsal ridges extending the full length of the blade axis. Despite the material constraints, however, stonesmiths working in the Moundville region adapted core-blade techniques to the local gravel-based chipped stone industry.

Since rounded gravel cherts lack natural flat surfaces, the first stage in the production of an adequate cobble blade core preform involved creating a flat surface to serve as a platform. Cobbles were heated and usable core preforms were selected from either heat-shattered fragments, or from manually split cobble fragments. The blocky shape of the shattered cobbles provided the necessary features for blade removal by: (a) overcoming the natural curvature of the stone, (b) providing adequate platform surfaces, (c) creating straighter non-cortical blade removal faces, and (d) establishing corners from which to initiate blade removal and establish guiding ridges for subsequent removals.

After selecting a suitable core preform, characteristics of the cobble geometry determined the amount of preparation needed to remove a blade. In certain cases a natural flat cortical surface was used as a platform for the removal of a single blade using a natural corner or edge as a guiding ridge. In other cases flat platform surfaces were prepared by removing one or more transverse flakes perpendicular to the blade removal face. Core ridges were also prepared with the use of a series of shaping flakes converging to create a single ridge. Blades were removed at an acute angle, greater than 70 but less than 90 degrees. Characteristics of the blade lip, platforms and bulbar surface suggest that both percussion and pressure techniques were used to remove blades. Acute platform angles were re-established by one or more transverse blows across the platform removing the exhausted platform edge. Hinge fractures occurring toward the proximal end of the core also required removal before further reduction of the core was possible. Due to the small size of the cobble cores, however, cores with hinge flaws were generally discarded or reused in a different technological or use context.

Blade cores in the Black Warrior assemblage represent a continuum from initial core reduction to core exhaustion. Although the sample size is small for the region as a whole, certain technological patterns are represented. I have distinguished two discrete categories of core remnants corresponding to cores with single versus multiple blade removals. Single blade removal cores include cobbles that were: (a) either aborted prior to complete reduction or, (b) used expediently for the removal of only one blade. The resulting product types are the amorphous and discoidal cores described in Chapter II. Overlap in the production of edge-retouched cobble tools may also occur within the amorphous core type. Both flakes and blades were removed from discoidal-shaped tabular cores.

In contrast, as many blades as possible (and only blades) were removed from other cobble cores. Exhausted types include conical and rectangular/wedge forms, the wedge shape resulting from the intersection of two platforms at right angles on a single core. The greater frequency of multiple blade core fragments may have resulted from a switch to bipolar percussion techniques as the size of the core was reduced.

Attributes of blade size and shape were affected by a combination of technological factors as well as core shape. Variation in blade width and thickness depends on (a) position of the blade in the core reduction sequence, (b) the type of tool used as a percussor, (c) placement of the tool on the core platform, and (d) percussion versus pressure removal techniques. Variation in blade length is affected by the morphology of the core and blade removal face, as well as the position of the blade in the sequence of core preparation and blade detachment (Crabtree 1968; Sollberger and Patterson 1976). Blade length and width attributes show the lowest proportion of variation about the mean (coefficient of variation = 18.0 and 19.0) suggesting a greater concern with controlling these variables relative to blade thickness (C.V.= 36.0).

Blade bit-tools were manufactured on non-cortical blades. These blades were obtained by either using a non-cortical fracture plane as the removal face, or by removing a series of at least three cortical flakes in order to remove a single non-cortical blade. The pattern of core reduction evidenced by dorsal cortex on the Black Warrior blades is similar to Late Archaic Poverty Point blades, which are also part of a gravel-based microblade industry (Webb and Gibson 1981). The presence and location of cortex remnants for the Black Warrior assemblage is provided in Table 17.

Table 17. Blade Dorsal Cortex Patterns

Location	n	%
No cortex	133	29
Entire dorsum	57	12
Right edge	46	10
Left edge	42	9
Distal end	75	16
Proximal end	39	8
Medial	8	2
Medial-distal	36	8
Medial-proximal	12	3
Proximal-distal	14	3
TOTAL	462	100

Webb and Gibson (1981) define primary cortex blades to refer to those blades with more than 50% of the dorsal surface covered with cortex. Secondary cortex blades have 50% or less dorsal cortex, and tertiary or interior blades are non-cortical. Over half of the waste blades in the Black Warrior assemblage are cortical, 20% of which are secondary blades resulting from preparation of the core exterior for the removal of interior blades. Secondary blades have a greater length range compared to interior blades, and 4% of the Black Warrior blades were over-passes, blades that spanned the full length of the core face removing a portion of the distal end of the core. Crabtree (1968) describes over-pass removals as attempts to remove thick blades or to straighten a removal face by detaching a blade designed to travel the full length of the core.

In a cobble blade-core industry, over-pass flakes would have provided a means of establishing an initial guiding ridge, as well as straightening the curve of the core face allowing for the production of a straighter blade running the full length of the core face. Comparisons between unretouched blade length and microtool length in Table 18 shows that longer blades were selected for the manufacture of bit-tools. Triangular blade shapes account for 74% of the sample. The blade sample as a whole represents the by-products from core preparation and initial core reduction. This is evidenced by small blades with convex, trapezoidal, and irregular cross-sections. A small proportion of the blade sample (5%) was either intentionally retouched or used.

Table 18. Unretouched and Retouched Blade Dimensions of Length Width and Thickness

		Length (mm)			Width (mm)			Thickness (mm)		
	n	Mean	S.D.	Range	Mean	S.D.	Range	Mean	S.D	Range
Unretouched Blades (non-cortical)	133	18.3	3.5	12-29	8.5	1.9	2-14	2.6	0.9	1-6
Retouched Blades	22	22.5	4.3	16-34	8.1	1.6	6-11	4.8	1.0	3-8

Bit-tool Manufacturing Techniques

Blade bit-tools were manufactured by means of both unifacial primary edge retouch and bifacial primary and secondary retouch. Unifacial bit-tools occur rarely in the assemblage and were characterized by either: (a) steep lateral retouch creating parallel dulled edges converging to form a rounded, blunt tip, or, (b) shallow retouch confined to the tip of the blade. These tools are illustrated in Figure 25.

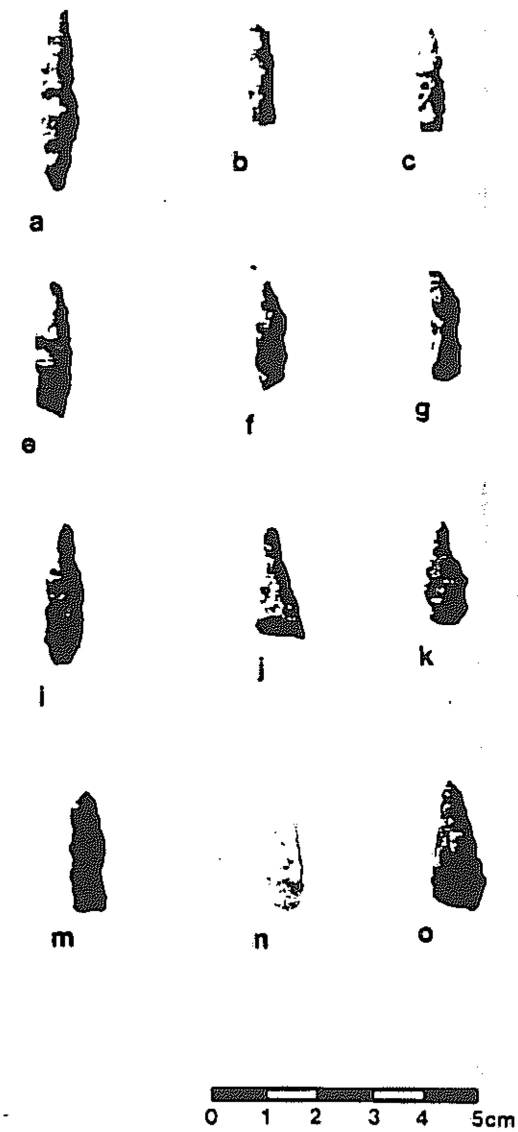


Figure 25. Blade bit-tools; a - d, cylindrical bit-tools; e - h, biconvex, group-1; i - l, biconvex, group-2; m - n, lateral; o - p, end. a. Ha92-22-14, b. Tu66-14-20, c. Ha7-46-5, d. Ha8-27-1, e. Tu2-15-5, f. Ha8-256-2, g. Tu259-5-21, h. Ha92-36-12, i. Ha107-11-4, j. Tu66-44-22, k. Tu66-43-13, l. Tu346-7-4, m. HaM6-19, n. (quartz) Ha92-40-6, o. Tu46-14-5, p. Ha8-270-2.

Large, thick ridged-blades were modified by bifacial pressure retouch into cylindrical blade bit-tools. These blades were most likely removed by percussion techniques. Retouch extended along the entire tool axis creating a uniform, cylindrical tool that could have been easily hafted and retooled in a socketed shaft.

Smaller blades were modified by either primary unifacial or bifacial secondary retouch. Two groups of biconvex bit-tools are distinguished based on the form of the blade preform and nature of retouch. One group of tools were manufactured on narrow, thick blades with prominent dorsal ridges. Thick cortical platforms suggest that these were percussion blades removed from an unprepared platform. Minimal retouch was used to shape the bit or straighten the proximal outline of the tool haft. Another group of tools were manufactured on thin, narrow blades that were bifacially retouched creating a tool with a slightly expanding biconvex-flattened haft, and a small cylindrical bit. These tools were made from interior blades removed from prepared core platforms most likely using pressure techniques. Tool retouch and form was constrained by the prominence of a dorsal ridge. If the ridge was prominent along the entire tool axis, the resulting form would most likely be cylindrical. In the majority of cases, the thickest section of the blade, where the dorsal ridge was most prominent, was incorporated in the tool bit, leaving a flatter, biconvex haft.

Summary

By examining features of the blades, cores, and retouched tools it is evident that a combination of technological, functional, and idiosyncratic constraints affected the final form of blade and flake bit-tools. Bit-tools were consistently manufactured on heated stones. Blade bit-tool design was contingent on the production of a preferred flake type prescribed by functional criteria, as shown by the consistent shape and size of the tool bits. The degree of conversion from blade to tool related to the design of the tool bit (large versus small), and attributes of the blade outline and form. Blade attributes were constrained, to a degree, by the use of small gravel cherts.

Flake tools in some cases are morphologically equivalent to blade bit-tools. The manufacture of bit-tools on blade preforms, however, enabled a more consistent and repeated production of a specific tool form. The degree of retouch was related to the design of the tool bit and blade characteristics, especially the dorsal ridge. Thus, in contrast to the less structured manufacture of flake bit-tools, blade bit-tools express a link betwen a tool design, a technological method of stone-working, and tool function. Tool hafting techniques evidenced by tool haft morphology suggest that both split and socketed hafts may have been employed in the use of these tools. The more uniform shape of the blade bit-tools may have facilitated hafting and retooling, especially in the case of a socketed haft where a worn or broken bit could easily be replaced.

There are no significant differences in the range of overall size of blade bit-tools (Table 12); although, cylindrical bit-tools tend to have longer bits than the other types. For a sample of 22 complete blade bit-tools the coefficient of variation is 19.0 for both length and width, and 21.0 for thickness.

While the production of blade bit-tools was a structured process compared to flake bit-tool manufacture, manufacturing strategies were not based on a consistent technique of core preparation and blade production. The variation in exhausted and discarded core morphology, although based on a small sample, suggests that core reduction techniques varied depending on the overall size and shape of the cobble core preform. The number of blades that could be successfully removed was also affected by core shape and size.

Technological Implications and Comparisons

Stone tool industries are recognized archaeologically because of the consistent application of a certain method, or style, of stone working. In attempting to interpret a technological style as such, both the methods and techniques of stone working must be evaluated together within the particular cultural and social context of which they are a part. The intent of this chapter has been to reconstruct the technological pattern of bit-tool production in the Black Warrior Valley. Manufacturing techniques were described in relation to a number of constraints that affected the final tool form. The implications of the technological structure for interpreting tool design and manufacturing strategies will now be examined within the region, and through comparisons with other microtool assemblages.

The pattern of stone working during the Late Woodland period in the Black Warrior and Tombigbee valleys is one of increasing reliance on local resources and the production of small flake tools. The majority of chipped stone tools were informal in the sense that a functional edge was the primary attribute considered in tool manufacturing strategies. In certain cases, however, special preforms were produced. Triangular arrow points and blade bit-tools are two of the more formal, or consistently produced tool types present in Late Woodland assemblages.

Flake bit-tools that are formally and technologically similar to the Black Warrior Valley tools are found on sites in the central Tombigbee drainage, on Cedar Creek, and in the Tennessee River drainage, from the Middle Woodland onward (Ensor 1981; Futato 1977, 1983, 1987; Rafferty and Starr 1986; Kline 1985; Faulkner 1968;

Faulkner and Graham 1966). Reduction methods were variable and retouch techniques generally involved minimal edge retouching. Tool bits are of three major forms: (a) tapering with an acute tip, (b) parallel-sided with blunted edges and a blunt point, and (c) cylindrical, or rod-shaped, sometimes referred to as "needles." Settlement data from the Tombigbee Valley indicate that microtools are most prevalent on larger village sites that were occupied for longer periods of time (Futato 1987; Rafferty and Starr 1986).

Blade bit-tools occur in Late Woodland lithic assemblages in the Tombigbee and Black Warrior river valleys. Unlike flake bit-tools, however, the technical, spatial, and temporal boundaries of blade bit-tools were more restricted. The production of blade bit-tools was bounded by a restricted reduction method, and the intended product was formally and technologically specific. Not unlike the production of triangular arrow points, the production of blade bit-tools involved the repeated manufacture of a fairly standardized product. One measure of production standardization that has been used in lithic studies focuses on two criteria: (a) consistency in production intent and procedures, both historically and spatially, and (b) consistency in production skill and success, and improvement through time (Arnold 1987; Hester and Shafer 1987). These measures enable one to infer technological behavior in prehistory. The organization of such behavior, however, is a social activity that must be inferred using other corrobative lines of evidence.

Blade-core industries link elements of tool design, manufacturing methods, and tool function. In the case of late prehistoric microlithic industries, tool use also appears to be focused on shell-working activities. However, other uses include bone and wood working and hide perforating. The Black Warrior Valley microlithic industry expresses a consistency in production intent. The fact that similar tools were produced in other areas at approximately the same time suggests that the technology was part of a stone tool tradition in the Southeast. Manufacturing procedures varied between flake and blade bit-tools, however blade bit-tool production was based on a distinct core technology.

Consistency in production skill and success were not examined in the course of this study. However, the redundancy in the production of blade bit-tools suggests a consistent application of manufacturing strategies and skills. The presence of multiple blade cores also suggests a controlled attempt at repeated removals of suitable bit-tool preforms and may also signal an increasing demand for the use of blade bit-tools. Raw material constraints, however, limited the number of blades that could be removed from a single core.

The Black Warrior Valley microlithic industry is technologically specfic in that the intent of the manufacturer was to produce a certain implement, a blade bit-tool. The organization and scale of production is consistent with other production strategies characteristic of chipped stone tool use in the region. In contrast, the Cahokia microlithic industry has been described as specialized in the sense that "it seems to have been designed to produce prismatic blades to be used as drill bits--with or without further retouching" (Yerkes 1983:503). The primary technological difference between the Mississippi Valley industries and the Black Warrior Valley industry is due to the structural differences between tabular and gravel cherts. The Cahokia, Zebree, and Carson industries are based on Crescent Quarry chert, a tabular chert that is found in eastern Missouri (Ives 1984). Ridged blades are easily produced from tabular cherts, whereas the curvature and smaller size of the Tuscaloosa gravel cherts were a constraint on the consistent production of straight-ridged blades. Also, ridged blades manufactured from tabular cherts require minimal retouch to modify a blade into a functional bit-tool. This difference is evident between the primarily bifacial gravel-based industries in the Southeast, and the unifacial bit-tools manufactured in the Mississippi Valley. In addition, a greater number of blades could be removed from the tabular based blade-core industries, and this feature was apparently taken advantage of. The majority of exhausted cores from Cahokia and Zebree are columnar-shaped resulting from maximum consecutive blade removals from opposing core platforms. The Cahokia cores have an average of 8 blade scars per core, which is more than twice the average for the Black Warrior Valley gravel chert industry.

In summary, the Black Warrior Valley microlithic industry can be described as stylistically and technologically similar to analogous and contemporary industries in other regions of the Southeast. The technological pattern or "culture" of the industry can be interpreted as a regional adaptation of a specific method of stone working designed to produce small bit-tools. The blade bit-tool assemblage, when compared to flake bit-tools, is a technologically discrete industry that is best explained in terms of changing production demands and cultural influences. Although based on a small sample, the industry in the Black Warrior Valley is best understood as a common component of West Jefferson, and perhaps Moundville I, stone tool technology. The organization of production appears to be consistent with local demand for a particular tool at the larger, more permanent settlements. There is no indication that the production of these tools was any more specialized than the production of triangular arrow points or other tools that combined specific tool shapes and functions.

A stone tool industry reflects a consistent pattern of cultural and technological constraints and choices that can be interpreted as defining a manufacturing process (Greber et al. 1981:491). Blade industries in the Eastern Woodlands were not constant through time or in all areas. Rather, the presence of these industries corresponded to peaks in increased social complexity involving local and regional interaction. It is within this context that late prehistoric microlithic industries are meaningful, rather than from typological and strict technological interpretations of the tools. While technological methods may be widespread and related in a socially and economically integrated culture area, particular techniques, raw materials, and idiosyncracies may be expected to vary relative to specific regional circumstances. In order to more fully understand the nature of the circumstances prompting the manufacture of bit-tools in the Moundville area, I now turn to a consideration of the functional implications of the tools and the technology.

CHAPTER IV

MICROTOOL USE

Microwear analysis is an archaeological method developed to directly infer tool use from microscopic traces of wear on tool edges that can be observed at high magnifications. The interpretation of stone tool uses has long been a challenge to archaeologists. Ethnographic and morphological analogy were the first means employed to infer prehistoric tool function. Although both continue to contribute valuable corroborative evidence for the interpretation of prehistoric tool use, the development of use-wear analysis has provided a more solid foundation on which to base inferences about the functions of prehistoric stone implements.

The first published report of the development and systematic application of the method was Semenov's book

Prehistoric Technology, published in English in 1964. Semenov relied on experimental, ethnographic, and modern observations of tools and tool use and recognized the significance and potential of microscopic use-wear traces (striations, polishes, and pitting) as evidence for inferring the use of stone tools (Cook and Dumont 1983; Vaughan 1985). Semenov's work was a turning point in the development of the method, and in his own words functional studies would,

> allow us to speak about ancient tools and their functions not conditionally and approximately, as we do with the typological method, but make it possible to explain the actual and concrete purpose of each tool, as it was when in use [Semenov 1964:6].

Following Semenov's lead, lithic analysts have developed and tested a variety of techniques that provide valuable information regarding: (a) the mechanics of edge fracturing and scarring relative to different hardnesses of worked materials (Tringham et al. 1974; Odell 1979, 1980; Odell and Odell-Vereecken 1980), (b) the formation and characteristics of wear polishes and striations diagnostic of specific types of worked or contact material and the motion of tool action or work (Keeley 1980; Vaughan 1985), and (c) the study of diagnostic inorganic residues and the chemical and physical alterations of the flint surface resulting in the formation of characteristic "polishes" (Anderson 1980a, 1980b; Anderson-Gerfaud 1981). Together these techniques are complementary and can be used separately or in conjunction with one another depending on the level of analysis and detail required by a given research problem. It is clear from the advances in method in the past 10 years that the contributions of each technique have inspired developments and will continue to further advance microwear analysis as a viable method.

The utility of microwear analysis as a method for inferring stone tool function has been unquestionably demonstrated in the work carried out following Semenov's publication. The observation that different materials produce experimentally distinct polish surfaces with distinctive textures, sheen and features on the microtopography of the flint surface, was initially put forth by Keeley in the early 1980s. A number of scholars working predominantly in the Old World have repeated Keeley's initial observations (Dumont 1982;

Moss and Newcomer 1982; Vaughan 1985; Bienenfeld 1986). This chapter describes the results of a microwear analysis conducted on the Black Warrior microtool sample. Following the method outlined by Keeley (1980) and Vaughan (1985), a reflected-light metallurgical microscope with magnifications ranging between 100x and 500x was used to identify microscopic wear traces. This technique was employed because it provides the most specific information on tool use with regard to the type of material worked and tool action.

In this study, microwear analysis is used to establish the use-context of a specific tool technology common in Late Woodland and early Mississippian societies. The specific goals are two-fold: (a) to document patterns of tool use with reference to both the individual tool edge, and the entire tool as a typological and technological entity, and (b) to establish the functional nature of the assemblage as a tool industry. This information can then be integrated with technological and distributional information to allow for a more complete and contextual understanding of the production activities involving microtools in the Moundville region.

The chapter is organized in the following way. First, theoretical and methodological considerations are discussed. This is followed by description of the experiments and characteristics of the replicated wear polishes. Next, comparisons are made between the experimental use-wear traces and the archaeological sample. Description of the functional determinations is outlined with reference to the individual tools, as well as technological and morphological variation. The chapter concludes with a summary of the functional, technological, and spatial information evidenced in the sample and the implications for the economic and social context of the industry.

Theoretical and Methodological Concerns

As an archaeological method, the relevance of microwear studies is directly linked to addressing specific problems in the prehistory of a given region (Odell 1982). Typical studies involve analysis at a specific site and the integration of functional information with paleo-economic and ecological data in order to reconstruct prehistoric activities at a particular location. Other applications have been aimed at a specific class of tools and the variability between tool form, technology and use in relation to specific issues of production. Economic activities at a specific site or an entire settlement region and culture may be examined depending on the particular problem at hand and the nature of the data base (Odell 1982).

Although a wide range of applications is possible, microwear studies also share a common interest in the integrated and contextual aspects of paleo-economy, ecology, and changing technologies through time (Odell 1982; Vaughan 1985). It is for the above reasons that, in the process of extrapolating from tool use to function, economic activities and sociocultural processes, other corroborative evidence (e.g. spatial, technological, ethnological, ethnohistorical) must also be evaluated. This is especially relevant since a direct cause-effect relationship cannot be assumed when comparing experimental and archaeological materials.

The intent of the present study is to link a particular tool technology to a given use-context. In addition to site-specific examination, the survey data allow application of the method at the regional and cultural level. Once tool use is determined for the assemblage as a whole, links between the technology and a production context can be examined throughout the settlement region.

In choosing a particular assemblage to apply microwear methods to, three methodological concerns to be addressed are: (a) the nature of the sample's depositional context, (b) the size and representativeness of the sample, and (c) the physical condition of the artifacts to be examined. This last issue is especially important since depositional conditions can damage tool surfaces or obliterate wear traces, rendering the assemblage unsuitable for use-wear analysis.

It is the responsibility of the analyst to determine the eligibility of an artifact assemblage from a given depositional context for the application of microwear techniques. Odell (1985) and Odell and Cowan (1987) have determined that for low-magnification studies focusing on edge-fracture patterns, damage from agricultural equipment is distinctive and can be factored out of the analysis in the majority of cases. The effects of natural surface modifications on the observation of polishes and striations, however, can be expected to vary depending on the age of the deposits and characteristics of the geologic depositional environment, as well as local climatic conditions (Stapert 1976).

Chemical processes in the soil can lead to the development of patinas or other deposits on the flint surfaces that obliterate wear traces, especially polishes and other surface features observed at higher magnifications. In the absence of surface modifying-processes, however, use-wear traces are distinguishable from natural features on the material surface (Stapert 1976). Characteristics of wear polishes such as surface texture, brightness, and distributional patterns on the tool surface can be differentiated from the surrounding natural unmodified surface topography of the flint or chert once the analyst is familiar with the materials and characteristic wear-patterns.

The majority of use-wear studies to date have included only excavated material. However Odell (1985), Stapert (1976) and Pope (n.d.) have applied microwear techniques, with varying degrees of success, to surface collections. Generally, surface-collected sites are not considered due to factors of post-depositional damage resulting from increased exposure, and component mixing of the materials (Odell 1985). However, if the integrity of surface assemblages can be established within acceptable bounds for a particular research problem, then surface collected materials should be considered. Indeed, surface scatters comprise a large proportion of the archaeological data base in many regions and, as such, provide a more representative range of site types and activities within a given settlement system. The issue of feasibility of use-wear analysis on surface-collected artifacts is resolvable only through evaluation of research objectives specific to a particular site or region. In the section that follows, the Black Warrior sample is described and the issues outlined above are addressed.

The Black Warrior Sample

Microtools examined in this study are primarily from 15 sites. A total of 105 tools were examined, 75% of which are from controlled surface collections, 15% are from mound test excavations, and 10% are from test excavations at the White site (Welch 1986). Since the combined assemblage was relatively small, all microtools were included, and the sample is therefore representative of the full range of morphological variability in the tool class.

The Black Warrior Valley artifacts occur in mixed silt/clay alluvial surface deposits and the tools appear to be in good condition considering they are primarily from surface contexts. No apparent modification of the materials in terms of patination or other natural damage was observed for either surface-collected or excavated artifacts. While the archaeological tools were undoubtedly subjected to damage to a degree before, during, and after deposition, initial examinations of a sample of the tools indicated that wear-traces were visible and recognizable. Although measures of the intensity of tool use are more problematic, high-power techniques can be successfully employed to identify tool use when polish is present, despite the problems of both natural and human damage. Although natural modification of the materials was not a problem in this study, there were situations where tools had been burned. Burning creates a patina-like surface that is uniformly glazed, cracked, and often discolored. The identification of use-wear traces was not possible for these pieces.

Microwear Traces

Two types of microwear traces--polishes and striations-- were studied on the experimental and archaeological tools. In the following discussion brief descriptions and summaries are presented for these classes of wear.

Microwear traces are based on the kinetics of working with the hand (Semenov 1964). Distinctive wear traces result from a combination of physical and chemical processes that depend on the properties of the tool material and nature of the work being done. The motion or action of work is revealed by striations, defined as linear marks on the tool surface, showing the direction of tool movement. Polishes form as a result of alterations of the tool surface during work, and as such, are indicative of tool motion. Both the distribution of wear-polish and intensity of polish development across the tool micro-topography are indicators of tool motion or action, as well as the material on which the tool was used (Vaughan 1985:24-5).

Use-wear striations are produced in two ways: (a) through the introduction of foreign particles such as sand or dust between the flint surface and the worked material, and (b) from microflakes removed from the working edge of the tool coming into contact with the material being worked (Mansur 1982). Striations can also result from natural causes (Stapert 1976, Vaughan 1985). Keeley only considers striations resulting from tool use when they are accompanied by wear-polishes (Keeley and Newcomer 1977:37). A similar approach was followed in this study. When striations are present, they generally occur in the same area as the polish and are easily recognized as part of the polish surface. Research on the mechanisms of striation formation has revealed a relationship between striation morphology and processes of polish formation linking the developmental processes of these two wear traces (Mansur 1982).

The study of micropolishes has come to be known as the "high-power" approach since the characteristics of the diagnostic polish traces can only be detected with magnifications of 200x and higher (Keeley 1980). Micropolishes are diagnostic of worked materials because their formation and physical characteristics depend on the characteristics of the specific worked substances (i.e., hardness, chemical and crystalline structure, amount of moisture). Length of use and texture of the chert are also factors that affect polish development, but in quantity, not quality (Vaughan 1985).

Recent interest in polish formation has been prompted by studies of plant polishes (Anderson 1980a; Anderson-Gerfaud 1981). Anderson-Gerfaud's work has shown that friction and heat produced during work leads to the dissolution of the flint surface, depending on the duration of work, the texture of the flint material, and the nature of the contact material (e.g., acidity, moisture, and the amount of silica gel present). Following dissolution of silica in the tool surface, a layer of amorphous silica gel forms on the surface of the contact area of the flint implement. This hypothesis of polish formation is known as the amorphous silica gel model (Anderson-Gerfaud 1981; Unger-Hamilton 1984; Vaughan 1985). Two other theories of polish formation were put forth prior to Anderson-Gerfaud's study. In the mid-1950s, Witthoft proposed the frictional-fusion theory. This theory is based on the notion of melting and fusion of the silica tool surface at the contact area as a result of intense frictional heat (Witthoft 1955, 1967). While changes in the molecular structure of flint occur as a result of induced heat, there is debate as to whether sufficient temperatures are generated by friction during tool use to melt the stone (Del Benė 1979; Anderson-Gerfaud 1981; Vaughan 1985). Finally, the abrasion model has been the most commonly accepted explanation of polish formation, regardless of the worked material (Vaughan 1985). This model states that as a result of the introduction of foreign abrasive particles during work there is a gradual loss of surficial material and smoothing of the flint surface by abrasion (e.g., Hayden 1979; Meeks et al. 1982).

The formation of use-wear polishes remains to be completely understood. Recent studies indicate that the processes are complex and involve both chemical alteration of the surface through dissolution and deposition of silica gel, as well as physical abrasion. Unger-Hamilton (1984) provides a summary of recent theories and research on the processes of polish formation. Friction appears to play a key role since it is the generation of heat that initiates chemical and molecular changes in the elements comprising the flint or chert material. The amount of moisture introduced through the contact material is also an important factor (Anderson 1980; Ungar-Hamilton 1984). Observations that polishes and/or constituents of the polish (e.g., bone apatite) are removed as a result of acid chemical baths suggests that some form of deposition of material residues occurs during the process of polish formation. The nature of these depositional materials, however, has yet to be unambiguously resolved (Keeley 1980; Plisson 1983; Ungar-Hamilton 1984). Other studies have also suggested that the genesis and diagenesis of the flint or chert, as well as the age of the material, should be taken into consideration (Masson et al. 1981; Unger-

Hamilton 1984).

Because the issue of the ontology of microwear polishes remains to be resolved, analysts commonly adopt a concept of "polish" that refers to any surface that reflects light, irrespective of its origin (Anderson-Gerfaud 1981; Vaughan 1985). A similar approach is followed in this study when using the term polish. Effects of use-wear (i.e., polishes and striations) can be studied and characterized within a given research framework apart from the technical aspects of origin or cause.

Although the mechanism of polish formation is still debated we do know that different contact materials produce distinctive polishes, especially when they are well developed (Keeley 1980). It has also been determined that polish develops in stages and that different textures of chert affect the rate of wear-polish development, but not the quality of the polish (Vaughan 1985). Stone tools of different materials are equally affected by physical and chemical damage prior to deposition, as a result of post-depositional processes (including the mechanical and chemical nature of the depositional environment), and during laboratory manipulation (Keeley 1980; Stapert 1976; Plisson 1983). Characteristics of polishes on the tool surfaces, however, are generally a result of tool use and the nature of the worked material rather than other extraneous variables.

In this study, damage to the collection was assessed and a series of use-wear experiments conducted in order to familiarize myself with both natural and use-related wear traces. Observations were also made concerning the natural, unused state of the raw material, and technological damage traces. Examination of the tools and the worked material was conducted at various stages throughout the use-wear experiments. Based on the published results of other researchers and my own experiments, tool use was determined through identification of micropolishes and striations. These assessments were based on the stage of polish development and degree to which the archaeological wear-traces matched those experimentally produced (Anderson-Gerfaud 1981; Vaughan 1985).

Methods and Variables

The sections that follow outline the methods and variables used in the experimental project. First the lithic materials used are described. This is followed by a discussion of the tool replication procedures, experiments conducted, and microscopy techniques used. Variables, methods of data analysis, and the issue of reliability are also outlined.

Lithic Materials

Tuscaloosa gravel cherts collected from two different gravel quarries along the Black Warrior River were used to replicate a series of microtools. A variety of cobbles were selected varying in size, color, and texture. The natural cobbles are primarily yellow and tan. In order to examine the quality of the material in terms of texture and inclusions, the cobbles were fractured after collection. Interior colors include tans, yellows, and mottled grays, and pinks. Surface sheen is dull and textures vary from fine to coarse. Textures often vary within a single chert cobble. Quartz fissures and crystal fragments are also common inclusions.

In order to replicate the archaeological assemblage it was necessary to heat-treat the raw material. For this procedure a laboratory kiln was used. Following procedures previously used to successfully heat-treat Tuscaloosa gravel cherts (Ensor 1981), both whole and fractured cobbles were placed in tins filled with sand and gradually heated by increasing the temperature 100 degrees every hour. The cherts were heated to 250, 350, and 500+ degrees Celsius. Maximum time in the kiln was six hours. The oven was turned off and left to cool overnight before removing the heated cherts. Materials heated between 150 and 350 degrees Celsius were found to replicate the archaeological materials. Temperatures in excess of 350 degrees resulted in a deep red color and the materials were more susceptible to shatter and crumbling rather than controlled fracturing. Cobbles heated within the 150 to 350 degree range were selected for tool replication.

Tool Replication, Experimental Procedures, and Techniques

The aim of microtool replication was to reproduce a usable implement that was morphologically similar to the archaeological tools. The tools were replicated in the laboratory by Phillip Waite. After examining the archaeological cores, blades, and micro-tools, heat-treated cobble fragments were selected as cores and blade-shaped flakes removed in both a systematic and opportunistic fashion. Core preparation and removal was carried out with an antler baton and percussion techniques. Antler pressure-flaking tools were used to manufacture the finished tools.

The use-wear experimental program involved drilling a series of materials that included fresh deer bone, a bear claw, soaked antler, dried hardwood, and fresh marine shell. Engraving experiments were also carried out on marine shell. Initial drilling experiments were conducted with a bow-drill, however the frequency of tool breakage precluded the continued use of this drilling technique. Instead, a small mechanical hand-drill was substituted for the bow-drill and the motion simulated. A mold and machinist plastic were used to form a sleeve around the tool for insertion into the drill chuck. The mold was designed to create a centered, straight axis of rotation during the drilling experiments. This technique proved to be of limited success since the plastic sleeve generally snapped after continued use, requiring several re-hafting episodes during the course of using a single drill. It was later discovered that simply wrapping the base or shaft of the tool in cotton and inserting the tool directly into the drill chuck was sufficient. The worked material was secured in a vise during the drilling procedure.

Since the objective of the experimental program was to replicate wear-polishes from the action of drilling and engraving, it was felt that the artificially imposed laboratory conditions would provide systematic, controlled results and not detract from the authenticity of the motions of tool work simulated for the purposes of this study.

Tools were used for 15 and 30 minute intervals at which point they were examined under the microscope. Duration of tool use was determined by the length of time necessary to observe the characteristics of polish formation and the distinctive features of a given contact material. At each observation point the tools were examined prior to cleaning and after cleaning with warm soapy water, alcohol, and dilute (20%) HCl and NaOH solutions. Alcohol was used to clean finger grease when tool edges were reexamined after the initial experiments had been conducted. Similar cleaning procedures were used on the archaeological pieces in order to insure comparability (Keeley 1980).

Edges were examined prior to use and at a series of observation points using an Olympus BHM metallurgical microscope. Polish identifications were carried out primarily at 200x, although the full 100x to 500x magnification range was employed. Photomicrographs recording the diagnostic polish traces were taken with an Olympus 35mm camera attachment. Technical Pan (100 ASA) film developed by Kodak especially for photomicrography was used to document the observed wear-traces.

Variables and Data Anlysis

Since the research presented in this study focuses on a single tool class, the experiments and analysis were defined by the nature of the tools under study. The objectives of the experimental program were: (a) to determine the range of possible wear patterns resulting from the use of the replicated tools on a restricted range of contact materials, and (b) to familiarize myself with the characteristics of the wear patterns replicated.

The two most informative and readily identified wear traces are micropolishes and striations. These two variables inform on the nature of the worked materials and action of the work carried out with the implement. The presence of striations, polishes, and microflaking were identified with both the naked eye and under high-power magnification (200x-500x). Characteristics of microflaking and edge rounding were noted for the tool class but were not systematically examined in this study.

Detailed attributes relating to microstriations and polishes were systematically coded and described for each tool examined. Attributes of striation morphology, orientation, and predominant surface were coded. Attributes of the micropolishes were described with reference to: (a) surface characteristics, including relative brightness or dullness (amount of light reflected), roughness or smoothness (texture), and the presence of topographical features such as pits and undulations; (b) distribution across the tool microtopography, and (c) the degree of linkage between the polish components in the development of the surface polish. Attributes of the micropolishes were described rather than numerically coded. Line drawings depicting the location of wear-traces on the tool surface accompanied each description. Use-wear attributes used in this study followed those described by Keeley (1980), Yerkes (1983), and Vaughan (1985).

The experimental wear-traces replicated were found to be comparable to those described independently in experiments conducted by other researchers (i.e., Keeley, Yerkes, and Vaughan). The characteristics of the well-developed polishes for each contact material were used as the "type-polish" for a given contact material. Determinations of archaeological micropolishes were based on a relative scale of certitude depending on the match between the experimental and archaeological examples. These determinations follow those outlined by Vaughan (1985) and include: (a) definite or at least "very highly probable" polish traces that are well-developed, (b) not as definite but "most likely" polish traces that are weakly developed, and (c) polish traces that are indeterminate or nondiagnostic due to lack of development or damage from natural or human-induced condition.

Results of the Experimental Replication of Wear-Traces

The results of the use-wear experiments are presented in the following sections by the type of wear and the category of worked material. Prior to describing the micropolishes on the used pieces, characteristics of the unused material surface are described, as well as effects from heat-treating and tool replication. Photomicrographs of the observed wear-polishes are presented along with each description.

Microchipping and Edge Rounding

Attributes of microchipping and edge rounding were not systematically studied in relation to different contact materials. However, certain observations were noted during the drilling tests.

It has been demonstrated that heat-treated materials are more susceptible to wear during use (Olausson 1983).

The reduced tensile strength caused by heating tends to increase the rate of microchipping during tool use beyond that which would normally occur. Microchipping during drilling tasks imparts both positive and negative effects to the tool. On the positive side, microchipping can be seen to shape the drill bit through extensive use, resulting in a more symmetric form determined by the size of the bore hole. However, the increased wear quickly reduces the sharpness of the tool edges, rendering the tool less effective and more susceptible to breakage during use.

Microchipping was most common on drills used to bore shell, the hardest material tested. Microchipping occurred less frequently while working the other materials. Step scars were most extensive on the shell drills. Also, microchips were visible in the dust in the bore hole only when drilling shell. The more extensive chipping during shell drilling may also explain the tendency for striations to be more common on the shell drills compared to the other materials.

Edge rounding was not observed on any of the experimental drills, however it is possible that the tools were not used for a long enough period of time to generate this. A worn, dull, abraded surface was observed with a hand lens on the immediate tips of the two shell drills. This feature was not visible on the other test drills.

Striations

Three morphological classes of striations were observed on the experimental tools. First are faint narrow striations that appear to be superficial rather than sunken into the polish surface; second, narrow and deep striations that appear more as grooves in the flint surface; and third, narrow striations that appear to be filled-in and part of the polish surface. Striations as they are described by Vaughan (1985:24) are "directional indicators" constituting features that are an integral part of the micropolish.

The orientation of the observed striations from drilling motion were perpendicular or diagonal to the tool axis. Striations were observed on tool edges and flake scar ridges on the dorsal and ventral tool surfaces. Striations observed on the tool used to engrave shell were not as prominent and were oriented parallel to the tool axis.

Striations were most apparent on the tools used to drill shell. After only 15 minutes of work, narrow, superficial striations were visible on the shell drills. As the duration of work increased, the morphology of the striations tended to change. After an additional 45 minutes (total time = 1 hour), the striations appeared to be filled-in and part of the wear polish, and more indicative of directionality. Finally, after an additional 30 minutes, the striations again appeared as superficial narrow lines but with darker interiors.

In contrast to working shell, striations were observed on the drill used to bore bone after only 30 minutes of work, and after 45 minutes of working antler. Striations on the antler drill were narrow, fine and superficial. The striations on the bone drill appeared as deep grooves and did not occur in any consistent pattern. Only faint striations observed at 500x were noted on the drill used to bore a series of holes in a bear claw.

Micropolishes

Micropolishes are characterized by four general features: (a) reflectivity in terms of brightness or dullness, (b) surface texture and features, (c) degree of linkage or development, and (d) distribution or formation across the microtopography of the tool surface.

The most distinctive feature of use-polishes is the distributional patterns of formation across the tool surface coming into contact with the worked material. As the polishes become increasingly developed, individual polish components tend to become linked forming a solid polish cover. It is for this reason that well-developed polishes are easily identified and generally unambiguous.

Polish formation over a stone surface follows a general pattern starting with the area immediatley in contact with the worked material surface. As work continues polish forms first on the higher points or crests (flake scar ridges) and then gradually spreads to the lower areas of the surface microtopography. If polish formation is not complete over a surface, dark interstitial spaces in the form of micropits and depressions occur as part of the polish surface.

Specific patterns of polish formation are affected by the type of contact material (e.g. moisture content), tool action (e.g. cutting, scraping, boring), and the texture of the stone. Boring action generates initial polish formation on the immediate contact points on the distal tip and point of the tool. The early formation of isolated areas of polish were observed in the interior of the microscars on the tool edges. Shell, antler, and bone polishes tended to form in linear strips and on the high points of the microtopography moving away from the edge. Wood polish formed on the high points of the microtopography and then quickly spread over the tool surface. Soaked antler polish also formed quickly, spreading in a flowing pattern over the contact area. In contrast, bone polish is a more localized formation developing only on the high points of the surface topography. Shell polish developed first as scattered flat polish components in the interior of microscars on the tool edge. As the duration of work increased the surface became increasingly covered and linked by the individual flat polish components. In all of the tests, wear patterns formed on both tool edges, the drill tips, and on prominent dorsal and ventral ridges. Since the direction of the drilling motion was alternating in simulated bow-drill action, wear-traces were not evenly developed on both tool edges. Rather, one edge tended to be more worn.

The Unused Flint Surface and Technological Effects

While characterization of the natural flint surface texture and constituents can best be accomplished through scanning electron microscopy, general features of the unused flint surface can be observed through optical microscopy (Vaughan 1985). In the discussion that follows, natural features of the Tuscaloosa gravel chert and technological effects from heat-alteration and tool manufacture are described. A photomicrograph of an unused tool surface is provided in Figure 26:a.

The range of textures in the gravel cherts used can be described as fine-grained and medium fine-grained, depending on the range of grain sizes and homogeneity of the chert matrix. The finer-grained material appears more homogeneous, lacking obvious crystalline structures or other reflective spots. The medium fine-grained materials have a coarser texture and individual crystalline structures are discernible within the matrix. These materials generally have more internal variability. Quartz crystals were common in the coarser-textured materials. Both the fine and medium-fine samples had a dull sheen or matte surface.

The effects of thermal alteration were tested by examining unheated archaeological specimens and the unheated and heated test materials. The major alteration of the material surface as a result of thermal alteration was the transformation of the matte surface into a greasy and lustrous surface with a fluid-like texture. Amorphous-shaped smooth areas of recrystallized quartz inclusions formed scattered patches of glass-like material. Microcracks were also present in the heat-altered surface. The presence of microcracks or dark lines have been observed on other heat-treated materials as well (Helle Juel-Jensen, personal communication; Weymouth and Mandeville 1975). The luster of the heat-treated material surfaces varied, corresponding to the texture of the material. The finer-grained samples exhibited a more intense glossy luster compared to the coarser-grained pieces. Both features of luster and cracking occurred between 200 and 250 degrees Celsius.

Shallow step and hinge scars were the most common damage resulting from tool manufacture. Microscars were also generally accompanied by abrasion along the tool edge. Occasional scratches, parallel striations, microcracks, and isolated bright spots were observed at higher magnifications.

In summary, wear traces resulting from tool manufacture were easily distinguished from use-related wear traces. On the other hand, heat-treatment had a more drastic effect on the physical state of the material. However, comparisons between unused heated and unheated materials enabled the recognition of changes in the appearance and features of the heated material. Once familiar with the high luster of the heat-altered surface, use-wear traces were easily discerned from the surrounding natural chert matrix.

Classification of Polish Types

The polish types resulting from drilling different contact materials are described below according to the material worked. In addition to the descriptions, major characteristics are outlined for each material. For a more comprehensive description of these polishes, the reader is referred to publications by Keeley (1980) and Vaughan (1985).

Bone Polish

Working fresh deer bone produced a bright greasy polish (Figure 26:b). A major characteristic of bone polish, also noted by other researchers, is the pitted appearance of the polish creating a rough surface texture. The pitted texture is related in part to the way bone polish forms on the surface, and exposure to HCl acid in solution baths. Bone polish is a more localized wear pattern compared to other polishes that spread across a surface through linkage development. Bone polish develops primarily on the higher points of the surface topography becoming more intense in those places of wear development. Since the polish is isolated, it has a latticed appearance

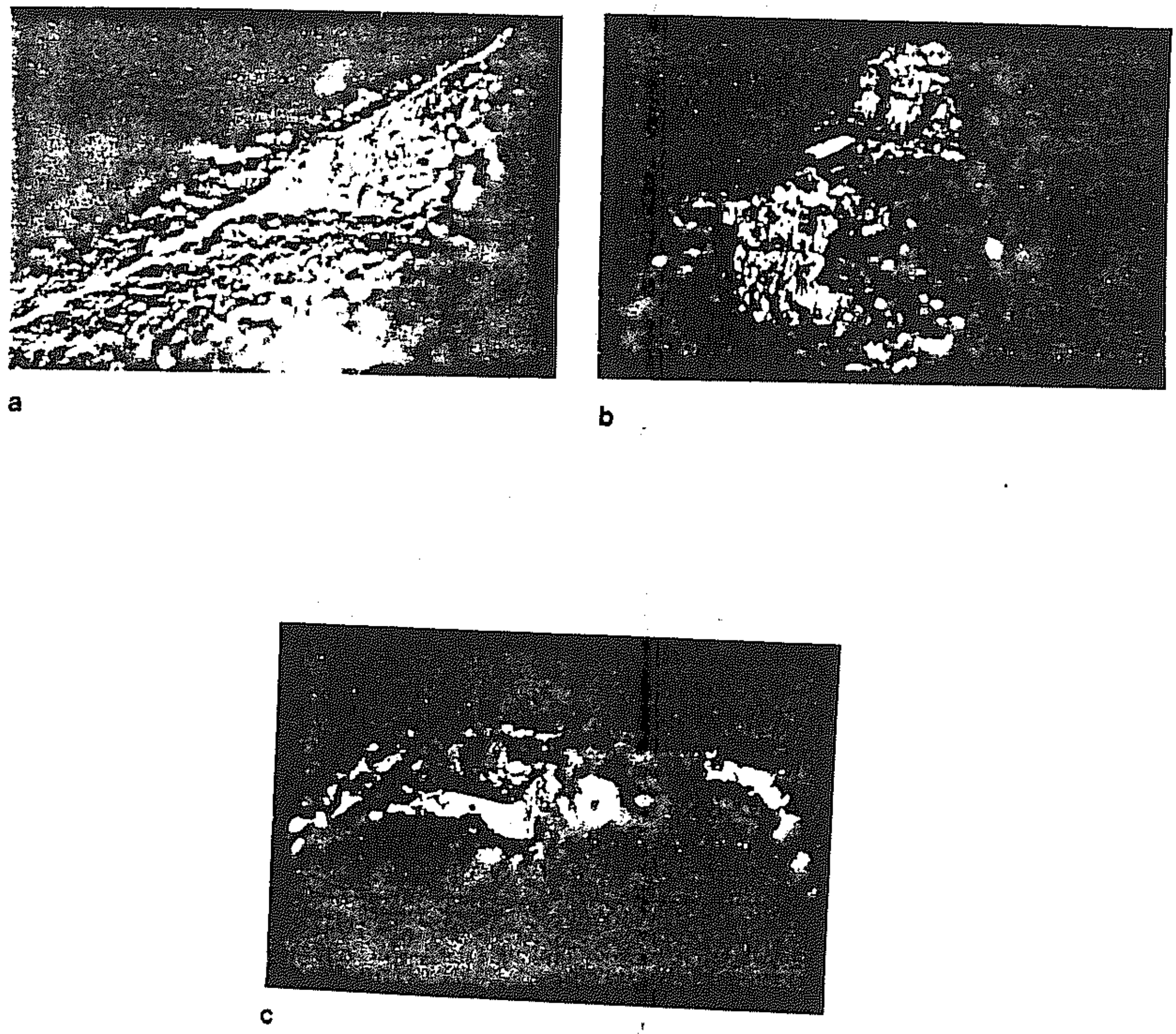


Figure 26. Experimental polishes; a. unused surface showing a flake scar ridge, b. deer bone polish, c. bear claw polish (enlarged prints are 800x, specimens photographed at 200x)

with micropits, depressions and interstitial spaces (Vaughan 1985:31). Hydrochloric acid also has the effect of removing bone residues from the polish surface adding to the pitted appearance of the surface texture (Keeley 1980; Anderson-Gerfaud 1981).

Examination of the bone drill prior to cleaning revealed a tendency for soft bone residues to adhere in large patches on the flat high points of the tool surface. This same pattern of wear distribution was noted after the tool was cleaned. At 500x the localized appearance of the polish is enhanced and well-developed areas have a wavy distribution. Deep striations or grooves occurred after 30 minutes of work.

Bear Claw Polish

Polish resulting from drilling a series of holes in a bear claw was similar to that of deer bone in luster and texture (Figure 26:c). The polish was bright and greasy, and the surface had a rough, pitted appearance. Polish formation is also restricted to the higher points on the surface. Fine, surficial striations were observed at 500x and were oriented perpendicular to the tool axis.

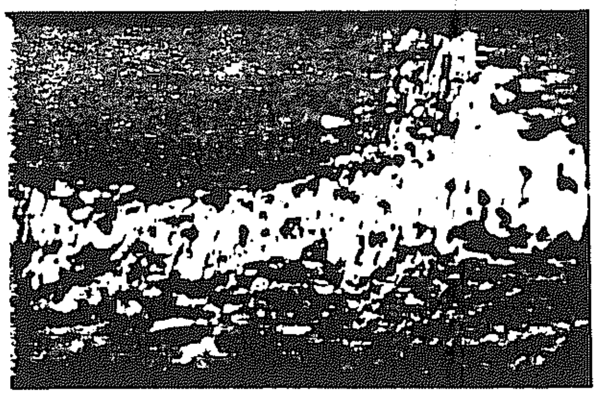
Antler Polish

Drilling antler soaked in water for 86 hours produced a bright, smooth-textured polish (Figure 27:b). Keeley (1980:56) has noted that scraping, planing, or graving antler produces a very bright and smooth polish. Although the texture is smooth, the polish surface has a domed rather than flat distribution. Because of the domed formation of the polish components, weak antler polish can resemble wood polish (Keeley 1980; Vaughan 1985). However, well-developed antler polish is more distinctive. As polish formation develops the separate polish domes become linked forming localized, linear polish surfaces with a wavy or undulating appearance. As polish development progresses, the doming effect spreads across the lower interstitial spaces. A "pockmarked" appearance results if linkage is not complete (Keeley 1980:56). At 500x the polish has a "layered" look and very fine striations were observed near the corner of the tip perpendicular to the edge.

When not well-developed, antler polish also resembles bone polish. However, one difference is that the bone-polish edge bevel tends to be truncated, whereas antler polish has undulating, smooth, and rounded-over edge bevels.

Wood Polish

Wood polish is similar to antler in luster and texture. The polish resulting from drilling a dried block of oak is bright and smooth (Figure 27:a). Polish forms domes around the higher points in the microtopography and linkage spreads rapidly forming a smooth, undulating polish cover. Unlike bone and antler polishes that form in a more localized pattern, wood polish is more extensive and evenly widespread along both the edge and the interior away from the edge (Vaughan 1985). When polish formation is not linked it forms a reticular lattice depending on the texture of the raw material. An overall smooth surface results when linkage occurs across the interstitial areas and depressions in the topograpy of the material surface (Vaughan 1985). Striations were not observed to form in the process of drilling wood.



a

b

Figure 27. Experimental polishes, a. wood polish, b. antler polish (enlarged prints are 800x, specimens photographed at 200x).

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Shell Polish

Drilling fresh marine conch shell forms a very distinctive and directional polish wear pattern (Figure 28). The polish surface is highly reflective and individual polish components are flat and smooth with a geometric or "platy" appearance. In contrast to bone and antler polishes that are localized, shell polish formation is extensive over the areas coming into direct contact with the worked substance. As the polish develops it it becomes more extensive and linked creating a continuous flat platy surface. It is likely that the flat formation structure of the polish results in the reflection of more light and a brighter polish surface. Well-developed shell polish is highly directional. This feature is also likely to be related to the extensive platy formation across the area of most extreme wear.

Depending on the degree of linkage, interstitial spaces appear as dark depressions and cracks or crevices in the polish matrix. Pits were observed in the polish at 500x magnification. Directional striations are also a prominent feature of shell polish as described earlier

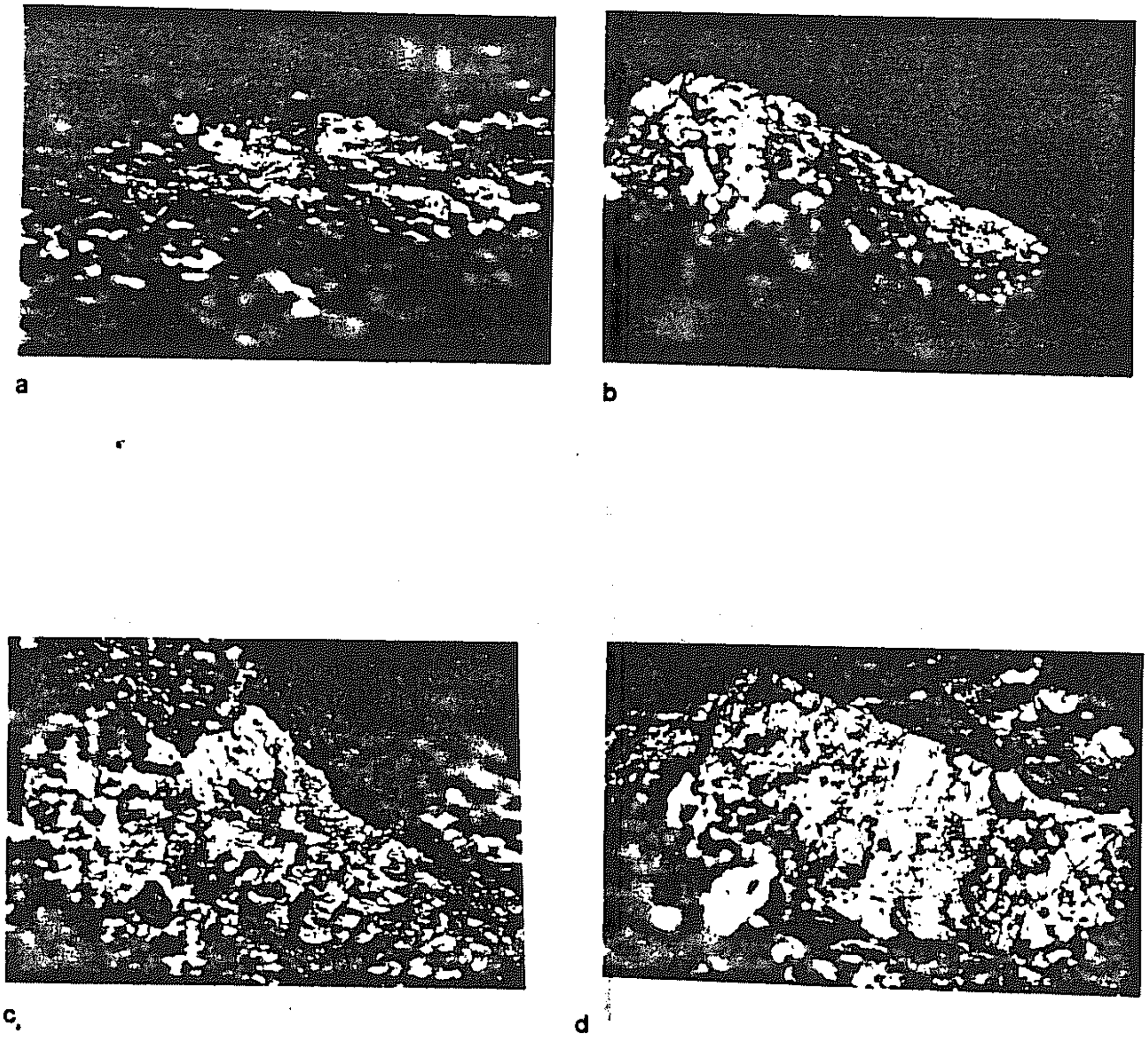

Figure 28. Examples of experimental shell polish (enlarged prints are 800x, specimens photographed at 200x).

(Yerkes 1983; Andrea Lain, personal communication).

Examination of the shell drills prior to cleaning indicated that shell residues tended to adhere to the stone surface in the flake scars and extensively across the tool surface. A similar polish wear pattern was observed after cleaning. This same phenomenon was observed for the bone drilling tests. In addition, extended exposure (1 hour) in hydrochloric acid solutions is also reported to dissolve shell polish components (Andrea Lain, personal communication). Characteristics of shell polish development and reactions with acid baths suggest that, at least in part, shell polish formation is an additive or depositional process.

Shell has not been as extensively tested for polish traces compared to more common substances such as bone, antler, wood, hide, etc. The results of shell experiments conducted during this study are consistent with descriptions reported by both Yerkes (1983) and Lain (personal communication).

Summary

Results of the experimental program confirm that the replicated microtools could be used to work a variety of substances that were most likely part of the material repertoire of the aboriginal environment. Diagnostic wear polishes were defined based on surface and distributional attributes.

While the issue of polish formation was not directly addressed in this study, optical examination of both the contact materials and the uncleaned and cleaned tools suggest that deposition of material residues occurs to some degree. Drilling also generates a great deal of frictional heat, especially when working substances with a high moisture content such as soaked antler and wood. Abrasion also affects the polish surface, especially when working with hard materials such as shell. Extensive microchipping during shell drilling is no doubt connected to the formation of striations that cut into the polish surface and the abrasion that forms on the wear surfaces on the tips of the shell drills. Microchipping also effectively removes previously developed polishes.

Directionality or tool motion was determined by the distribution of polishes on the tool edges and surfaces and by directional striations within the polish surface. These features were most apparent on the shell drills. The polish developed in linear patterns parallel or diagonal to the tool axis. Striations formed diagonal and perpendicular to the direction of polish formation and to the tool axis. These patterns are indicative of rotary motion and form on major contact pressure points on the bit edges, dorsal and ventral ridges, and tip.

Shell was the hardest material to work. Both experimental shell drill bits eventually broke during use. Because of torsion from vertical and rotary pressures, drills are suseptible to bending use-breakage (Odell 1981). The high frequency of broken microtools in the Black Warrior assemblage with overhanging break surfaces is not surprising.

Based on the results of the experimental program, the replicated well-developed wear traces were found to be distinctive and diagnostic of the categories of worked materials. Weakly developed polishes were found to overlap between bone and antler and bone and shell. However the action of drilling tended to produce well-developed polishes after a short time.

Functional Determinations of the Black Warrior Microtools

The archaeological tools were examined following the same procedures and techniques used to examine the experimental tools. The same variables as those examined on the experimental drills were also used in evaluating contact material and action wear traces on the archaeological pieces. Each piece was examined along both edges and dorsal and ventral surfaces. Both polishes and striations were recorded. Photomicrographs were taken to document typical examples of the range of use-wear patterns observed (Figures 29 and 30). Assessments of tool function are based on individual wear traces and are used to evaluate the functional integrity of the tool technology. Summaries of the use-wear results are presented in Tables 19 through 23.

Worked Material

The principal wear trace observed on the Black Warrior bit-tool edges was that of shell (see Tables 19 and 20). Wear traces resembling shell polish were observed on 60% of the tools examined. Well-developed shell polish was identified on 15 of the 63 shell-working tools identified as drills. Extensive well-developed shell polish was identified as having a bright-white reflective surface, and a smooth, flat, platy texture (Figure 29). Interstitial areas not covered appeared as dark cracks or crevices in the polish matrix. Micropits and fine, narrow striations were commonly observed as part of the polish formation. Extensive areas of polish formation tended to occur on the dorsal aspect of the tool and along the immediate bit edges. Extensively linked polish traces also tended to be directional, forming in linear, parallel patterns indicating rotary tool motion. Well-developed polishes also tended to form more extensively on the finer-grained varieties of the Tuscaloosa cherts.

Moderate and weak traces of shell polish were observed on 48 of the 63 shell-working tools examined. Wear traces

Table 19. Summary of Use-Wear Results for the Black Warrior Valley Bit-tool Sample

Action:	Material Worked: Shell	most likely Shell	Bone	Shell/ Bone	Shell/ Wood	Dry Hide	Dry Hide/ Wood	under	no data	Row total	Row %
Engraving	-	6	1	1	1	-	-	4	-	13	12
Boring	15	34	3	10	1	-	-	1	-	64	62
Engraving/ Boring	-	2	-	-	-	-	-	-	-	2	3
Perforating	-	-	-	-	-	3	2	-	-	5	5
Uncertain	-	6	-	2	-	-	-	5	8	21	20
Column Total	15	48	4	13	2	3	2	10	8	105	
Column %	14	46	4	12	1	3	2	10	8		100

Table 20. Summary of Use-Wear Results for Bit-tool Subtypes - Worked Material

	Blade Bit-tools					Flake Bit-tools					
Use-Wear:	Biconvex Group 1	Biconvex Group 2	Cylindrical	Uniface Lateral	End	Triangular	Flake Biface	Flake Uniface	Frag.	Total	Row %
Shell	12	17	15	-	-	8	3	3	5	63	60
Bone	1	1	-	-	-	1	-	-	1	4	4
Dry Hide	-	-	-	1	-	-	-	1	1	3	3
Dry Hide/Wood	-	-	-	-	1	-	1	-	-	2	2
Shell/Bone	1	3	1	-	-	1	3	-	4	13	12
Wood	-	-	1	-	-	-	-	-	-	1	1
Undet.	1	1	1	-	1	3	-	-	3	10	10
No Data	-	2	2	1	-	1	-	-	3	9	9
Total	15	24	20	2	2	14	7	4	17	105	
Column %	14	23	19	2	2	13	7	4	16		100

Table 21. Summary of Use-Wear Results for Bit-tool Subtypes- Tool Motion

	Blade Bit-tools			Flake Bit-tools							
Motion:	Biconvex Group 1	Biconvex Group 2	Cylindrical	Unifacial Lateral	End	Triangular	Flake Biface	Flake Uniface	Frag.	Total	Row %
Rotary/ Boring	11	20	14	-	-	7	4	2	7	64	61
Lateral/ Engraving	3	-	1	-	1	2	2	1	2	13	12
Perforating	-	-	-	1	1	-	1	1	1	5	5
Rotary/ Lateral	-	-	2	-	-	1	-	-	-	3	3
Undet.	1	2	1	-	-	3	-	-	4	12	11
No Data	-	2	2	1	-	1	-	-	3	9	9
Total	15	24	20	2	2	14	7	4	17	105	
Column %	14	23	19	2	2	13	7	4	16		100

Table 22. Use-wear Results Summarizing Tool Morphology and Use

Type/Subtype/ Group:	Shell Drill	Shell Graver	Shell D/G	Shell Indet	Bone Drill	Bone Graver	DH Perf	Wood Drill	DH/W Perf	S/B D/G	Indet	No Data	Row Total	Row %
Biconvex, Group 1	9	2	-	1	1	-	-	-	-	1	1	-	15	14
Biconvex, Group 2	15	-	-	2	1	-	-	-	-	3	1	2	24	23
Cylindrical	12	-	2	1	-	-	-	1	-	1	1	2	20	19
Uniface Blade, Lateral	-	-	-	-	-	-	1	-	-	-	-	-	1	2
Uniface Blade, End	-	-	-	-	-	-	-	-	1	-	1	-	2	2
Triangular	6	1	-	1	-	1	-	-	-	1	3	1	14	13
Flake, Biface	2	1	-	-	-	-	-	-	1	3	-	-	7	7
Flake, Uniface	2	1	-	-	-	-	1	-	-	-	-	-	4	4
Fragment	3	1	-	1	1	-	1	-	-	4	3	3	17	16
Column Total	49	6	2	6	3	1	3	1	2	13	10	9	105	
Column %	49	6	2	6	3	1	3	1	2	12	10	9		100

key: D/G - drill/graver
S/B - shell/bone
DH - dry hide
W - wood
Perf - perforator
Indet - indeterminate

Table 23. Summary of Morphological, Technological, and Functional Characteristics of the Black Warrior Valley Bit-tool Assemblage

Bit-tool Morphological Type	Technology	Use
Biconvex, Group 1	Blade	Shell/Bone Boring/Engraving
Biconvex, Group 2	Blade	Shell/Bone Boring
Cylindrical	Blade	Shell/Bone/Wood Boring/Engraving
Unifacial-lateral	Blade	Dry Hide Perforating
Unifacial-end	Blade	Dry Hide/Wood Engraving/Perforating
Triangular	Flake	Shell/Bone Boring/Engraving
Flake Biface	Flake	Shell/Dry Hide Boring/Engraving/ Perforating
Flake Uniface	Flake	Shell/Dry Hide Boring/Engraving/ Perforating (?)

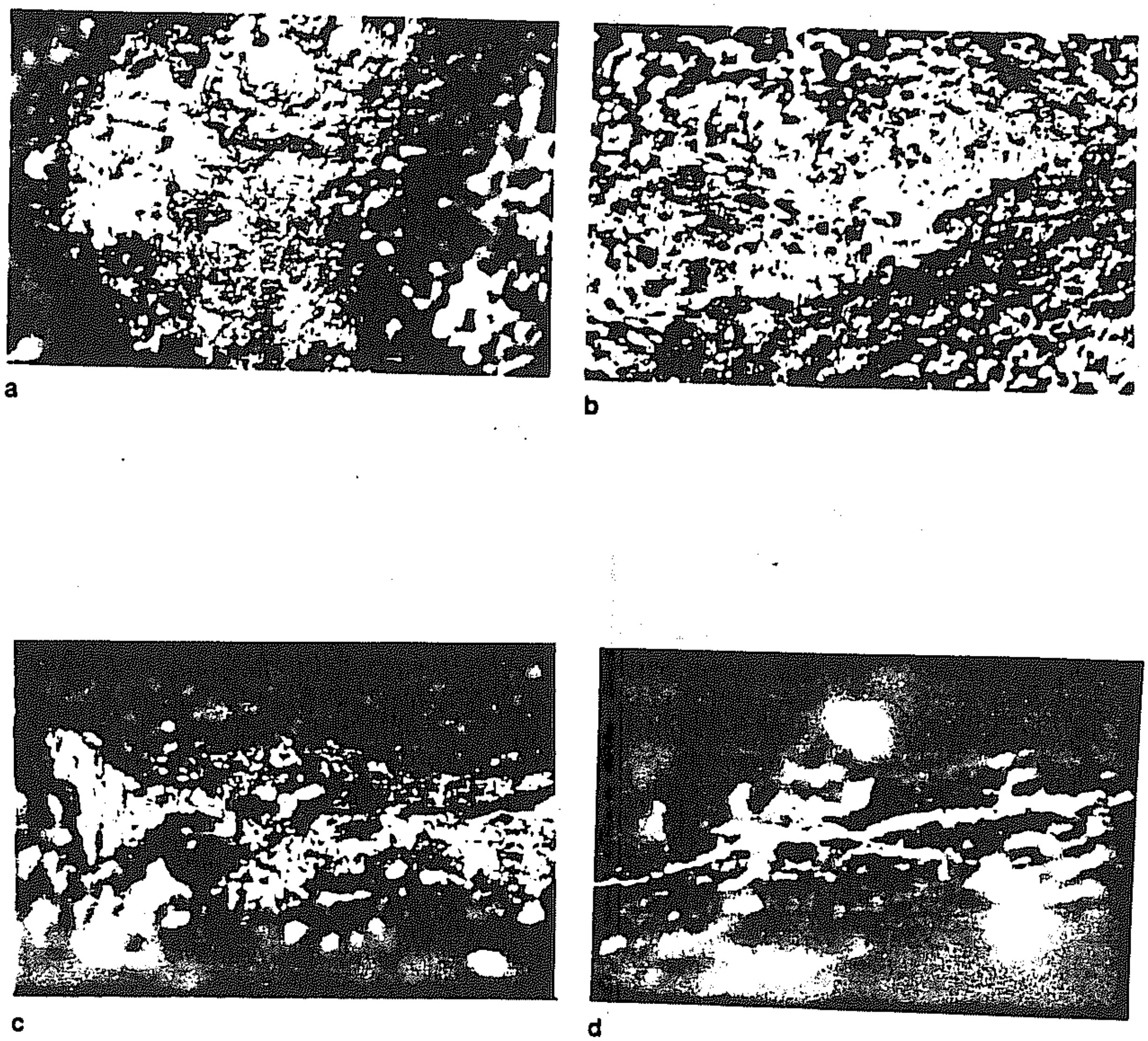

Figure 29. Archaeological examples of shell polish; a - c, shell drills, d, shell engraving tool (tool axis is parallel to the field of observation; enlarged prints are 800x, specimens photographed at 200x).

in this category are not extensively formed in that there were no linked patches of polish. Bright, flat, and platy polish components similar to well-developed shell polish were present on the tool edges and bit surfaces. These scattered traces formed on all edges near the tip of the bit and on both high and low points on the surface topography. Striations, micropitting and directionality of polish formation were also features of the lesser-developed shell polishes.

Polishes other than shell accounted for 23% of the sample and included bone, dry hide, and overlapping traces of shell/bone, shell/wood, and dry hide/wood (Figure 30). Although dry hide perforating experiments were not conducted in the experimental program, dry hide traces are very diagnostic and were identified from other published accounts (Keeley 1980). Dry hide wear is characterized by an intense dulling of the tool edges and a matte surface texture. Prehaps one of the most diagnostic features of this polish is the presence of small, very regular circular-shaped pits in the microtopography of the worn surface (Keeley 1980:49). Keeley (ibid.:50) has suggested

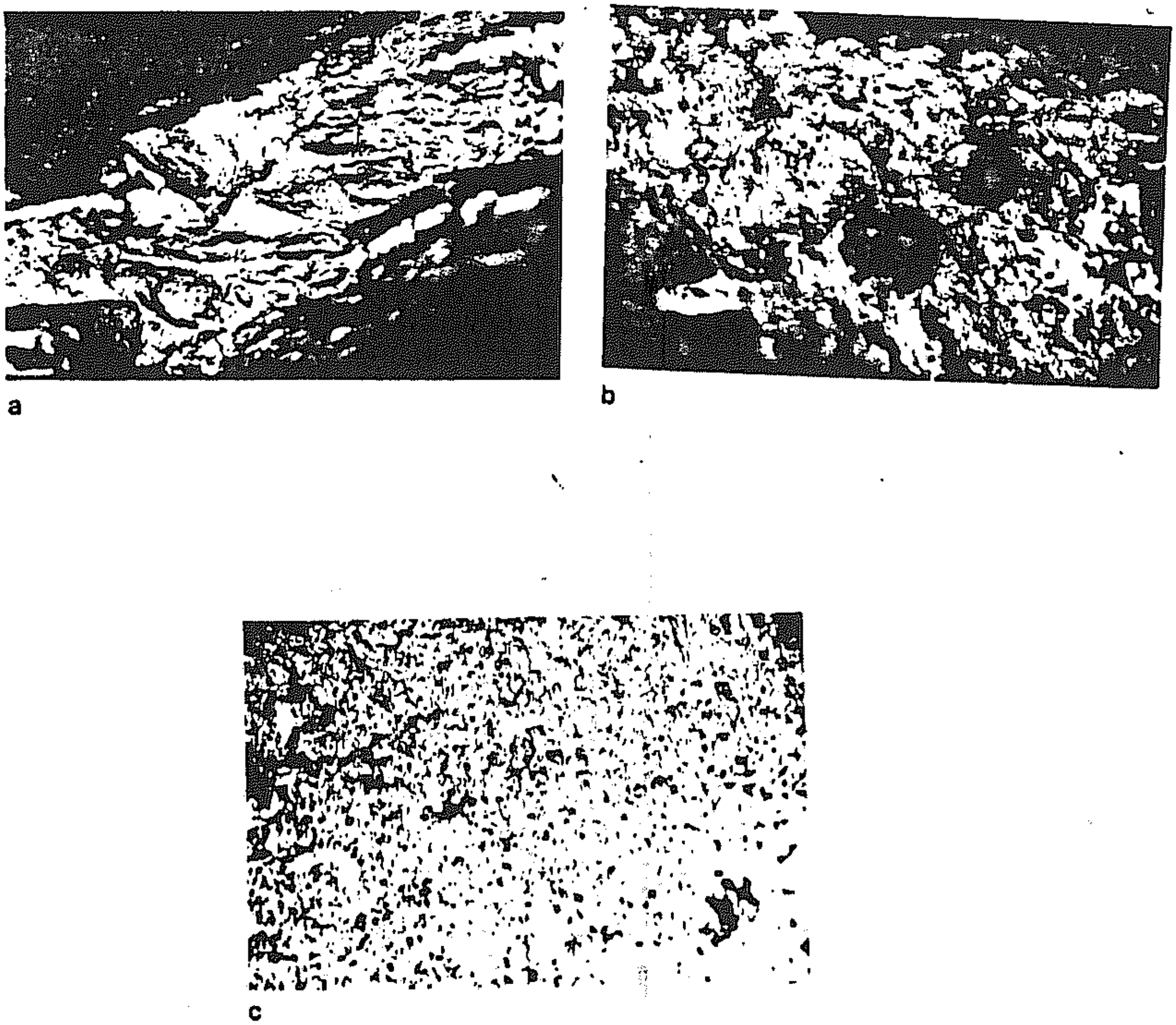

Figure 30. Examples of archaeological polishes; a. bone polish, b. dry hide polish showing circular pit depressions, c. wood/fiber haft polish (tool axis parallel to the field of observation; enlarged prints are 800x, specimens photographed at 200x).

that these pits may be "micropotlids", small thermal spalls resulting from the intense thermal stress from the frictional heat developed as a result of working dry hide. This feature is unique to dry hide polish (see Figure 30:b).

Action

Actions involving microtool use indicate that in most cases the tools were used in rotary-drilling or boring motions (see Tables 19 and 21). Of a total of 80 tools with identifiable motion traces, 65 (81%) were diagnostic of rotary motion. Directional striations were oriented diagonally and perpendicular to the tool axis. Well-developed polish traces tended to form in linear directions across the tool microtopography parallel to the tool axis. Extensively developed striations tended to form in a regular, parallel pattern suggesting the possible use of a bow-drill. Microchipping and polish formation also tended to form more extensively on one edge as opposed to both tool edges. Twelve of the tools show parallel linear striations and polish traces resulting from engraving action. Overlap between rotary and grooving actions were observed on the edges of three tools.

Rotary-boring motion was used to work shell (75%), bone (5%), shell/bone (15%), wood/shell (2%), and indeterminate materials (3%). Grooving-engraving motion was observed to a lesser extent on shell (50%), and also on bone (8%), shell/bone (8%), and indeterminate materials (33%). A combination of both rotary and engraving actions were identified on two tools used to work shell and one tool with traces of both shell and bone. Although action traces were not present on the hide and hide/wood tools, it is probable that they were used to perforate hide. Tool breakage patterns revealed that breaks most likely occurred as a result of stress involving torsion from rotary action. Characteristic breaks included lateral and transverse medial twist breaks, and flat, horizontal medial and distal breaks leaving overhang projections from the break surface (Odell 1981).

Although hafting experiments were not conducted in this study, traces of wear caused by hafting was observed on over half of the tools examined. Wood-like rectilinear wear patterns were found on the tool shaft pressure points at the base corners, shoulders, and along dorsal flake scar ridges (Figure 30:c). Hafting traces were observed for tools used on shell, bone, and wood involving both rotary and graving actions.

Functional Evaluation of the Microtool Class

Turning from the individual tools, I now examine patterns of bit-tool use for the tool class as a whole. When links between form and function are examined for the technological categories presented in Chapter II, the use-wear results indicate that although the majority of the blade tools were used to drill shell, both blade and flake bit-tools were used to perforate dry hide and to work bone and wood. Summaries of the morphological and functional tool comparisons are provided in Tables 20 and 22.

Of the 105 tools analyzed, 87 tools (83%) show identifiable wear traces resulting from intentional use. Of that total, 18 tools (21%) show signs of extensive use as observed by a high frequency of wear traces per tool, well-developed polishes, and alteration of the tool bit. Shell wear polishes were identified for 15 (83%) of the most intensively used tools. The more intensively used tools also tended to be retouched to a greater extent. For example, blade tools with minimal retouch tended to show less developed usewear traces than the more extensively retouched biconvex and cylindrical bit-tools. When the proportions of extensively used tools in the technological categories are examined for the 87 tools with use-related wear traces, blade tools show a higher proportion of intensive use (21%) compared to flake bit-tools (7%). On the whole, cylindrical bit-tools were the most intensively used group, with half of the 20 cylindrical tools exhibiting evidence of moderate to well-developed wear, in contrast to 8 (19%) of the 43 biconvex tools. Bit-tools with well-developed wear traces are shown in Figure 31.

Nearly 90% of the used tools with identifiable wear traces were used in single-action tasks, either boring or graving. There were only two cases of tools with evidence of both engraving and boring tasks. Boring actions are the predominant use-task represented, with three-fourths of the sample of 87 used tools showing rotary wear traces. Cylindrical microtools were used almost exclusively as

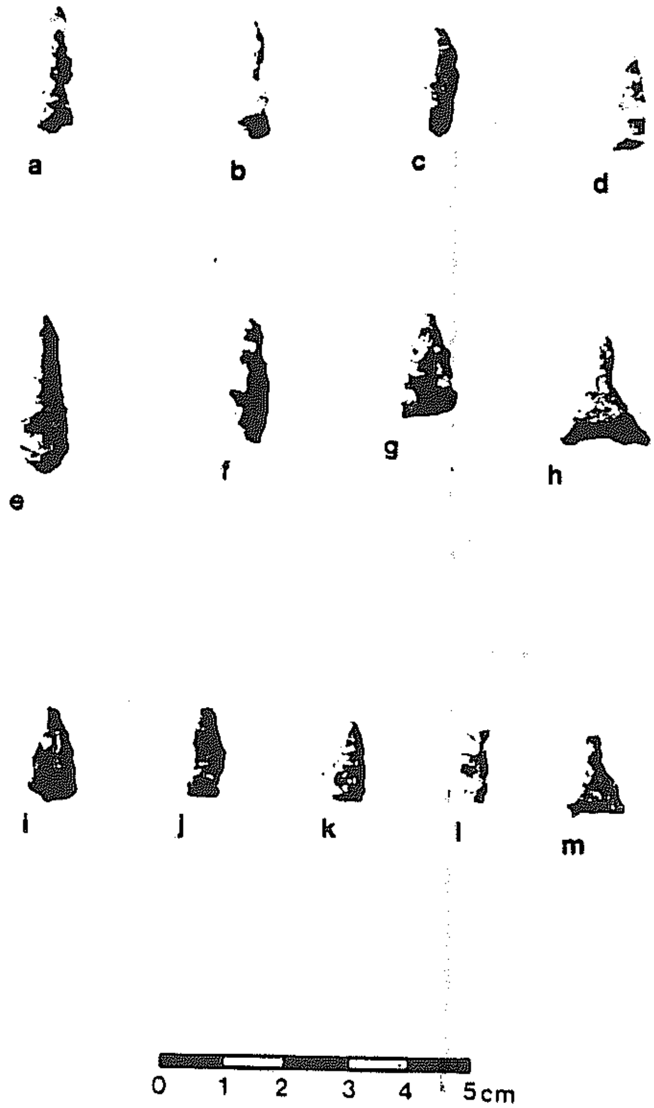

Figure 31. Examples of extensively worn shell-working bit-tools. a. Tu48-CBC, b. Tu398-3-1, c. Tu65-1-28, d. Ha8-233-1, e. Ha8-267-1, f. Tu66-45-16, g. Tu346-7-4, h. Tu66-31-11, i. Tu66-44-21, j. Ha8-209-1, k. Tu259-8-27, l. Tu259-12-26, m. Tu259-8-28.

drills; only two cylindrical tools were used as engraving tools. Although the sample is smaller, engraving tools tend to be more common among the biconvex blade bits and flake bit-tool types. Hide perforating tools were made from both blades and flakes.

Bit-tools were used predominantly, but not exclusively, on a single contact substance. A large proportion of the tools were used in single tasks involving shell (72%), and to a lesser extent bone (5%), and dry hide (3%). Multiple uses evidenced by overlapping wear traces occurred less frequently accounting for 19% of 87 used tools. Distributions of worked materials between the technological and morphological categories indicate more varied use-activities for the biconvex blade bit-tools. In addition to shell, blade bit-tools were used on other substances including bone, dry hide, and dry hide/wood. The hide-working tools were unifacially retouched. Two of the eleven flake bit-tools were used to perforate dry hide and dry hide/wood. Triangular bit-tools were used primarily as shell drills and engraving tools. In contrast, cylindrical bit-tools were used exclusively in shell-working activities, albeit two were used in overlapping activities involving bone and wood substances. The cylindrical tool used to work wood, in addition to shell, is morphologically distinct in that it has a nearly completely cylindrical cross-section (Figure 14:h). The morphological/ technological and functional tool attributes are summarized in Table 23.

In contrast to the more cylindrical-shaped bits of the stone drills, engraving and perforating tools tend to have either a flattened or triangular cross-section at the working end of the tool. These tools are characterized by either a unifacial or bifacial projection of variable length, width, and thickness (Figure 32). Hide-perforating tools are also morphologically distinct. The tool shown in Figure 32:d, has been steeply retouched along both edges, which have been blunted and rounded through use. In addition to a rounded, blunt projection, other hide-working tools have shorter unifacial projections similar to traditional graver-tool descriptions (Figure 32:1 and p).

Turning to the issue of duration of tool use, relatively longer tool use can be seen to characterize the more extensively retouched cylindrical and biconvex

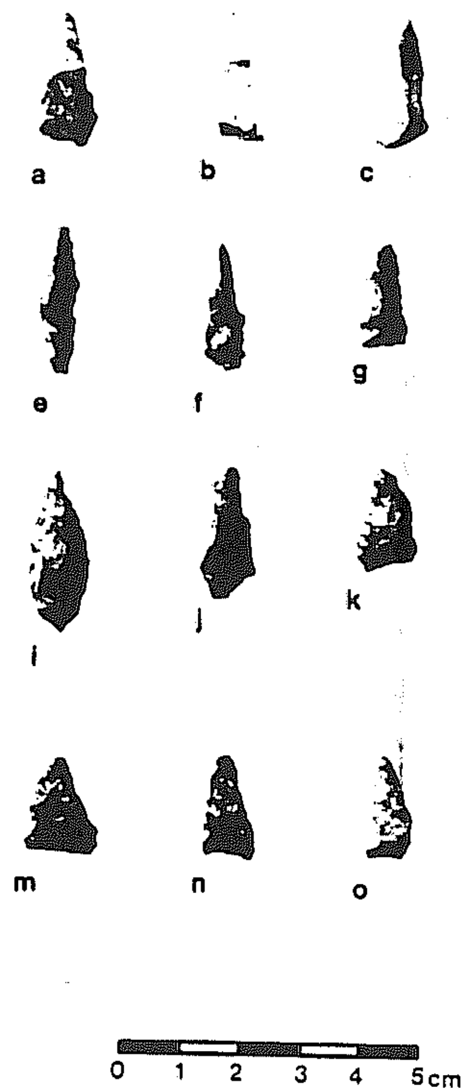

Figure 32. Examples of engraving and perforating tools.
a. Tu46-14-5, b. Tu66-15-3, c. Ha8-270-2, d. HaM6-19,
e. Ha92-32-19, f. Ha8-91-2, g. Ha92-11-21, h. Tu259-13-28,
i. Ha8-123-2, j. Tu259-5-20, k. Ha92-16-33, l. Tu66-16,
m. Tu46-14-2, n. Ha92-25-13, o. Ha92-31-15, p. Tu66-49-23.

microdrills. Gravers and perforators tend to show less extensive wear. Although most shell-working tools were used for short periods prior to breaking, 20% of the tools show signs of extended periods of use in shell-working activities. Tools involved in more than one task also show moderate to short use-duration.

This study has shown that the bit-tool technology in the Moundville region was used to bore shells. However, these tools were also used to engrave, bore and perforate bone, wood, and dry hide. One particular tool form, cylindrical bit-tools, were used most intensively to drill shell.

Spatial Distributions and Implications for the Social Context of Microtool Use

Up to this point I have focused on the technological and functional variability within the microlithic tool assemblage. Bit-tools in the Moundville region were manufactured from local chert resources. Cobbles were modified into cores from which blade-shaped flakes could be removed and used for the manufacture of small boring, engraving, and perforating tools. Results of the use-wear study have shown that these tools were used to manufacture items of bone, wood, hide, and shell. Drilling shell, most likely for the manufacture of beads and other ornaments, was the most frequent activity for which these tools were manufactured.

In order to address the social context of tool use within a community setting, I now turn to a discussion of the relationships between tool distributions, settlement patterns, and site formation processes in the local settlement region. The data from which the following discussion is based are summarized in Tables 24 and 25. Although the small size of the tool sample limits a rigorous study of spatial patterning, distributional data suggest that tool use was part of domestic productive activities.

A major contribution of the UMMA survey was to clarify the chronology, size, and organization of known Moundville phase settlements in a 25 km stretch north and south of the Moundville site. Spatial studies conducted subsequent to the survey have demonstrated that the majority of sites previously interpreted as large Moundville phase villages were actually scatters of West Jefferson phase ceramics (Bozeman 1982). Moundville phase sherd scatters, while in most cases overlapping with West Jefferson components, are

Table 24. Site Size and Artifact Frequencies for West Jefferson and Moundville Phase Sites

Site	Site Size (ha)	# Bit-tools	# Other Tools	#Grog Sherds	#Shell Sherds
1Tu66	2.6	37	519	17,324	288
1Tu259	.8	10	258	8631	90
1Ha92	1.5	16	435	7204	309
1Tu2	1.0	6	44	446	326
1Tu46	.8	3	26	140	29
1Ha107	.5	1	34	167	271
1Tu65	.3	2	56	1438	23
1Ha91	.6	-	22	38	223
1Tu56	.5	-	38	1028	41
1Tu64	.4	-	12	278	18
1Ha15	1.4	-	38	3151	441
1Tu42	2.4	-	119	3301	1674

Table 25. Artifact Densities per Grid Unit ($400m^2$) and Bit-tool/Grog Sherd ratios for West Jefferson and Moundville Phase Sites

Site	#Grog Sherds per 400 m^2	#Shell Sherds per 400 m^2	#Bit-tools Tools per 400 m^2	#Other Tools per 400 m^2	Bit-~~tool:~~ tool: Sherd Ratio
1Tu66	266.523	4.430	.569	7.984	.002
1Tu259	431.550	4.500	.500	12.900	.001
1Ha92	192.106	8.240	.426	11.600	.002
1Tu2	17.840	13.040	.240	1.760	.013
1Tu46	7.000	1.450	.150	1.300	.021
1Ha107	13.360	21.680	.080	2.720	.006
1Tu65	191.733	3.066	.266	7.466	.001
1Ha91	2.533	14.866	-	1.466	-
1Tu56	82.240	3.280	-	3.040	-
1Tu64	27.800	1.800	-	1.200	-
1Ha15	90.028	12.600	-	1.085	-
1Tu42	55.016	27.900	-	1.983	-

considerably less dense and more isolated. With the exclusion of 1Tu42, the mean sherd frequency for Moundville phase sites is only 188 sherds per site. This contrasts sharply with West Jefferson phase sherd scatters that are commonly in excess of 1000 sherds per site. Thus, in the Moundville region, as in other areas of Mississippian settlement, the majority of the late prehistoric population was dispersed into primarily horticultural rural communities, most likely consisting of nuclear or extended families. Archaeologically these settlements are referred to as "farmsteads" (Knight and Solis 1983; Peebles 1987; Mistovich 1988; Welch, in press).

While the settlement organization of Moundville phase components appears straightforward, West Jefferson phase settlements are somewhat more elusive. West Jefferson phase components occur throughout the valley, and there is quite a bit of variation in site size and density of debris scatters. Sites nearer the Fall Line, upstream from 1Tu66, are reported to cover between 3 and 5 ha (Alexander 1982:131). West Jefferson phase components south of the Fall Line in the vicinity of Moundville range in size from 0.3 to 2.6 ha. West Jefferson sites on the upper Cahaba

River and in the Bessemer area are generally small, less than 0.03 ha (Ensor 1979; Steponaitis 1983). The majority of West Jefferson sites in the Moundville vicinity range in size between 0.3 and 1.0 ha. The West Jefferson component at the Moundville site is estimated to cover between 0.5 and 1.5 ha (Walthall and Wimberly 1978:123; Steponaitis 1983:151-2). Of the 12 sites listed in Table 24, 8 are between 0.5 and 1.5 ha.

Excavation of outlying sites in the Moundville region consists of limited testing at a few West Jefferson phase sites. Data from this area, combined with data from the Tombigbee Valley, however, have determined Late Woodland and emergent Mississippian settlements to be of two general types: a) floodplain base camps or villages, and b) smaller transitory camps (Jenkins and Krause 1986; Welch, in press). In the central Tombigbee Valley, late Miller III sites have been interpreted to include both warm and cold season base camps, as well as smaller transient settlements. A trend towards nucleation of communities in these larger base camp settlements also occurs at this time (Jenkins and Krause 1986). Data from the Black Warrior

Valley, above the Fall Line, and from the Bessemer area, suggests that population density was low in these areas compared to the region south of the Fall Line and the central Tombigbee Valley (Welch, in press:46). Excavation and analysis of small West Jefferson sites in both areas have determined that these settlements were short-term seasonal reoccupations of the same floodplain localities (O'Hear 1975; Ensor 1979; Mistovich 1988; Welch, in press).

In a recent survey of archaeological data from the Tombigbee, Moundville, and Bessemer areas, Welch (in press:35) postulates the model size of West Jefferson communities in the Moundville region to be between 0.2 and 0.5 ha. Sites larger than 0.5 ha are interpreted as overlapping reoccupations of the same location, preferably a terrace above the mean annual flood level downstream from the Fall Line. Welch (ibid.:36) argues that these West Jefferson settlements most likely would have been abandoned during the flood season (late winter-early spring), at which time communities would have dispersed to smaller temporary sites on higher terraces or in the uplands. While such a scenario remains to be tested in the Moundville region, the available data on seasonality appear to support this pattern of settlement (Welch, in press). On the other hand, it is possible that West Jefferson sherd scatters between 0.5 and 2.0 ha, common in the Moundville region, may in some cases be larger villages rather than a conglomeration of overlapping occupations of smaller groups.

Returning to the settlement data in the Moundville region, we see that West Jefferson components were dispersed throughout the 25 km survey area north and south of Moundville. As shown in Tables 24 and 25, there is also quite a bit of variation in both the size and density of grog-tempered sherd scatters. Five sites fall within the model size range of West Jefferson communities as defined by Welch (in press). These sites range in size between 0.3 and 0.6 ha. Variation in ceramic densities between sites suggests that there are complexities in terms of the intensity and/or nature of settlement types. Given the present settlement model, low density sites such as 1Ha91, 1Ha107, 1Tu46, and 1Tu64, may represent a combination of short-term occupations, special purpose sites, and settlements reoccupied by a single extended or nuclear family. At 1Tu56, 80% of the sherds on the site surface are concentrated in an area covering only .12 ha. Such a small area of concentrated debris suggests a small cluster of structures, most likely representing a single household. The remaining 7 sites range between 0.8 and 2.6 ha. Following Welch's argument, these sites would be interpreted as reoccupations of a base camp settlement or village. Spatial distributions of sherds across these larger sites indicate that high density concentrations of debris generally cover an area no greater than 0.5 ha. Sites with both high and low density sherd scatters occur within this size range of West Jefferson components. Based on sherd densities, the most intensively occupied sites are 1Tu66, 1Tu259, and 1Ha92. These sites consist of continuous scatters of debris most likely resulting from a longer span of settlement and, consequently, a greater number of aggregate households. These sites would fall under the category of base camp/village. Sites with lower ceramic densities, such as 1Tu2 and 1Tu46, may represent short-term occupations by smaller groups. Two sites, 1Ha15 and 1Tu42, fall between the two extremes of high and low density sherd scatters.

To summarize, settlement data based on results of the UMMA survey have clarified the general nature of variation between West Jefferson and Moundville phase communities in the Black Warrior Valley. Moundville phase occupations are considerably less dense than the majority of West Jefferson phase components. While Moundville phase settlements appear to be isolated farmsteads scattered throughout the area, West Jefferson phase communities were more concentrated in larger base camps or villages. The degree to which such sites were occupied year-round, however, is not known. It is possible, based on the presence of low-density West Jefferson phase sites, that a settlement pattern of dispersed households, not unlike Moundville phase farmsteads, was also present during the preceding West Jefferson phase.

Turning to the distributiion of bit-tools between sites, we see from Table 24 that there is quite a range in tool counts between sites. In order to interpret the nature of this variability I have examined relationships between bit-tool frequencies and West Jefferson component size and density. Component density at a given site is interpreted here as the intensity of site occupation and is measured by the number of grog tempered sherds per 400 m^2, the size of the gridded collection units.

In view of the present interpretation of West Jefferson phase community organization, one would expect to find differences in artifact frequencies between sites based, in part, on the duration of site occupation over time and/or the number of aggregate households that occupied a given location. If certain sites, such as base camps or villages, were occupied by a larger aggregate population over time, one would expect to find a greater density of everyday domestic debris at these sites. Indeed, this pattern is suggested by the relationships between variables of bit-tool frequency, settlement size, and component density. For example, when bit-tool frequency is plotted against site size, as shown in Figure 33, we see a strong positive association between these variables (Pearsons r = 0.980). Likewise, when ceramic density is plotted aganist bit-tool density, (Figure 34), a strong positive association is also suggested (Pearsons r = 0.854).

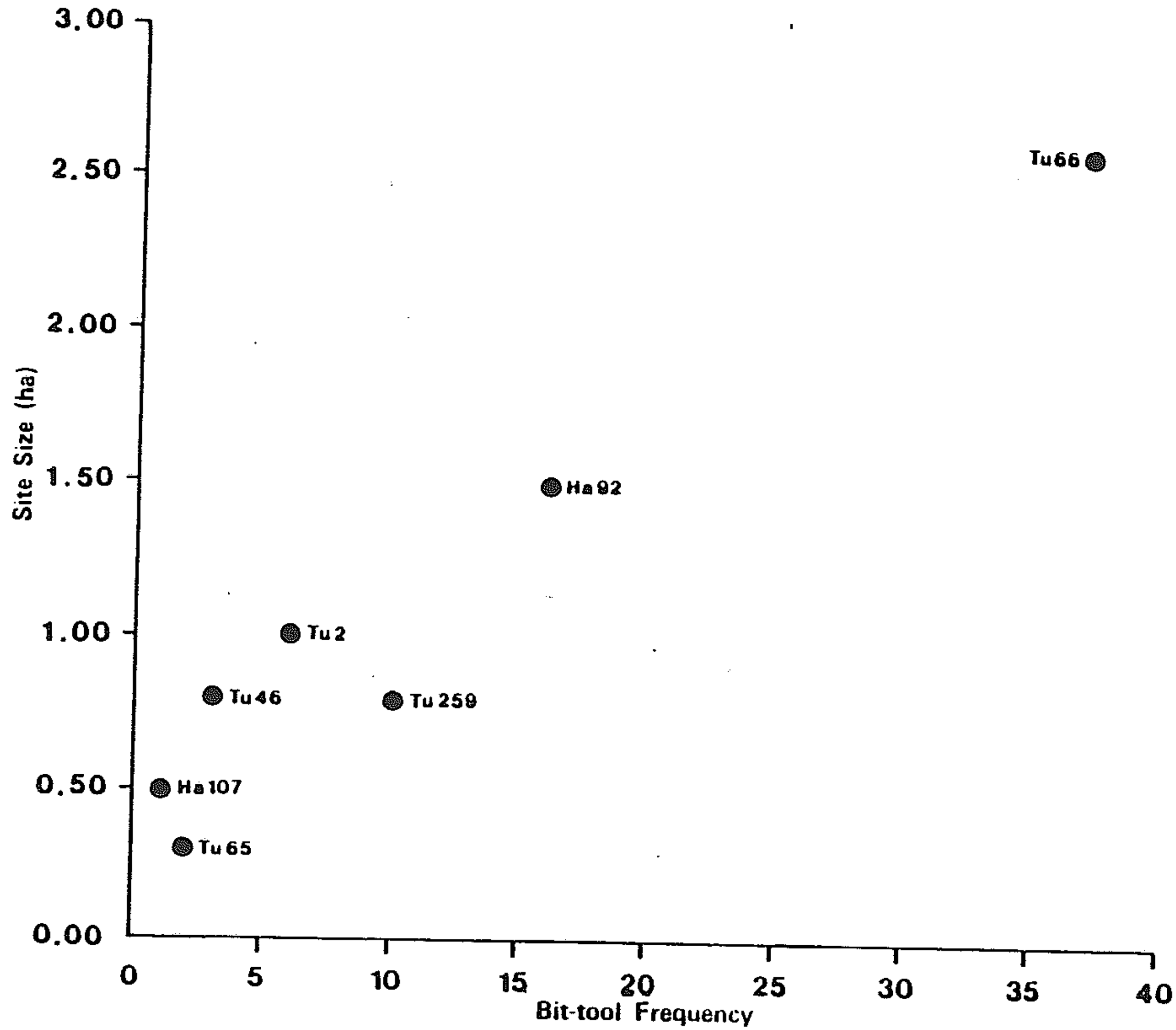

Figure 33. Scatter plot of site size versus bit-tool frequency for Moundville area sites.

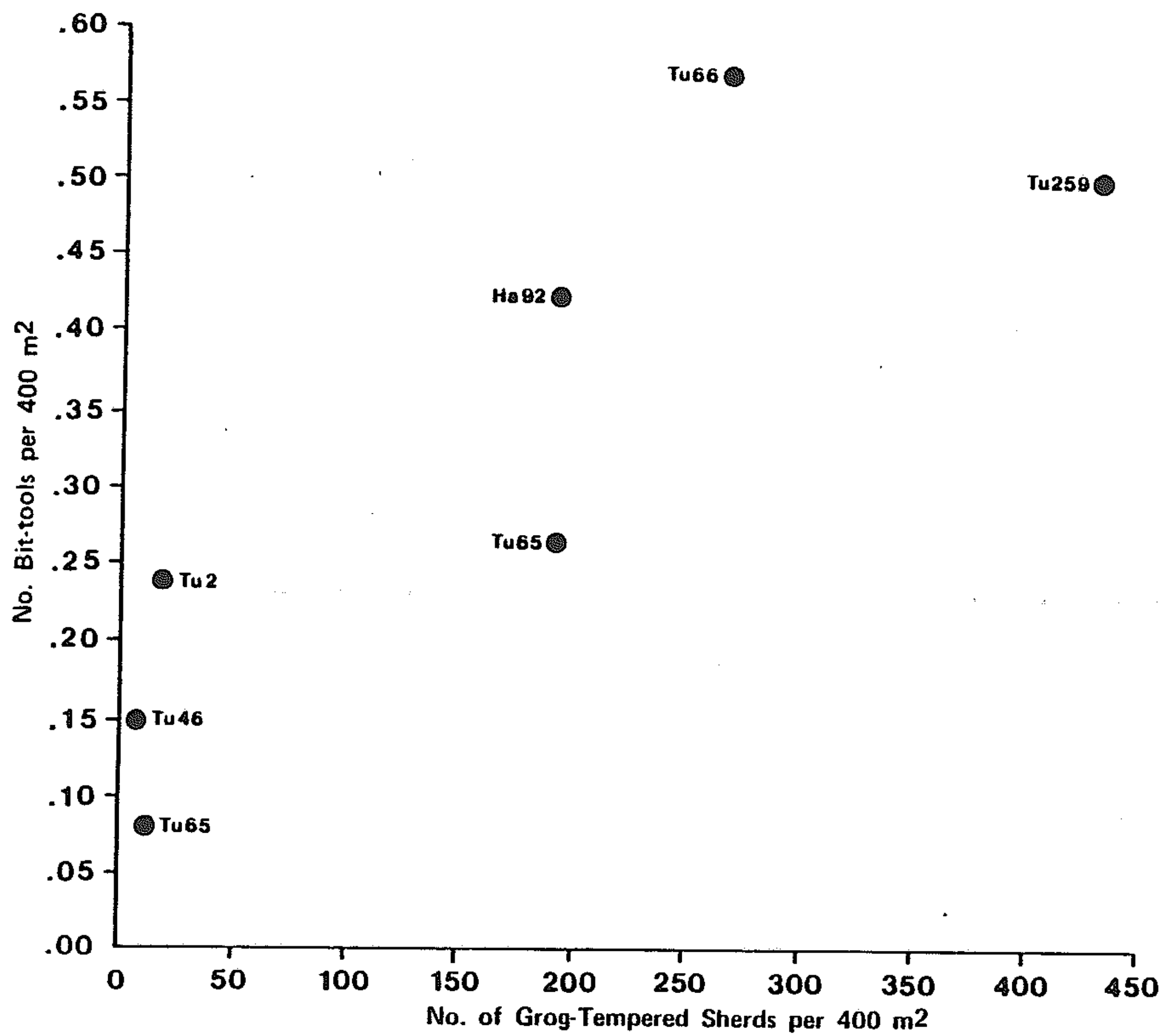

Figure 34. Scatter plot of grog-tempered ceramic density versus bit-tool density for Moundville area sites.

Both site size and component density appear to be factors affecting variation in bit-tool distributions between sites where such tools are found. The greatest concentrations of bit-tools are at sites interpreted as base camps or villages such as 1Tu66, 1Tu259, and 1Ha92. These sites also have higher densities of other chipped stone tools (8.0, 13.0, and 12.0), compared to sites interpreted as shorter term occupations with tool densities ranging between 1 and 3 tools per 400 m^2. In addition, the uniform proportions of bit-tools to sherds at these larger base camp/village sites suggests that the use of these tools occurred at a more-or-less constant rate. Bit-tools are also dispersed across site areas. With the exception of 4 bit-tools recovered from a single grid unit at 1Tu259, bit-tools were found in 40% to 60% of the 20 x 20 m grid units at these larger sites with 100 or more West Jefferson phase sherds. The presence of bit-tools, albeit in smaller numbers, at settlements occupied either for a shorter period of time, or by a smaller number of aggregate households, suggests that the same productive activities occurred at these sites as at the larger settlements.

These data, taken together, can be interpreted as suggesting that activities involving the use of bit-tools were common among the majority of West Jefferson phase settlements in the Moundville region. As expected, those settlements occupied by a greater number of aggregate households, most likely larger base camps or villages, produced the greater number of these tools. Moreover, the ratio of bit-tools to sherds among these larger sites suggests that activities involving the use of bit-tools occurred at a more-or-less constant rate, a pattern expected for productive activities taking place in a domestic social context.

While the preceding discussion has focused on sites where bit-tools have been found, such tools were not present on all of the sites surveyed. Sites lacking bit-tools vary in the size and intensity of settlement occupation, and in some cases overlap with certain low-density West Jefferson sites where bit-tools were found. However, these sites also tend to have low densities (1.2, 3.0) of other chipped stone tools, suggesting a more restricted range of activities. Nonetheless the absence of bit-tools at certain settlements indicates that the use of these tools was not evenly distributed within this region of the valley, especially among settlements occupied by a smaller aggregate population or for a shorter period of time.

In summary, a number of factors, including household size, settlement size, duration of site occupation, and temporal variation are most likely linked to the distribution of bit-tools between sites. Thus, any interpretation of these data must be viewed as tentative at best. However, given the nature of Late Woodland and emergent Mississippian phase settlements in the Black Warrior Valley and neighboring regions, the distribution of bit-tools between sites suggests that such tools were commonly used in everyday productive activities. These activities occurred with greater frequency or regularity at base camps or villages that housed a greater aggregate population during this time period. In addition, shell-working tools account for under half of the used bit-tools at 1Tu66 and 1Ha92, suggesting that bit-tool use was more varied at these settlements. On the other hand, all of the bit-tools with identifiable wear traces were used in shell-working activities at 1Tu259. The somewhat more concentrated distribution of bit-tools, also at 1Tu259, may indicate a greater focus on shell-working at this particular settlement.

CHAPTER V

CONCLUSION

The intent of the preceding chapters has been to examine the classification, chronology, technology, use, and social context of a microtool assemblage from sites in the Moundville area. The artifactual evidence documenting a microlithic industry in this region of Mississippian settlement has been presented. Functional and technological studies were undertaken in order to link tool technology and use. This has been done as a first stage in the recognition and description of a particular technology within a regional framework. It is now possible to bring together these various lines of evidence, and in so doing, present a more complete picture of this technology in the Moundville region.

Microtool industries in the Southeast combine both flake and blade tools, the production of which is based on local raw materials. In the Moundville region, microtools include small flake and blade bit-tools designed for use as perforators, drills, and engraving tools. The production of blade-bit tools can be interpreted as specialized in a technical sense, in that a specific core technology was required to produce a desired tool blank, the formal design of which was prescribed by functional criteria. Small flake-tools, including bit-tools, used in everyday domestic productive contexts, were common among late prehistoric stone technologies throughout the Southeast. Morphological variation within the Black Warrior Valley assemblage can be related to manufacturing strategies and intended tool use. Although certain implements were stylistically and functionally similar, some tools were made on flakes, and others on blades. This variability within the tool class is only understood when links between technology and function are examined within the larger technological context of which the tools are a part.

Archaeological evidence in other regions of

Mississippian settlement suggest a direct relationship between microlithic industries and the manufacturing of shell beads at a time when Mississippian polities were emerging (Yerkes 1983; Morse 1974). Steponaitis (1986a:392) has noted that it is probably not coincidental that microtools, abraders, and shell manufacturing debris are most prevalent at this time. Shell beads are commonly found in burials of people of all ages during the earlier part of the Late Woodland period in the Southeast. It is also not a coincidence that blade-tool technologies in Eastern Woodlands prehistory correspond to periods of increasing social complexity. During these periods, demand for material objects, and a general increase in productive and ritual activities would have required changes in stone tool technologies, of which blade tools were most likely a part. In both the Late Archaic and early Mississippian periods, an increasing frequency and restriction within the population of marine shell beads is documented in the archaeological record (Winters 1968; Peebles 1987). Strings of shell beads found in Moundville phase burials peak between A.D.1050 and 1250 (Peebles 1987:Figure 6). Microtools in the Moundville region appear to be most prevalent during the West Jefferson phase, immediately preceding the Mississippian emergence in this area.

This study has shown that the bit-tools from the Moundville area were used to drill and engrave shell and bone, to drill wood, and perforate dry hide. Blade bit-tools were used primarily in shell-drilling activities, especially the more cylindrically-shaped tools. Thus, consistent with data from the Cahokia region, the Moundville area microtool industry was used to manufacture shell goods. The fact that these tools were also used to work other materials suggests that they were not restricted to a single productive context. On the other hand, the use of bit-tools in shell-working activities does emphasize the importance of shell items, most likely beads, among the emergent Mississippian communities in the Moundville region.

Microlithic bit-tools made on flakes and blades are found among stone tool assemblages from Late Woodland sites in the Tennessee drainage, late Miller III sites in the central and upper portions of the Tombigbee drainage, and West Jefferson sites north and south of the Fall Line in the Black Warrior Valley. The widespread distribution of these tools at a number of settlements suggests that the productive activities requiring their use were common among Late Woodland populations in this region of the Southeast. Survey and excavation of sites in the Black Warrior Valley have recovered bit-tools in the lithic assemblages from small settlements as well as larger base camps or villages that were occupied on a more permanent basis. In the Moundville area, productive activities involving bit-tools occurred more regularly at larger base camps or villages. It is at these larger settlements that we find a greater diversity and density of chipped stone tools in general, including bit-tools. Bit-tools are also present at smaller settlements and low-density sites. However, the frequency with which these tools occur is not as constant as for the larger, more densely populated settlements. A single blade bit-tool was recovered at a small West Jefferson phase site north of the Fall Line in the Cahaba drainage (1Je34) (Ensor 1979:17, Figure 11). The majority of microtools recovered in the central Tombigbee Valley are from the Lubbub archaeological locality. Microtools, blades, and cores were found at the site 1Pi33, where the industry dates to the late Miller III component (Ensor 1981). At 1Pi33, 89 bit-tools were found together with shell debris in one fill layer of a large refuse pit (Ensor 1981). Unfinished bit-tools were also reported to have been found with an adult male burial from the subsequent early Mississippian Summerville component in this area (Ensor 1981, 1984).

It is probably not inconsequential that a microlithic industry is present in a late Miller III context in an area of early Mississippian emergence in the central Tombigbee Valley. Similarly, a microlithic industry in the Moundville area during the West Jefferson phase further supports the connection between this technology and shell bead manufacturing at a time when Mississippian polities were emerging.

A similar trend is documented in the Cahokia area where microtools are reported from a number of early Mississippian Lohmann phase sites (A.D. 900 to 1050). Microtools in this region are found in domestic household contexts at scattered early Mississippian farmsteads, as well as larger mound center settlements (Yerkes 1984). In the subsequent Stirling phase (A.D.1050-1150), the frequency of microtool finds is reported to decrease in the American Bottom. These tools continue to occur at smaller outlying sites in the bottoms as well as the uplands. However, there is an apparent increase in the frequency of microtools at mound center sites such as Cahokia, Mitchell, and the BBB Motor site (Yerkes 1984:19-22). Concentrations of larger numbers of microlithic tools and debris at these mound center sites may be related to increased activities involving the production of shell beads and other ornaments at these locations, especially if the procurement of marine shell was restricted to mound center elites. On the other hand, a greater concentration of the population at these sites may also explain the increase in microtools found at mound center/temple towns on the American Bottom. The use of the same raw material, tabular Crescent Quarry chert, for the production of microtools at early Mississippian mound center sites at Cahokia, Zebree, and Carson Mound may be of relevance to a nondomestic production context at these sites. A greater number of tools per core could be produced using this material, which was exported from the Cahokia region to other mound center settlements in the Mississippi Valley.

In the Southeast, shell manufacturing debris was found in an elite residence at the early Mississippian mound center site of Cemochechobee (Schnell et al. 1981). It is perhaps noteworthy that microlithic tools have not been found at early Mississippian nonmound villages in the Tombigbee region, such as the Kellogg and Tibbee Creek sites (Atkinson et al. 1980; O'Hear 1981). Individuals buried in village cemeteries at these two sites, however, were found with both freshwater and marine shell beads. This variability suggests that bit-tool use may have occurred more frequently at mound center sites during the early Mississppian period, rather than at smaller farmstead settlements. The single conical blade core from the Moundville I site, 1Tu50, may be further evidence of this trend.

The results of the present study have documented a microlithic industry, including both flake and blade bit-tools, as part of the local stone technology of West Jefferson communities in the Moundville region. These implements were used primarily to drill shell, but other productive uses are also evidenced. Implements classified as bit-tools were found to occur most frequently at large base camps or villages, and less frequently at smaller, less intensively occupied sites. Based on the present evidence, there is no reason to suspect that productive activities involving this technology were organized at a scale beyond domestic production. The distribution of bit-tools at a number of Late Woodland sites in the Tombigbee and Tennessee drainages attests to the common use of these tools at this time. The importance of one particular item, shell beads, is also attested to by the increasing frequency of tool production and use in emergent and early Mississippian times, such as in the Lubbub and Moundville areas. The microlithic industry at larger mound centers such as Cahokia and Zebree best exemplify the changes in the organization of microtool technology most likely due to an increasing demand for shell beads at this time.

APPENDIX A

APPENDIX A.

Metrical and Nonmetrical Attributes of the Microlithic Industry

The following tables A.1 through A.7 include all lithic materials examined in the course of this study. Table A.1 contains attributes of the blade core sample, Table A.2, contains attributes of the blade sample, Table A.3 contains attributes of the unfinished bit-tools, and Tables A.4 through A.7 contain all attributes measured on the bit-tool sample. The first two to three columns of each table contain artifact identification information including site number, field specimen number (FSM), and catalogue number. A key is provided on the preceding page for each table.

Table A.1 Key

BRLF - length of blade removal face

ANGLEP - platform angle

COREFRAG - core fragment

PLTFREM - platform rejuvenation flake

Table A.1. Blade Core Attributes

OBS	SITE	FSM	SHAPE	WEIGHT	LENGTH	WIDTH	THICKNESS	BRFL	ANGLEP
1	HA15	21	AMORPHOUS	29.2	44.3	27.6	22.0	17.4	82
2	HA15	8	COREFRAG	6.7	.	.	.	.	82
3	HA15	2	COREFRAG	6.4	.	.	.	.	83
4	HA7	46	COREFRAG	2.9	.	.	.	.	84
5	HA92	22	AMORPHOUS	27.4	44.8	29.9	23.0	43.1	.
6	HA92	2	AMORPHOUS	7.2	21.1	20.0	14.4	17.4	83
7	HA92	5	AMORPHOUS	23.8	41.8	26.5	21.4	31.6	81
8	HA92	17	AMORPHOUS	13.5	37.2	30.2	13.0	33.7	80
9	HA92	33	AMORPHOUS	27.6	45.3	32.8	21.3	25.1	90
10	HA92	18	AMORPHOUS	6.3	29.2	22.4	13.8	18.1	90
11	HA92	16	CONICAL	12.0	30.5	26.6	19.2	19.5	90
12	HA92	45	CONICAL	8.2	30.2	27.9	15.2	25.2	86
13	HA92	37	COREFRAG	3.5	.	.	.	.	.
14	HA92	3	COREFRAG	10.3	.	.	.	.	87
15	HA92	32	COREFRAG	5.6	.	.	.	.	89
16	HA92	9	COREFRAG	5.9	.	.	.	.	92
17	HA92	2	DISCOIDAL	8.7	34.4	21.9	17.7	16.0	85
18	HA92	32	PLTFREM	10.1	.	.	.	.	84
19	HA92	21	PLTFREM	3.2	.	.	.	.	82
20	HA92	11	RECTANGLE	10.1	30.7	24.2	15.0	20.0	90
21	TUM2	1	COREFRAG	5.7	.	.	.	.	86
22	TUM2	1	RECTANGLE	10.1	24.0	23.4	17.5	24.1	90
23	TUM7	5	AMORPHOUS	15.1	30.0	27.5	20.0	22.3	90
24	TU2	21	AMORPHOUS	20.1	41.0	21.5	18.2	40.4	83
25	TU2	6	COREFRAG	3.6	.	.	.	.	67
26	TU2	35	COREFRAG	5.4	.	.	.	.	86
27	TU259	9	CONICAL	8.5	30.0	23.0	13.9	24.0	79
28	TU259	16	DISCOIDAL	18.6	41.3	26.9	22.8	22.3	80
29	TU259	14	DISCOIDAL	19.5	39.2	29.5	19.6	20.6	87
30	TU262	.	PLTFREM	2.9	.	.	.	.	91
31	TU42	29	AMORPHOUS	8.3	28.2	19.3	13.3	26.8	89
32	TU42	66	AMORPHOUS	11.8	29.1	24.8	19.1	28.7	87
33	TU42	51	CONICAL	6.2	25.5	22.1	13.2	17.2	85
34	TU42	49	COREFRAG	9.2	.	.	.	.	87
35	TU42	50	COREFRAG	3.0	.	.	.	.	.
36	TU42	58	PLTFREM	3.4	.	.	.	.	90
37	TU50	124	CONICAL	7.4	29.3	27.2	12.5	19.2	73
38	TU56	22	DISCOIDAL	5.4	25.7	17.4	11.1	23.5	78
39	TU56	29	PLTFREM	3.7	.	.	.	.	72
40	TU59		AMORPHOUS	10.6	37.8	26.0	12.9	15.9	79
41	TU64	9	COREFRAG	6.0	.	.	.	.	.

(continued)

Table A.1 (continued)

OBS	SITE	FSM	SHAPE	WEIGHT	LENGTH	WIDTH	THICKNESS	BRFL	ANGLEP
42	TU66	40	AMORPHOUS	10.6	31.9	22.2	18.3	22.0	78
43	TU66	30	AMORPHOUS	16.0	34.7	23.3	20.3	23.1	90
44	TU66	31	AMORPHOUS	9.8	28.5	28.0	15.4	19.3	80
45	TU66	51	AMORPHOUS	26.7	33.5	31.1	24.6	23.7	90
46	TU66	42	AMORPHOUS	8.5	26.0	21.9	18.3	22.1	90
47	TU66	14	AMORPHOUS	13.0	32.1	20.4	14.6	32.2	90
48	TU66	40	CONICAL	10.1	29.0	25.2	14.9	24.3	90
49	TU66	69	CONICAL	5.1	24.9	23.4	10.1	17.2	90
50	TU66	69	COREFRAG	5.3	25.3	19.0	14.6	21.1	90
51	TU66	47	COREFRAG	4.4	.	.	.	.	.
52	TU66	68	COREFRAG	4.3	.	.	.	.	76
53	TU66	14	COREFRAG	2.4	.	.	.	.	.
54	TU66	31	COREFRAG	6.1	.	.	.	.	81
55	TU66	30	COREFRAG	1.9	.	.	.	.	79
56	TU66	20	COREFRAG	5.7	.	.	.	.	77
57	TU66	65	COREFRAG	5.6	.	.	.	.	82
58	TU66	17	DISCOIDAL	20.7	44.3	27.9	17.0	31.4	85
59	TU66	70	DISCOIDAL	23.8	42.2	26.7	20.7	21.5	90
60	TU66	31	PLTFREM	13.1	.	.	.	.	98
61	TU66	45	PLTFREM	3.6	.	.	.	.	89
62	TU66	42	PLTFREM	5.1	.	.	.	.	83
63	TU66	16	WEDGE	8.9	28.7	21.1	17.8	22.1	90

Table A.2 Key

XSECT - medial cross-section

THICKNESS - thickness

WDTH - width/thickness

LWD - length/width

COND - breakage condition:

Codes for Condition and Cortex Attributes:

C - complete

M - medial

P - proximal

D - distal

R - right side of blade

L - left side of blade

Codes for Cross-section Attributes:

TRI - triangular

TRA - trapezoidal

IRR - irregular (more than two dorsal ridges)

Table A.2. Blade Attributes

OBS	SITE	FSM	COND	CORTEX	XSECT	LENGTH	WIDTH	THICKNES	WDTH	LWD
1	HAM1	21	C	ABSENT	IRR	21.0	9.3	1.6	5.81250	2.25806
2	HAM1	32	C	PD	TRI	22.7	10.5	6.0	1.75000	2.16190
3	HAM1	5	MD	ABSENT	TRI	28.8	7.4	3.0	2.46667	3.89189
4	HAM1	26	PM	ABSENT	TRI	16.6	8.6	2.8	3.07143	1.93023
5	HAM1	12	PM	PM	TRI	26.9	10.3	3.5	2.94286	2.61165
6	HAM8	3	C	PMDL	TRI	20.8	10.7	3.2	3.34375	1.94393
7	HAM8	10	C	M	TRI	22.9	8.4	4.2	2.00000	2.72619
8	HAM8	8	PM	P	TRI	14.3	5.7	2.4	2.37500	2.50877
9	HA15	5	C	P	TRI	20.7	10.4	5.8	1.79310	1.99038
10	HA15	25	C	PMDL	TRI	24.6	11.1	3.6	3.08333	2.21622
11	HA15	22	C	PMD	CONVEX	18.8	8.4	2.4	3.50000	2.23810
12	HA15	25	C	D	TRI	17.5	4.5	2.7	1.66667	3.88889
13	HA15	22	MD	ABSENT	TRI	15.9	10.2	3.4	3.00000	1.55882
14	HA15	22	MD	ABSENT	TRI	15.0	7.4	1.8	4.11111	2.02703
15	HA7	49	C	PMDL	TRI	18.3	7.0	2.3	3.04348	2.61429
16	HA7	24	C	ABSENT	TRI	20.0	8.0	4.1	1.95122	2.50000
17	HA7	46	C	PM	TRI	18.3	6.7	4.2	1.59524	2.73134
18	HA7	49	C	ABSENT	TRA	13.0	5.4	1.9	2.84211	2.40741
19	HA7	49	C	ABSENT	TRI	16.2	8.4	1.9	4.42105	1.92857
20	HA7	46	C	D	IRR	12.2	6.1	1.1	5.54545	2.00000
21	HA7	50	C	D	TRI	17.0	10.1	3.3	3.06061	1.68317
22	HA7	25	C	ABSENT	TRI	15.7	9.1	2.1	4.33333	1.72527
23	HA7	50	C	PMD	CONVEX	20.1	9.4	3.4	2.76471	2.13830
24	HA7	33	C	PMDR	TRA	17.5	10.3	2.4	4.29167	1.69903
25	HA7	50	C	D	TRI	17.2	7.5	2.8	2.67857	2.29333
26	HA7	33	C	PD	TRI	18.6	9.0	3.7	2.43243	2.06667
27	HA7	26	C	D	TRI	24.7	8.4	3.1	2.70968	2.94048
28	HA7	33	C	PMD	TRI	21.1	7.3	3.1	2.35484	2.89041
29	HA7	47	C	PMD	TRI	17.2	6.9	2.5	2.76000	2.49275
30	HA7	46	C	D	TRI	17.0	8.5	2.9	2.93103	2.00000

(continued)

Table A.2 (continued)

OBS	SITE	FSM	COND	CORTEX	XSECT	LENGTH	WIDTH	THICKNESS	WDTH	LWD
31	HA7	50	M	M	TRI	15.3	7.4	2.6	2.84615	2.06757
32	HA7	50	MD	MD	TRA	16.5	10.2	3.5	2.91429	1.61765
33	HA7	2	MD	MD	CONVEX	17.2	6.4	2.0	3.20000	2.68750
34	HA7	49	MD	M	TRI	16.7	6.4	3.5	1.82857	2.60937
35	HA7	49	P	ABSENT	TRI	9.0	6.2	2.2	2.81818	1.45161
36	HA7	33	P	ABSENT	TRA	8.4	6.9	1.7	4.05882	1.21739
37	HA7	38	PM	ABSENT	TRA	14.5	8.0	3.5	2.28571	1.81250
38	HA7	49	PM	P	TRI	11.8	6.1	1.7	3.58824	1.93443
39	HA7	46	PM	PM	TRI	16.1	7.1	3.1	2.29032	2.26761
40	HA7	49	PM	PM	TRA	13.0	7.2	2.3	3.13043	1.80556
41	HA7	50	PM	ABSENT	TRI	14.2	6.0	2.2	2.72727	2.36667
42	HA8	3	C	D	TRI	16.0	7.4	2.6	2.84615	2.16216
43	HA92	8	C	ABSENT	TRI	25.7	8.2	3.4	2.41176	3.13415
44	HA92	22	C	D	TRA	22.2	7.5	3.0	2.50000	2.96000
45	HA92	37	C	PMDR	TRI	20.1	7.5	3.8	1.97368	2.68000
46	HA92	11	C	PMDL	TRI	16.6	8.0	2.1	3.80952	2.07500
47	HA92	32	C	MDL	TRI	24.3	10.0	2.6	3.84615	2.43000
48	HA92	38	C	MDL	TRI	20.7	10.5	2.6	4.03846	1.97143
49	HA92	8	C	ABSENT	TRI	16.6	7.9	2.0	3.95000	2.10127
50	HA92	1	C	PMDL	TRI	23.5	8.7	2.8	3.10714	2.70115
51	HA92	21	C	PMDL	TRI	20.2	8.6	5.0	1.72000	2.34884
52	HA92	31	C	MDR	TRI	21.5	9.9	2.7	3.66667	2.17172
53	HA92	33	C	D	TRI	19.6	8.7	3.0	2.90000	2.25287
54	HA92	38	C	D	TRI	17.4	8.3	2.6	3.19231	2.09639
55	HA92	8	C	ABSENT	TRI	18.1	6.6	2.2	3.00000	2.74242
56	HA92	40	C	PMDL	TRI	18.3	10.3	2.9	3.55172	1.77670
57	HA92	45	C	PMD	CONVEX	28.2	12.6	4.4	2.86364	2.23810
58	HA92	38	C	D	TRI	16.7	8.3	2.2	3.77273	2.01205
59	HA92	20	C	PMD	TRI	21.8	11.0	4.3	2.55814	1.98182
60	HA92	40	C	PMDR	TRI	18.4	8.8	3.2	2.75000	2.09091

(continued)

Table A.2 (continued)

OBS	SITE	FSM	COND	CORTEX	XSECT	LENGTH	WIDTH	THICKNES	WDTH	LND
91	HA92	14	C	ABSENT	TRI	18.8	8.3	2.8	2.96429	2.26506
92	HA92	8	C	MDL	TRI	14.7	7.5	1.9	3.94737	1.96000
93	HA92	36	C	PM	TRI	20.3	6.1	3.5	1.74286	3.32787
94	HA92	26	C	ABSENT	TRI	15.8	7.2	2.7	2.66667	2.19444
95	HA92	16	C	D	TRI	15.2	6.5	1.9	3.42105	2.33846
96	HA92	5	C	D	TRI	14.1	8.0	1.8	4.44444	1.76250
97	HA92	10	C	MD	TRI	17.3	8.6	2.5	3.44000	2.01163
98	HA92	21	C	ABSENT	TRI	16.4	6.8	2.0	3.40000	2.41176
99	HA92	7	C	ABSENT	TRI	13.9	5.8	1.0	5.80000	2.39655
100	HA92	40	C	ABSENT	TRI	19.1	8.9	2.6	3.42308	2.14607
101	HA92	16	C	ABSENT	TRI	17.2	7.4	2.5	2.96000	2.32432
102	HA92	5	C	PMD	TRI	15.6	7.1	2.3	3.08696	2.19718
103	HA92	1	C	ABSENT	TRI	21.3	8.7	3.3	2.63636	2.44828
104	HA92	11	C	PMDR	TRI	17.0	8.4	1.9	4.42105	2.02381
105	HA92	43	C	PMDR	TRI	13.2	6.4	1.6	4.00000	2.06250
106	HA92	10	C	P	TRI	17.4	7.4	2.6	2.84615	2.35135
107	HA92	10	C	ABSENT	TRI	18.0	7.5	2.9	2.58621	2.40000
108	HA92	9	C	D	TRI	15.8	5.0	2.4	2.08333	3.16000
109	HA92	2	C	ABSENT	TRI	15.1	7.7	2.0	3.85000	1.96104
110	HA92	14	C	ABSENT	TRI	17.7	7.9	3.1	2.54839	2.24051
111	HA92	2	C	ABSENT	TRI	13.1	5.3	1.4	3.78571	2.47170
112	HA92	38	C	ABSENT	TRI	20.1	9.9	4.0	2.47500	2.03030
113	HA92	38	C	PMDR	CONVEX	21.3	9.1	3.0	3.03333	2.34066
114	HA92	10	C	ABSENT	TRI	19.3	7.8	3.0	2.60000	2.47436
115	HA92	38	C	D	TRI	24.1	10.8	2.8	3.85714	2.23148
116	HA92	12	C	ABSENT	TRI	18.5	8.7	3.2	2.71875	2.12644
117	HA92	21	C	PMD	TRI	26.4	12.6	2.7	4.66667	2.09524
118	HA92	38	C	MDR	TRA	16.4	8.2	3.1	2.64516	2.00000
119	HA92	14	C	PMD	TRI	20.7	10.1	4.4	2.29545	2.04950
120	HA92	37	C	ABSENT	IRR	20.2	9.4	2.5	3.76000	2.14894
121	HA92	3	C	PMD	CONVEX	19.7	7.7	3.3	2.33333	2.55844
122	HA92	3	C	PD	TRA	20.7	9.1	3.3	2.75758	2.27473
123	HA92	11	C	D	TRI	22.3	7.3	3.7	1.97297	3.05479
124	HA92	11	C	ABSENT	TRI	27.5	6.5	2.3	2.82609	4.23077

(continued)

Table A.2 (continued)

OBS	SITE	FSM	COND	CORTEX	XSECT	LENGTH	WIDTH	THICKNES	WDTH	LWD
61	HA92	42	C	PMDR	TRI	19.8	9.1	4.2	2.16667	2.17582
62	HA92	36	C	D	TRI	14.2	8.2	2.0	4.10000	1.73171
63	HA92	14	C	PMDL	TRI	21.2	9.8	3.8	2.57895	2.16327
64	HA92	42	C	ABSENT	TRI	19.9	7.4	2.3	3.21739	2.68919
65	HA92	8	C	P	TRI	18.4	8.8	2.9	3.03448	2.09091
66	HA92	32	C	PMD	CONVEX	16.9	9.1	2.5	3.64000	1.85714
67	HA92	36	C	ABSENT	TRI	16.2	9.9	2.3	4.30435	1.63636
68	HA92	14	C	D	TRI	22.5	9.3	3.8	2.44737	2.41935
69	HA92	21	C	PMDR	TRI	15.8	7.3	2.5	2.92000	2.16438
70	HA92	45	C	MDR	TRA	17.7	9.1	2.5	3.64000	1.94505
71	HA92	35	C	D	TRI	19.2	10.3	4.0	2.57500	1.86408
72	HA92	22	C	D	TRI	15.5	8.0	2.4	3.33333	1.93750
73	HA92	11	C	P	TRI	16.4	7.4	2.3	3.21739	2.21622
74	HA92	40	C	MDR	TRA	18.7	8.2	2.6	3.15385	2.28049
75	HA92	23	C	PMD	CONVEX	18.1	7.0	1.7	4.11765	2.58571
76	HA92	8	C	PD	TRI	20.3	9.4	3.4	2.76471	2.15957
77	HA92	11	C	PMDL	TRA	13.6	5.7	1.6	3.56250	2.38596
78	HA92	22	C	D	TRI	17.0	10.2	2.3	4.43478	1.66667
79	HA92	43	C	PMDR	TRI	16.3	8.1	3.5	2.31429	2.01235
80	HA92	43	C	PMDL	TRI	18.5	7.1	1.7	4.17647	2.60563
81	HA92	43	C	D	TRI	15.1	5.0	2.4	2.08333	3.02000
82	HA92	22	C	PMDR	TRI	15.5	7.4	3.1	2.38710	2.09459
83	HA92	37	C	PMDR	TRI	16.8	8.3	3.2	2.59375	2.02410
84	HA92	25	C	PMDL	TRI	18.1	9.6	3.8	2.52632	1.88542
85	HA92	37	C	ABSENT	TRI	13.1	8.2	1.3	6.30769	1.59756
86	HA92	11	C	ABSENT	TRI	13.5	6.9	1.7	4.05882	1.95652
87	HA92	39	C	ABSENT	TRA	16.4	9.6	2.3	4.17391	1.70833
88	HA92	43	C	D	TRI	17.7	8.5	3.5	2.42857	2.08235
89	HA92	32	C	ABSENT	TRA	13.6	7.6	2.1	3.61905	1.78947
90	HA92	8	C	PMDR	TRI	15.2	6.7	2.3	2.91304	2.26866

(continued)

Table A.2 (continued)

OBS	SITE	FSM	COND	CORTEX	XSECT	LENGTH	WIDTH	THICKNES	WDTH	LND
125	HA92	33	C	PMDL	TRI	22.7	12.2	3.0	4.06667	1.36066
126	HA92	16	C	P	TRI	16.7	7.6	2.1	3.61905	2.19737
127	HA92	22	C	MDR	TRI	17.0	8.0	1.8	4.44444	2.12500
128	HA92	36	C	ABSENT	TRI	17.0	10.0	2.8	3.57143	1.70000
129	HA92	40	C	P	IRR	19.4	10.6	4.4	2.40909	1.83019
130	HA92	2	C	MD	CONVEX	20.2	8.4	2.0	4.20000	2.40476
131	HA92	42	C	D	TRA	16.6	6.5	1.7	3.82353	2.55385
132	HA92	45	C	MDL	TRI	16.4	6.4	3.3	1.93939	2.56250
133	HA92	42	C	PMD	CONVEX	13.6	6.7	2.3	2.91304	2.02985
134	HA92	2	C	D	TRI	19.7	8.6	3.1	2.77419	2.29070
135	HA92	41	C	PD	TRI	13.3	6.0	2.5	2.40000	2.21667
136	HA92	16	C	P	TRI	16.1	7.5	1.5	5.00000	2.14667
137	HA92	38	C	PMDR	TRI	17.1	7.7	3.5	2.20000	2.22078
138	HA92	32	C	PMDL	TRA	16.6	7.7	2.5	3.08000	2.15584
139	HA92	11	C	PMDR	TRI	16.1	8.5	1.6	5.31250	1.89412
140	HA92	2	C	PML	TRI	22.8	10.1	3.7	2.72973	2.25743
141	HA92	22	C	ABSENT	TRI	16.7	8.2	1.7	4.82353	2.03659
142	HA92	38	C	ABSENT	TRI	20.2	9.3	3.2	2.90625	2.17204
143	HA92	36	C	D	TRI	19.4	12.2	2.7	4.51852	1.59016
144	HA92	16	C	PMDR	TRI	17.7	8.3	2.8	2.96429	2.13253
145	HA92	14	C	ABSENT	TRA	20.0	9.2	3.3	2.78788	2.17391
146	HA92	10	C	PMDR	TRI	23.1	11.2	3.7	3.02703	2.06250
147	HA92	22	C	PMDR	TRI	18.5	10.0	4.3	2.32558	1.85000
148	HA92	32	C	P	TRI	16.3	7.9	2.2	3.59091	2.06329
149	HA92	43	C	PMDL	TRI	17.2	8.2	2.6	3.15385	2.09756
150	HA92	31	C	ABSENT	TRI	22.1	9.9	2.8	3.53571	2.23232
151	HA92	21	C	D	TRI	26.1	12.5	5.8	2.15517	2.08800
152	HA92	3	C	PMD	CONVEX	17.5	7.4	2.4	3.08333	2.36486
153	HA92	8	C	MDL	TRI	16.6	7.0	2.0	3.50000	2.37143
154	HA92	42	C	PMD	CONVEX	19.1	8.4	2.6	3.23077	2.27381
155	HA92	9	C	ABSENT	TRI	14.7	7.2	2.4	3.00000	2.04167
156	HA92	13	C	ABSENT	TRI	20.8	9.8	2.4	4.08333	2.12245
157	HA92	16	C	ABSENT	TRI	17.5	7.1	2.7	2.62963	2.46479

(continued)

Table A.2 (continued)

OBS	SITE	FSM	COND	CORTEX	XSECT	LENGTH	WIDTH	THICKNES	WDTH	LWD
158	HA92	32	C	ABSENT	TRI	23.1	9.4	4.6	2.04348	2.45745
159	HA92	25	C	D	TRI	21.3	9.0	3.2	2.81250	2.36667
160	HA92	5	C	PD	TRI	24.4	10.1	3.7	2.72973	2.41584
161	HA92	32	C	PMDL	TRI	30.7	9.7	7.1	1.36620	3.16495
162	HA92	37	C	MDL	TRA	21.8	10.7	3.2	3.34375	2.03738
163	HA92	45	C	PL	TRA	21.4	9.5	2.6	3.65385	2.25263
164	HA92	43	C	ABSENT	TRI	27.6	14.3	3.4	4.20588	1.93007
165	HA92	1	C	P	IRR	18.8	8.8	2.7	3.25926	2.13636
166	HA92	30	C	ABSENT	TRI	24.4	9.1	2.6	3.50000	2.68132
167	HA92	20	C	D	TRA	14.8	7.1	1.8	3.94444	2.08451
168	HA92	44	C	ABSENT	TRI	22.6	10.2	3.3	3.09091	2.21569
169	HA92	37	D	ABSENT	TRI	11.2	8.7	1.7	5.11765	1.28736
170	HA92	42	D	D	TRI	12.6	9.2	3.3	2.78788	1.36957
171	HA92	25	D	ABSENT	TRI	10.8	8.7	2.1	4.14286	1.24138
172	HA92	41	M	M	TRI	12.5	9.7	3.0	3.23333	1.28866
173	HA92	43	M	ABSENT	ND	18.7	7.8	3.3	2.36364	2.39744
174	HA92	1	M	ABSENT	TRI	12.1	10.5	2.7	3.88889	1.15238
175	HA92	27	M	ABSENT	TRI	17.3	7.4	3.2	2.31250	2.33784
176	HA92	35	M	ABSENT	TRI	7.5	8.2	2.2	3.72727	0.91463
177	HA92	25	M	M	TRI	16.7	13.0	3.7	3.51351	1.28462
178	HA92	5	M	M	TRI	14.1	6.8	2.2	3.09091	2.07353
179	HA92	16	M	ABSENT	TRI	19.4	11.1	3.2	3.46875	1.74775
180	HA92	38	M	ABSENT	TRA	13.8	8.3	1.6	5.18750	1.66265
181	HA92	27	M	ABSENT	TRI	12.6	10.2	1.9	5.36842	1.23529
182	HA92	32	MD	MDL	TRI	19.7	6.2	4.6	1.34783	3.17742
183	HA92	22	MD	MDL	TRI	19.3	6.2	3.3	1.87879	3.11290
184	HA92	13	MD	MDR	TRI	21.4	8.0	2.7	2.96296	2.67500
185	HA92	12	MD	ABSENT	TRI	19.4	6.9	1.7	4.05882	2.81159
186	HA92	11	MD	D	TRI	14.5	6.4	3.3	1.93939	2.26563
187	HA92	37	MD	MDR	TRI	16.5	7.2	3.4	2.11765	2.29167
188	HA92	27	MD	MDR	TRA	14.3	9.1	3.5	2.60000	1.57143
189	HA92	38	MD	M	TRI	20.0	8.4	3.5	2.40000	2.38095

(continued)

Table A.2 (continued)

OBS	SITE	FSM	COND	CORTEX	XSECT	LENGTH	WIDTH	THICKNES	WDTH	LWD
190	HA92	27	MD	ABSENT	TRA	13.6	7.3	2.1	3.47619	1.86301
191	HA92	8	MD	ABSENT	TRI	14.7	6.8	1.5	4.53333	2.16176
192	HA92	8	MD	MDL	TRI	18.8	9.7	4.3	2.25581	1.93814
193	HA92	43	MD	MDR	TRA	14.2	6.4	2.0	3.20000	2.21875
194	HA92	26	MD	ABSENT	TRI	12.8	9.5	2.1	4.52381	1.34737
195	HA92	8	MD	ABSENT	TRI	12.5	6.0	1.2	5.00000	2.08333
196	HA92	13	MD	ABSENT	TRI	10.8	5.8	2.1	2.76190	1.86207
197	HA92	8	MD	MD	TRI	21.6	10.2	4.7	2.17021	2.11765
198	HA92	22	MD	MDR	TRI	15.1	6.4	2.4	2.66667	2.35938
199	HA92	16	MD	MD	CONVEX	22.1	8.8	3.9	2.25641	2.51136
200	HA92	37	MD	MD	CONVEX	20.5	8.9	3.3	2.69697	2.30337
201	HA92	28	MD	D	TRI	20.3	8.9	3.4	2.61765	2.28090
202	HA92	43	MD	ABSENT	TRI	18.2	9.7	3.5	2.77143	1.87629
203	HA92	8	MD	MDL	TRI	20.3	9.8	3.2	3.06250	2.07143
204	HA92	12	MD	MDL	TRI	22.6	10.5	5.5	1.90909	2.15238
205	HA92	36	MD	D	TRI	19.4	11.2	4.7	2.38298	1.73214
206	HA92	27	MD	MD	CONVEX	18.8	6.7	2.5	2.68000	2.80597
207	HA92	42	MD	MD	CONVEX	17.6	7.2	1.8	4.00000	2.44444
208	HA92	22	MD	D	TRI	18.3	8.5	2.5	3.40000	2.15294
209	HA92	4	P	P	TRA	14.6	11.4	3.6	3.16667	1.28070
210	HA92	41	P	ABSENT	TRI	12.3	9.4	2.8	3.35714	1.30851
211	HA92	45	P	P	TRI	10.6	7.1	2.2	3.22727	1.49296
212	HA92	22	P	ABSENT	TRA	13.3	11.1	1.7	6.52941	1.19820
213	HA92	37	P	ABSENT	TRI	12.1	7.3	2.1	3.47619	1.65753
214	HA92	2	P	ABSENT	TRI	8.5	7.6	1.8	4.22222	1.11842
215	HA92	41	P	ABSENT	TRI	10.6	9.6	3.6	2.66667	1.10417
216	HA92	39	P	ABSENT	TRI	10.1	8.3	1.8	4.61111	1.21687
217	HA92	30	P	ABSENT	TRI	9.7	10.3	2.0	5.15000	0.94175
218	HA92	22	P	P	TRI	9.9	11.2	2.8	4.00000	0.88393
219	HA92	32	P	P	TRI	14.0	12.6	3.6	3.50000	1.11111
220	HA92	3	PM	ABSENT	TRI	16.4	8.8	2.5	3.52000	1.86364
221	HA92	22	PM	ABSENT	TRA	16.6	9.5	2.9	3.27586	1.74737
222	HA92	22	PM	PML	TRI	21.2	7.3	3.1	2.35484	2.90411
223	HA92	33	PM	ABSENT	TRI	16.7	9.2	1.5	6.13333	1.81522

(continued)

Table A.2 (continued)

OBS	SITE	FSM	COND	CORTEX	XSECT	LENGTH	WIDTH	THICKNES	WDTH	LWD
224	HA92	11	PM	M	TRA	15.7	7.2	2.1	3.42857	2.18056
225	HA92	45	PM	ABSENT	TRI	18.2	8.7	3.0	2.90000	2.09195
226	HA92	1	PM	ABSENT	TRI	17.1	8.7	2.4	3.62500	1.96552
227	HA92	5	PM	M	TRI	18.2	10.1	2.3	4.39130	1.80198
228	HA92	9	PM	ABSENT	TRI	18.3	7.8	3.5	2.22857	2.34615
229	HA92	43	PM	ABSENT	TRI	15.4	8.8	1.8	4.88889	1.75000
230	HA92	22	PM	ABSENT	TRI	12.6	7.6	2.1	3.61905	1.65789
231	HA92	18	PM	ABSENT	TRI	14.6	8.3	3.9	2.12821	1.75904
232	HA92	22	PM	ABSENT	TRA	13.4	8.6	1.5	5.73333	1.55814
233	HA92	22	PM	ABSENT	TRI	14.6	8.0	2.1	3.80952	1.82500
234	HA92	15	PM	ABSENT	TRI	16.4	6.8	3.1	2.19355	2.41176
235	HA92	1	PM	PM	TRI	21.4	9.2	3.3	2.78788	2.32609
236	HA92	21	PM	PM	TRI	18.9	5.7	2.7	2.11111	3.31579
237	HA92	7	PMD	PMDR	TRA	17.3	7.7	3.9	1.97436	2.24675
238	TUM7	2	C	ABSENT	TRI	14.7	9.0	1.8	5.00000	1.63333
239	TUM7	5	C	PMD	CONVEX	15.7	7.1	2.3	3.08696	2.21127
240	TUM7	3	C	ABSENT	TRA	14.5	7.5	2.5	3.00000	1.93333
241	TUM7	3	C	PMD	TRI	16.1	7.9	2.6	3.03846	2.03797
242	TUM7	3	C	ABSENT	TRI	16.5	7.5	2.2	3.40909	2.20000
243	TUM7	4	C	PMD	TRI	21.5	8.6	2.6	3.30769	2.50000
244	TUM7	2	M	M	TRI	17.7	8.0	4.6	1.73913	2.21250
245	TUM7	3	P	ABSENT	TRI	10.7	7.4	3.3	2.24242	1.44595
246	TUM7	6	PM	ABSENT	TRI	16.5	8.2	1.8	4.55556	2.01220
247	TUM7	4	PM	PM	TRA	15.3	9.6	2.0	4.80000	1.59375
248	TU2	26	C	PMDR	TRI	24.6	9.6	5.7	1.68421	2.56250
249	TU2	15	C	PML	TRI	23.6	7.5	3.9	1.92308	3.14667
250	TU2	26	C	PMDL	TRI	16.3	6.8	2.8	2.42857	2.39706
251	TU2	13	C	PMDR	TRI	20.5	9.2	4.8	1.91667	2.22826
252	TU2	3	C	PMD	TRI	19.1	8.4	3.2	2.62500	2.27381
253	TU2	13	C	D	TRI	24.0	9.8	3.8	2.57895	2.44898
254	TU2	11	C	ABSENT	TRI	24.0	11.8	5.9	2.00000	2.03390
255	TU2	3	C	PMDR	TRI	15.7	8.2	1.9	4.31579	1.91463
256	TU2	35	C	ABSENT	TRI	19.0	9.1	2.9	3.13793	2.08791
257	TU2	4	C	PMDL	TRI	18.5	8.6	2.3	3.73913	2.15116

(continued)

Table A.2 (continued)

OBS	SITE	FSM	COND	CORTEX	XSECT	LENGTH	WIDTH	THICKNES	WDTH	LWD
258	TU2	35	C	ABSENT	TRI	12.4	8.5	1.3	6.53846	1.45882
259	TU2	10	C	D	TRA	17.9	7.5	2.0	3.75000	2.38667
260	TU2	35	C	D	TRI	14.2	5.5	2.3	2.39130	2.58182
261	TU2	12	C	PMD	TRI	16.7	7.5	3.5	2.14286	2.22667
262	TU2	12	C	PMDR	TRA	26.1	12.2	4.8	2.54167	2.13934
263	TU2	11	D	ABSENT	TRI	10.3	7.7	3.0	2.56667	1.33766
264	TU2	4	MD	D	TRI	17.9	6.5	3.9	1.66667	2.75385
265	TU2	4	MD	MD	TRI	16.5	7.5	3.1	2.41935	2.20000
266	TU2	6	MD	MD	TRI	15.4	6.3	2.0	3.15000	2.44444
267	TU2	27	P	ABSENT	TRA	9.7	11.1	2.7	4.11111	0.87387
268	TU2	35	P	ABSENT	TRI	8.5	3.5	1.8	1.94444	2.42857
269	TU2	30	P	ABSENT	TRI	11.6	8.9	2.4	3.70833	1.30337
270	TU2	3	PM	ABSENT	TRI	14.4	6.4	1.6	4.00000	2.25000
271	TU2	4	PM	P	TRI	13.6	8.2	3.2	2.56250	1.65854
272	TU2	4	PM	ABSENT	TRI	16.6	7.3	3.0	2.43333	2.27397
273	TU240A	6	C	ABSENT	TRI	16.7	7.7	1.4	5.50000	2.16883
274	TU240A	6	PM	PM	TRA	26.5	17.6	4.6	3.82609	1.50563
275	TU240B	2	C	MD	IRR	30.0	11.6	3.5	3.31429	2.58621
276	TU240B	2	C	ABSENT	TRI	22.4	10.3	2.7	3.81481	2.17476
277	TU240C	4	C	ABSENT	TRI	26.2	13.7	4.2	3.26190	1.91241
278	TU259	8	C	P	TRI	19.4	7.5	5.2	1.44231	2.58667
279	TU259	15	C	ABSENT	TRA	17.1	8.2	1.5	5.46667	2.08537
280	TU259	7	C	MD	TRA	20.2	10.3	2.4	4.29167	1.96117
281	TU259	8	C	PMDR	TRI	19.6	8.0	3.9	2.05128	2.45000
282	TU259	9	C	PMD	TRI	24.9	9.7	4.3	2.25581	2.56701
283	TU259	6	C	ABSENT	TRI	20.6	9.3	3.4	2.73529	2.21505
284	TU259	13	C	PMDR	TRI	19.2	11.0	3.2	3.43750	1.74545
285	TU259	11	C	PMDL	TRI	21.1	8.4	2.6	3.23077	2.51190
286	TU259	11	C	PMD	TRI	17.2	8.8	2.9	3.03448	1.95455
287	TU259	9	C	PMD	CONVEX	23.5	9.9	2.7	3.66667	2.37374
288	TU259	4	C	ABSENT	TRI	23.7	12.4	3.1	4.00000	1.91129
289	TU259	5	C	M	TRI	16.9	7.2	4.3	1.67442	2.34722
290	TU259	13	C	MDR	TRI	17.6	8.0	2.7	2.96296	2.20000

(continued)

Table A.2 (continued)

OBS	SITE	FSM	COND	CORTEX	XSECT	LENGTH	WIDTH	THICKNES	WDTH	LND
291	TU259	6	C	PMD	TRI	23.3	9.6	3.6	2.66667	2.42708
292	TU259	11	C	ABSENT	TRI	18.0	8.4	4.3	1.95349	2.14286
293	TU259	13	C	ABSENT	IRR	19.6	9.0	2.2	4.09091	2.17778
294	TU259	7	C	D	TRI	19.2	9.0	4.0	2.25000	2.13333
295	TU259	7	C	P	TRI	16.3	6.0	2.0	3.00000	2.71667
296	TU259	4	C	D	TRI	18.6	8.4	3.4	2.47059	2.21429
297	TU259	17	C	D	TRI	21.2	11.2	4.7	2.38298	1.89286
298	TU259	14	C	D	TRI	21.9	8.2	2.7	3.03704	2.67073
299	TU259	5	C	PMDL	TRI	25.2	11.3	4.1	2.75610	2.23009
300	TU259	8	C	PMR	TRI	22.5	6.3	3.8	1.65789	3.57143
301	TU259	11	C	PMDL	TRI	16.1	7.4	2.4	3.08333	2.17568
302	TU259	4	C	ABSENT	TRI	16.1	6.3	1.1	5.72727	2.55556
303	TU259	12	C	PMDR	TRI	14.3	8.2	2.2	3.72727	1.74390
304	TU259	14	C	ABSENT	TRA	20.2	7.0	2.7	2.59259	2.88571
305	TU259	11	C	MR	TRI	21.6	8.0	3.3	2.42424	2.70000
306	TU259	14	C	ABSENT	TRI	22.1	8.7	5.6	1.55357	2.54023
307	TU259	15	C	D	TRI	21.6	9.7	3.1	3.12903	2.22680
308	TU259	6	C	ABSENT	IRR	11.9	11.1	2.1	5.28571	1.07207
309	TU259	13	C	D	TRI	21.0	8.0	2.6	3.07692	2.62500
310	TU259	4	C	ABSENT	TRI	19.4	10.2	3.4	3.00000	1.90196
311	TU259	5	C	ABSENT	TRI	20.0	6.4	2.0	3.20000	3.12500
312	TU259	9	C	D	TRA	19.2	9.6	2.5	3.84000	2.00000
313	TU259	8	C	DR	TRI	18.0	8.3	2.7	3.07407	2.16867
314	TU259	9	C	PMDR	TRA	27.7	9.5	3.3	2.87879	2.91579
315	TU259	5	C	P	TRI	23.0	11.6	3.5	3.31429	1.98276
316	TU259	8	C	ABSENT	TRI	20.3	11.5	2.7	4.25926	1.76522
317	TU259	8	C	ABSENT	IRR	20.3	10.7	3.8	2.81579	1.89720
318	TU259	10	C	ABSENT	TRI	19.0	9.4	2.7	3.48148	2.02128
319	TU259	7	C	PM	TRI	17.1	8.7	3.2	2.71875	1.96552
320	TU259	12	C	ABSENT	TRI	18.7	8.3	2.4	3.45833	2.25301
321	TU259	5	C	D	IRR	15.4	8.5	1.7	5.00000	1.81176
322	TU259	8	C	PMDL	TRI	18.6	8.7	2.4	3.62500	2.13793
323	TU259	12	C	MDL	IRR	15.5	7.5	2.2	3.40909	2.06667

(continued)

Table A.2 (continued)

OBS	SITE	FSM	COND	CORTEX	XSECT	LENGTH	WIDTH	THICKNES	WDTH	LWD
324	TU259	9	C	PMD	CONVEX	27.4	9.5	2.5	3.80000	2.88421
325	TU259	14	C	ABSENT	TRA	17.2	8.1	2.8	2.89286	2.12346
326	TU259	4	C	MDL	TRI	20.9	11.4	5.1	2.23529	1.83333
327	TU259	12	C	D	TRI	16.6	5.6	2.6	2.15385	2.96429
328	TU259	12	C	PMDL	TRA	15.5	5.5	2.0	2.75000	2.81818
329	TU259	14	C	ABSENT	TRI	15.3	6.7	2.0	3.35000	2.28358
330	TU259	13	C	PMDR	TRI	14.4	7.6	3.8	2.00000	1.89474
331	TU259	13	C	PMDL	TRI	15.1	8.5	2.7	3.14815	1.77647
332	TU259	9	C	PMDR	TRI	14.4	7.4	2.4	3.08333	1.94595
333	TU259	9	C	ABSENT	TRI	15.0	7.4	2.1	3.52381	2.02703
334	TU259	8	C	D	TRA	21.0	10.0	2.8	3.57143	2.10000
335	TU259	12	C	P	TRI	13.9	9.4	1.6	5.87500	1.47872
336	TU259	4	C	PMDL	TRA	14.8	7.3	2.7	2.70370	2.02740
337	TU259	9	C	PMD	TRI	17.0	8.2	3.2	2.56250	2.07317
338	TU259	9	C	PMDR	TRI	15.5	8.4	2.3	3.65217	1.84524
339	TU259	4	C	PR	TRI	16.8	7.2	2.1	3.42857	2.33333
340	TU259	13	C	ABSENT	TRI	16.7	6.8	2.3	2.95652	2.45588
341	TU259	13	C	PDL	TRI	18.8	8.5	2.7	3.14815	2.21176
342	TU259	8	C	ABSENT	TRI	17.5	8.3	4.3	1.93023	2.10843
343	TU259	6	C	ABSENT	TRI	14.1	7.5	2.4	3.12500	1.88000
344	TU259	6	C	ABSENT	IRR	12.8	6.6	1.1	6.00000	1.93939
345	TU259	14	C	ABSENT	IRR	13.7	5.9	2.3	2.56522	2.32203
346	TU259	12	C	ABSENT	TRI	14.4	6.5	2.3	2.82609	2.21538
347	TU259	16	C	ABSENT	TRI	16.6	6.4	1.3	4.92308	2.59375
348	TU259	8	C	D	TRI	14.4	7.3	1.9	3.84211	1.97260
349	TU259	7	C	MD	IRR	22.0	10.5	3.4	3.08824	2.09524
350	TU259	14	C	ABSENT	TRI	15.8	6.4	2.4	2.66667	2.46875
351	TU259	15	C	PMD	CONVEX	20.4	10.5	3.3	3.18182	1.94286
352	TU259	13	C	PMDR	TRI	27.5	11.4	5.8	1.96552	2.41228
353	TU259	5	C	ABSENT	TRI	13.0	6.4	2.3	2.78261	2.03125
354	TU259	6	C	PMDL	TRI	12.0	6.3	1.5	4.20000	1.90476
355	TU259	14	C	ABSENT	TRI	17.5	7.6	2.2	3.45455	2.30263
356	TU259	13	C	ABSENT	TRI	17.7	10.2	3.1	3.29032	1.73529

(continued)

Table A.2 (continued)

OBS	SITE	FSM	COND	CORTEX	XSECT	LENGTH	WIDTH	THICKNES	WDTH	LWD
357	TU259	11	C	PD	TRI	16.2	7.6	3.7	2.05405	2.13158
358	TU259	6	C	ABSENT	IRR	14.4	6.1	1.6	3.81250	2.36066
359	TU259	13	C	PMD	TRI	15.2	6.8	1.4	4.85714	2.23529
360	TU259	6	C	D	TRI	20.2	13.6	3.2	4.25000	1.48529
361	TU259	13	C	PMD	TRI	17.3	8.0	2.5	3.20000	2.16250
362	TU259	5	C	PMDL	TRA	26.0	10.5	2.6	4.03846	2.47619
363	TU259	2	C	PD	TRI	22.2	10.3	5.1	2.01961	2.15534
364	TU259	5	C	PMDR	TRI	19.2	9.0	2.6	3.46154	2.13333
365	TU259	4	C	PMDL	TRI	21.8	10.1	3.6	2.80556	2.15842
366	TU259	4	C	PML	TRI	15.3	7.7	2.1	3.66667	1.98701
367	TU259	14	C	ABSENT	TRI	21.2	12.7	4.0	3.17500	1.66929
368	TU259	13	C	ABSENT	TRI	15.3	8.6	1.8	4.77778	1.77907
369	TU259	2	C	ABSENT	TRI	21.5	8.5	2.6	3.26923	2.52941
370	TU259	5	C	PMDR	TRI	31.0	13.5	3.8	3.55263	2.29630
371	TU259	7	C	P	TRA	12.3	6.0	1.5	4.00000	2.05000
372	TU259	8	C	ABSENT	TRI	20.5	9.7	2.3	4.21739	2.11340
373	TU259	5	C	PM	IRR	18.9	9.3	2.0	4.65000	2.03226
374	TU259	7	C	P	TRI	20.3	12.8	4.2	3.04762	1.58594
375	TU259	6	C	ABSENT	IRR	13.7	7.2	1.6	4.50000	1.90278
376	TU259	6	C	D	TRI	17.5	10.7	4.1	2.60976	1.63551
377	TU259	15	C	D	TRI	20.8	11.6	3.5	3.31429	1.79310
378	TU259	2	C	ABSENT	TRA	22.5	10.5	4.0	2.62500	2.14286
379	TU259	6	C	PMDR	TRI	29.1	9.5	3.1	3.06452	3.06316
380	TU259	13	M	ABSENT	TRI	12.9	5.5	1.5	3.66667	2.34545
381	TU259	8	M	M	TRI	14.5	8.3	2.0	4.15000	1.74699
382	TU259	13	M	ABSENT	TRI	13.7	7.9	1.7	4.64706	1.73418
383	TU259	11	M	M	TRI	13.6	6.6	4.2	1.57143	2.06061
384	TU259	13	M	ABSENT	IRR	13.5	7.9	1.0	7.90000	1.70886
385	TU259	6	M	M	TRI	15.2	7.1	3.1	2.29032	2.14085
386	TU259	8	M	ABSENT	TRI	12.2	9.5	2.7	3.51852	1.28421
387	TU259	9	MD	D	TRI	18.9	8.3	2.9	2.86207	2.27711
388	TU259	8	MD	MD	TRI	18.5	8.3	2.8	2.96429	2.22892
389	TU259	10	MD	M	TRI	23.6	9.4	5.2	1.80769	2.51064
390	TU259	6	MD	MD	CONVEX	19.7	10.2	3.0	3.40000	1.93137

(continued)

Table A.2 (continued)

OBS	SITE	FSM	COND	CORTEX	XSECT	LENGTH	WIDTH	THICKNES	WDTH	LWD
391	TU259	13	MD	ABSENT	TRA	13.6	8.2	3.3	2.48485	1.65854
392	TU259	7	MD	MD	TRI	16.4	7.2	2.5	2.88000	2.27778
393	TU259	16	MD	ABSENT	TRI	16.0	6.1	1.6	3.81250	2.62295
394	TU259	1	MD	ABSENT	IRR	16.5	9.0	1.6	5.62500	1.83333
395	TU259	8	MD	ABSENT	IRR	11.8	6.6	1.3	5.07692	1.78788
396	TU259	12	MD	D	TRI	12.6	5.9	2.3	2.56522	2.13559
397	TU259	13	MD	MD	TRI	12.9	7.7	2.9	2.65517	1.67532
398	TU259	1	MD	ABSENT	TRA	19.9	9.0	1.6	5.62500	2.21111
399	TU259	10	MD	MD	TRI	16.3	6.6	2.8	2.35714	2.46970
400	TU259	7	MD	ABSENT	TRI	14.0	6.1	1.4	4.35714	2.29508
401	TU259	9	MD	MD	TRI	15.2	6.7	1.6	4.18750	2.26866
402	TU259	1	MD	D	TRI	14.3	8.3	2.3	3.60870	1.72289
403	TU259	13	P	ABSENT	TRI	10.1	8.2	1.7	4.82353	1.23171
404	TU259	13	P	ABSENT	TRI	10.5	9.0	2.3	3.91304	1.16667
405	TU259	4	P	ABSENT	TRI	7.5	7.4	1.7	4.35294	1.01351
406	TU259	8	P	ABSENT	TRI	10.1	8.3	2.4	3.45833	1.21687
407	TU259	13	PM	PM	TRI	17.6	8.6	2.6	3.30769	2.04651
408	TU259	13	PM	M	TRA	19.4	8.1	3.2	2.53125	2.39506
409	TU259	8	PM	ABSENT	TRI	24.0	12.3	2.2	5.59091	1.95122
410	TU259	13	PM	ABSENT	IRR	16.7	8.4	1.5	5.60000	1.98810
411	TU259	6	PM	ABSENT	TRI	17.7	9.7	3.2	3.03125	1.82474
412	TU259	5	PM	ABSENT	TRI	26.3	10.4	3.6	2.88889	2.52885
413	TU259	5	PM	P	TRI	15.4	10.2	3.6	2.83333	1.50980
414	TU259	13	PM	P	TRI	16.4	7.0	4.0	1.75000	2.34286
415	TU259	14	PM	PM	TRI	23.4	10.9	3.0	3.63333	2.14679
416	TU259	4	PM	ABSENT	TRI	15.1	6.6	2.3	2.86957	2.28788
417	TU259	4	PM	P	IRR	21.3	10.6	4.4	2.40909	2.00943
418	TU259	12	PM	ABSENT	TRI	16.3	8.4	2.0	4.20000	1.94048
419	TU259	5	PM	PM	TRI	14.1	7.8	2.5	3.12000	1.80769
420	TU259	9	PM	ABSENT	TRI	16.1	11.0	2.1	5.23810	1.46364
421	TU259	6	PM	PM	TRI	16.8	7.5	2.7	2.77778	2.24000
422	TU259	12	PM	ABSENT	TRI	12.4	6.9	1.8	3.83333	1.79710
423	TU259	12	PM	ABSENT	TRI	16.3	13.6	5.1	2.66667	1.19853

(continued)

Table A.2 (continued)

OBS	SITE	FSM	COND	CORTEX	XSECT	LENGTH	WIDTH	THICKNES	WDTH	LWD
424	TU259	11	PM	ABSENT	TRI	10.4	8.3	1.2	6.91667	1.25301
425	TU259	7	PM	ABSENT	TRI	15.2	8.8	2.4	3.66667	1.72727
426	TU259	7	PM	ABSENT	IRR	22.0	10.0	3.3	3.03030	2.20000
427	TU259	20	PM	PM	TRI	20.3	9.4	3.8	2.47368	2.15957
428	TU259	14	PM	PM	TRI	15.2	7.5	2.8	2.67857	2.02667
429	TU259	5	PM	M	TRI	12.9	6.8	2.6	2.61538	1.89706
430	TU259	11	PMD	ABSENT	TRI	27.7	7.9	2.2	3.59091	3.50633
431	TU259	5	PMD	ABSENT	TRA	19.1	7.2	2.1	3.42857	2.65278
432	TU259	8	PMD	PMDL	TRI	22.3	8.7	3.5	2.48571	2.56322
433	TU346	1	C	PMDL	TRI	21.0	9.9	3.5	2.82857	2.12121
434	TU346	16	C	D	IRR	19.4	8.7	3.0	2.90000	2.22989
435	TU346	15	C	D	IRR	16.8	7.7	1.8	4.27778	2.18182
436	TU346	16	C	ABSENT	TRI	19.7	8.8	2.3	3.82609	2.23864
437	TU346	15	C	ABSENT	TRI	17.0	9.6	1.5	6.40000	1.77083
438	TU346	15	D	ABSENT	TRI	9.6	6.8	1.8	3.77778	1.41176
439	TU346	1	MD	MD	TRI	20.5	6.5	3.3	1.96970	3.15385
440	TU346	7	P	P	TRI	8.6	9.4	2.2	4.27273	0.91489
441	TU346	14	PM	PM	TRI	14.6	6.8	2.2	3.09091	2.14706
442	TU346	7	PM	PM	TRI	16.2	13.1	3.9	3.35897	1.23664
443	TU346	15	PM	P	TRI	15.9	6.9	2.5	2.76000	2.30435
444	TU346	6	PM	ABSENT	TRA	14.7	7.4	1.5	4.93333	1.98649
445	TU42	49	C	M	TRI	23.1	10.8	3.7	2.91892	2.13889
446	TU42	65	C	ABSENT	TRA	21.2	10.5	2.9	3.62069	2.01905
447	TU42	60	C	ABSENT	IRR	24.2	11.7	1.8	6.50000	2.06838
448	TU42	26	C	D	TRI	18.9	7.9	3.8	2.07895	2.39241
449	TU42	51	C	ABSENT	TRI	17.6	6.6	1.6	4.12500	2.66667
450	TU42	48	C	MDR	TRI	22.2	8.7	3.2	2.71875	2.55172
451	TU42	66	C	P	TRI	18.2	10.1	2.2	4.59091	1.80198
452	TU42	54	C	P	TRI	23.4	12.0	2.9	4.13793	1.95000
453	TU42	60	C	PMDL	TRI	22.2	10.0	5.5	1.81818	2.22000
454	TU42	49	C	ABSENT	TRI	19.0	10.3	2.7	3.81481	1.84466
455	TU42	49	C	ABSENT	TRI	24.2	13.0	4.4	2.95455	1.86154

(continued)

Table A.2 (continued)

OBS	SITE	FSM	COND	CORTEX	XSECT	LENGTH	WIDTH	THICKNES	WDTH	LWD
456	TU42	65	C	MD	TRI	23.5	12.2	4.5	2.71111	1.92623
457	TU42	41	M	M	TRA	21.3	11.4	3.3	3.45455	1.86842
458	TU42	45	M	M	TRA	16.6	6.6	2.4	2.75000	2.51515
459	TU42	29	M	ABSENT	TRI	16.4	12.1	4.4	2.75000	1.35537
460	TU42	65	MD	D	TRI	14.9	8.5	2.2	3.86364	1.75294
461	TU42	29	MD	ABSENT	TRI	11.1	11.6	2.8	4.14286	0.95690
462	TU42	51	MD	ABSENT	TRI	11.7	7.6	2.4	3.16667	1.53947
463	TU42	51	P	ABSENT	TRI	12.6	11.3	3.1	3.64516	1.11504
464	TU42	29	PM	PM	CONVEX	21.9	9.6	3.7	2.59459	2.28125
465	TU42	65	PM	M	TRI	12.4	8.2	3.0	2.73333	1.51220
466	TU42	36	PM	P	TRI	16.6	8.9	2.7	3.29630	1.86517
467	TU42	65	PM	PM	CONVEX	21.2	8.5	2.8	3.03571	2.49412
468	TU42	44	PM	PM	TRI	18.4	7.9	3.1	2.54839	2.32911
469	TU42	50	PM	PM	TRI	18.4	6.4	3.2	2.00000	2.87500
470	TU42	65	PM	ABSENT	TRI	23.1	11.4	4.2	2.71429	2.02632
471	TU42	65	PM	M	TRI	26.2	15.5	4.9	3.16327	1.69032
472	TU42	54	PMD	PM	TRI	21.3	9.7	5.0	1.94000	2.19588
473	TU46	8	C	MD	IRR	24.0	9.8	4.8	2.04167	2.44898
474	TU46	18	C	ABSENT	TRI	23.4	7.5	2.8	2.67857	3.12000
475	TU46	9	C	PD	TRI	24.1	12.1	2.7	4.48148	1.99174
476	TU46	14	C	D	TRI	15.7	6.4	1.9	3.36842	2.45313
477	TU46	11	C	P	TRI	20.3	5.6	3.9	1.43590	3.62500
478	TU46	8	M	ABSENT	TRI	12.7	9.4	1.8	5.22222	1.35106
479	TU46	47	M	ABSENT	TRI	14.1	9.2	2.8	3.28571	1.53261
480	TU46	24	MD	ABSENT	TRI	13.2	6.4	1.8	3.55556	2.06250
481	TU46	8	P	ABSENT	TRI	8.4	9.3	1.6	5.81250	0.90323
482	TU56	22	C	MDL	TRI	19.1	8.4	2.3	3.65217	2.27381
483	TU56	28	C	P	TRI	16.8	8.0	1.5	5.33333	2.10000
484	TU56	22	C	ABSENT	TRI	17.7	6.9	2.5	2.76000	2.56522
485	TU56	25	C	PMDR	TRI	16.1	7.1	2.4	2.95833	2.26761
486	TU56	22	C	PMDL	TRI	17.7	9.2	2.5	3.68000	1.92391
487	TU56	22	C	PMD	CONVEX	17.4	8.5	3.1	2.74194	2.04706
488	TU56	25	C	MD	TRI	15.9	7.9	2.8	2.82143	2.01266
489	TU56	22	C	D	TRI	20.1	9.8	3.0	3.26667	2.05102
490	TU56	25	C	PMDL	TRA	17.6	7.5	1.3	5.76923	2.34667
491	TU56	22	C	ABSENT	TRA	20.7	7.8	2.7	2.88889	2.65385
492	TU56	25	C	PD	IRR	14.8	6.4	1.4	4.57143	2.31250
493	TU56	26	D	D	TRA	10.7	8.1	1.6	5.06250	1.32099
494	TU56	25	M	ABSENT	TRI	24.0	5.7	2.5	2.28000	4.21053
495	TU56	25	MD	ABSENT	TRI	18.5	10.5	2.9	3.62069	1.76190
496	TU56	22	MD	ABSENT	TRI	14.4	7.8	3.7	2.10811	1.84615

(continued)

Table A.2 (continued)

OBS	SITE	FSM	COND	CORTEX	XSECT	LENGTH	WIDTH	THICKNES	WDTH	LWD
497	TU56	25	PM	ABSENT	TRI	16.1	10.2	2.5	4.08000	1.57843
498	TU56	25	PM	M	TRI	17.5	7.1	4.4	1.61364	2.46479
499	TU56	22	PM	ABSENT	TRI	11.6	6.4	1.1	5.81818	1.81250
500	TU56	22	PM	PM	CONVEX	17.2	8.1	3.8	2.13158	2.12346
501	TU58		C	D	TRI	18.3	9.6	2.5	3.84000	1.90625
502	TU58		C	PMDL	TRI	29.7	9.4	6.0	1.56667	3.15957
503	TU58		C	D	TRA	16.6	9.6	1.8	5.33333	1.72917
504	TU58		PM	ABSENT	TRI	17.0	9.3	2.7	3.44444	1.82796
505	TU59	1	C	ABSENT	IRR	16.9	10.0	2.7	3.70370	1.69000
506	TU59	1	C	PMDL	TRI	23.8	10.3	4.0	2.57500	2.31068
507	TU59		C	ABSENT	TRI	27.8	11.3	1.8	6.27778	2.46018
508	TU6	15	C	MD	TRI	17.5	8.3	2.3	3.60870	2.10843
509	TU6	30	M	M	TRI	17.3	8.5	3.1	2.74194	2.03529
510	TU62	1	C	MD	IRR	18.0	10.3	2.6	3.96154	1.74757
511	TU62	1	M	M	TRI	17.0	7.2	3.3	2.18182	2.36111
512	TU62	1	MD	MD	TRI	14.5	7.3	3.3	2.21212	1.98630
513	TU62	1	P	P	TRA	11.0	10.4	2.6	4.00000	1.05769
514	TU62	1	PM	ABSENT	TRI	15.0	12.1	3.0	4.03333	1.23967
515	TU62	1	PM	ABSENT	IRR	12.3	6.0	1.9	3.15789	2.05000
516	TU62	2	PM	PM	TRI	15.1	8.7	2.7	3.22222	1.73563
517	TU62	1	PM	ABSENT	TRA	12.7	7.4	1.5	4.93333	1.71622
518	TU62	1	PM	M	TRI	14.4	8.5	2.9	2.93103	1.69412
519	TU64	7	C	ABSENT	TRI	28.6	12.4	3.2	3.87500	2.30645
520	TU64	1	MD	ABSENT	TRA	20.9	13.2	3.3	4.00000	1.58333
521	TU64	1	PM	M	TRI	16.8	9.1	4.6	1.97826	1.84615
522	TU65	1	C	MD	IRR	19.8	10.1	3.1	3.25806	1.96040
523	TU65	6	C	D	TRI	26.5	13.5	4.3	3.13953	1.96296
524	TU65	8	C	ABSENT	IRR	20.5	9.7	3.4	2.85294	2.11340
525	TU65	9	C	PMD	CONVEX	20.6	7.7	2.7	2.85185	2.67532
526	TU65	6	C	ABSENT	TRI	16.8	9.2	1.1	8.36364	1.82609
527	TU65	8	C	PMDR	TRA	19.3	8.9	2.2	4.04545	2.16854
528	TU65	6	C	PMD	CONVEX	24.1	8.3	2.7	3.07407	2.90361
529	TU65	1	C	ABSENT	TRA	17.2	7.5	2.2	3.40909	2.29333
530	TU65	9	C	PMDR	TRI	18.5	8.3	2.7	3.07407	2.22892
531	TU65	9	C	MD	TRI	22.0	10.5	3.7	2.83784	2.09524
532	TU65	5	C	PMR	TRI	17.2	7.4	2.6	2.84615	2.32432
533	TU65	9	C	PMDL	TRI	19.0	8.3	2.9	2.86207	2.28916
534	TU65	7	C	PMDR	TRI	15.5	8.1	2.7	3.00000	1.91358
535	TU65	6	C	PMDR	TRI	17.2	8.3	2.7	3.07407	2.07229
536	TU65	6	C	PMD	CONVEX	17.4	9.2	2.5	3.68000	[illegible]
537	TU65	8	C	PMD	CONVEX	14.4	5.9	1.6	3.68750	2.44068
538	TU65	9	C	ABSENT	TRI	17.1	6.6	1.5	4.40000	2.59091
539	TU65	7	C	ABSENT	TRI	13.4	6.8	1.3	5.23077	1.97059
540	TU65	9	C	D	TRI	18.4	12.1	2.3	5.26087	1.52066

(continued)

Table A.2 (continued)

OBS	SITE	FSM	COND	CORTEX	XSECT	LENGTH	WIDTH	THICKNES	WDTH	LWD
541	TU65	1	C	PML	TRI	16.1	7.1	2.2	3.22727	2.26761
542	TU65	8	C	D	TRI	19.5	9.3	3.5	2.65714	2.09677
543	TU65	7	C	PMD	CONVEX	17.4	9.1	2.4	3.79167	1.91209
544	TU65	6	C	M	IRR	20.9	10.2	2.5	4.08000	2.04902
545	TU65	5	C	D	TRI	19.3	8.8	4.1	2.14634	2.19318
546	TU65	5	C	P	TRI	13.4	7.4	2.7	2.74074	1.81081
547	TU65	9	C	ABSENT	TRI	15.5	6.5	3.6	1.80556	2.38462
548	TU65	9	D	ABSENT	TRI	12.3	8.7	4.7	1.85106	1.41379
549	TU65	9	M	M	TRI	20.1	6.4	3.9	1.64103	3.14062
550	TU65	6	MD	MD	TRI	20.0	7.3	3.6	2.02778	2.73973
551	TU65	8	MD	MD	TRI	19.4	9.5	6.2	1.53226	2.04211
552	TU65	10	P	ABSENT	TRI	9.9	7.2	1.7	4.23529	1.37500
553	TU65	1	P	ABSENT	TRI	9.4	8.0	1.5	5.33333	1.17500
554	TU65	5	P	ABSENT	TRI	8.4	8.1	1.7	4.76471	1.03704
555	TU65	9	P	ABSENT	TRI	10.7	9.6	1.5	6.40000	1.11458
556	TU65	1	P	ABSENT	TRA	9.1	8.5	1.4	6.07143	1.07059
557	TU65	7	P	P	TRI	7.9	8.3	2.2	3.77273	0.95181
558	TU65	1	PM	ABSENT	TRI	25.9	13.2	5.2	2.53846	1.96212
559	TU65	7	PM	PM	TRA	14.0	9.1	1.5	6.06667	1.53846
560	TU65	7	PM	M	TRI	11.9	8.8	2.3	3.82609	1.35227
561	TU65	7	PM	ABSENT	TRI	14.0	9.2	2.4	3.83333	1.52174
562	TU65	8	PM	PM	CONVEX	15.9	9.6	2.8	3.42857	1.65625
563	TU66	12	C	D	TRI	38.3	13.4	5.3	2.52830	2.85821
564	TU66	44	C	PMDL	TRI	23.6	8.4	2.5	3.36000	2.80952
565	TU66	44	C	MDR	TRI	21.7	9.9	3.9	2.53846	2.19192
566	TU66	68	C	PMD	TRI	23.2	9.1	2.7	3.37037	2.54945
567	TU66	39	C	D	TRI	23.4	11.0	4.2	2.61905	2.12727
568	TU66	41	C	P	TRI	17.8	5.9	5.3	1.11321	3.01695
569	TU66	44	C	MDR	TRI	22.9	9.5	3.4	2.79412	2.41053
570	TU66	12	C	ABSENT	TRI	21.2	9.4	3.0	3.13333	2.25532
571	TU66	47	C	ABSENT	TRI	18.9	8.0	2.2	3.63636	2.36250
572	TU66	13	C	PMD	CONVEX	19.7	7.5	3.1	2.41935	2.62667
573	TU66	29	C	D	TRI	18.9	8.6	2.6	3.30769	2.19767
574	TU66	30	C	D	IRR	19.5	10.4	3.7	2.81081	1.87500
575	TU66	52	C	PMDL	TRA	20.8	9.1	3.7	2.45946	2.28571
576	TU66	39	C	P	TRI	21.0	9.5	6.4	1.48438	2.21053
577	TU66	65	C	PMD	TRI	22.7	11.0	9.5	1.15789	2.06364
578	TU66	38	C	PD	TRA	18.5	8.3	4.4	1.88636	2.22892
579	TU66	44	C	PMDR	TRI	17.2	8.5	3.5	2.42857	2.02353
580	TU66	14	C	ABSENT	TRI	22.0	11.9	6.2	1.91935	1.84874
581	TU66	15	C	ABSENT	TRI	20.3	8.3	2.4	3.45833	2.44578

(continued)

Table A.2 (continued)

OBS	SITE	FSM	COND	CORTEX	XSECT	LENGTH	WIDTH	THICKNES	WDTH	LWD
582	TU66	14	C	P	TRI	25.7	11.3	5.7	1.98246	2.27434
583	TU66	41	C	MDL	TRI	18.9	8.8	2.6	3.38462	2.14773
584	TU66	44	C	ABSENT	TRI	17.7	5.4	4.7	1.14894	3.27778
585	TU66	65	C	P	TRI	16.5	10.0	3.3	3.03030	1.65000
586	TU66	43	C	P	TRI	18.2	8.5	2.6	3.26923	2.14118
587	TU66	30	C	P	TRI	19.1	8.6	2.7	3.18519	2.22093
588	TU66	48	C	ABSENT	TRI	17.7	9.0	2.2	4.09091	1.96667
589	TU66	30	C	P	TRI	18.8	10.0	3.6	2.77778	1.88000
590	TU66	39	C	M	IRR	19.5	9.5	2.4	3.95833	2.05263
591	TU66	31	C	D	TRI	17.8	12.1	4.9	2.46939	1.47107
592	TU66	16	C	ABSENT	TRI	19.4	8.5	2.7	3.14815	2.28235
593	TU66	43	C	ABSENT	TRI	15.7	2.2	2.9	0.75862	7.13636
594	TU66	30	C	D	TRA	21.4	9.6	2.6	3.69231	2.22917
595	TU66	49	C	D	TRI	17.4	9.5	2.5	3.80000	1.83158
596	TU66	29	C	PMDL	TRI	21.3	12.5	4.1	3.04878	1.70400
597	TU66	48	C	P	TRI	23.7	8.3	4.5	1.84444	2.85542
598	TU66	16	C	PMDR	TRA	19.9	9.0	3.5	2.57143	2.21111
599	TU66	30	C	ABSENT	TRI	18.3	7.3	2.4	3.04167	2.50685
600	TU66	15	C	PD	TRI	19.9	8.2	3.3	2.48485	2.42683
601	TU66	44	C	PMD	TRI	20.8	8.8	5.7	1.54386	2.36364
602	TU66	16	C	PD	TRA	17.6	13.0	3.3	3.93939	1.35385
603	TU66	31	C	D	TRA	21.9	18.8	6.2	3.03226	1.16489
604	TU66	38	C	PMDR	TRI	15.8	7.7	1.9	4.05263	2.05195
605	TU66	43	C	D	TRI	16.6	9.3	3.5	2.65714	1.78495
606	TU66	14	C	P	TRA	17.4	13.0	3.6	3.61111	1.33846
607	TU66	15	C	PMD	TRA	25.0	13.0	5.5	2.36364	1.92308
608	TU66	42	C	D	TRI	17.3	9.6	2.1	4.57143	1.80208
609	TU66	14	C	P	TRI	15.7	7.5	3.7	2.02703	2.09333
610	TU66	44	C	D	TRA	14.7	8.8	2.7	3.25926	1.67045
611	TU66	14	C	MDL	TRI	17.5	9.8	3.2	3.06250	1.78571
612	TU66	47	C	P	TRA	25.2	12.4	3.7	3.35135	2.03226
613	TU66	38	C	D	TRI	17.2	12.3	3.0	4.10000	1.39837
614	TU66	30	C	ABSENT	TRI	17.8	7.3	1.9	3.84211	2.43836
615	TU66	33	C	M	TRI	15.5	8.2	3.1	2.64516	1.89024
616	TU66	41	C	D	TRI	17.0	8.6	3.6	2.38889	1.97674
617	TU66	41	C	P	IRR	16.9	11.4	2.4	4.75000	1.48246
618	TU66	44	C	MDR	TRI	17.8	8.3	4.2	1.97619	2.14458
619	TU66	20	C	PML	TRA	20.7	10.0	2.7	3.70370	2.07000
620	TU66	16	C	ABSENT	TRI	16.9	11.3	2.3	4.91304	1.49558
621	TU66	23	C	P	TRI	19.4	9.2	5.5	1.67273	2.10870

(continued)

Table A.2 (continued)

OBS	SITE	FSM	COND	CORTEX	XSECT	LENGTH	WIDTH	THICKNES	WDTH	LWD
622	TU66	44	C	ABSENT	TRI	16.9	9.1	2.1	4.33333	1.85714
623	TU66	45	C	PMD	CONVEX	22.9	10.9	3.3	3.30303	2.10092
624	TU66	14	C	PMDR	TRA	20.4	10.8	4.0	2.70000	1.88889
625	TU66	47	C	PMD	TRI	18.3	9.2	2.4	3.83333	1.98913
626	TU66	69	C	PMDR	TRI	23.5	11.1	3.8	2.92105	2.11712
627	TU66	12	C	PMDR	TRI	20.6	12.2	4.6	2.65217	1.68852
628	TU66	44	C	M	TRA	21.5	10.3	4.2	2.45238	2.08738
629	TU66	15	C	PMD	TRI	23.3	12.4	5.3	2.33962	1.87903
630	TU66	45	C	P	TRA	23.8	9.3	2.2	4.22727	2.55914
631	TU66	17	C	ABSENT	TRI	14.9	6.2	1.7	3.64706	2.40323
632	TU66	30	C	ABSENT	TRI	13.1	6.2	2.3	2.69565	2.11290
633	TU66	39	C	P	TRI	13.3	6.9	2.0	3.45000	1.92754
634	TU66	41	C	PMDL	TRI	15.0	6.3	1.6	3.93750	2.38095
635	TU66	15	C	PMD	TRI	22.6	10.0	4.1	2.43902	2.26000
636	TU66	69	C	PMD	TRI	15.3	6.4	3.6	1.77778	2.39063
637	TU66	33	C	PMDL	TRI	20.5	8.5	3.2	2.65625	2.41176
638	TU66	16	C	ABSENT	CONVEX	12.3	6.1	1.3	4.69231	2.01639
639	TU66	30	C	D	TRA	16.1	9.8	3.2	3.06250	1.64286
640	TU66	16	C	PMDL	TRA	17.2	7.6	3.8	2.00000	2.26316
641	TU66	15	C	MDL	TRI	16.5	9.3	3.0	3.10000	1.77419
642	TU66	31	C	PMDR	TRI	15.7	6.8	2.9	2.34483	2.30882
643	TU66	69	C	ABSENT	TRI	18.1	8.7	2.7	3.22222	2.08046
644	TU66	23	C	D	IRR	13.4	8.7	1.9	4.57895	1.54023
645	TU66	31	C	MDL	TRI	20.0	11.5	4.2	2.73810	1.73913
646	TU66	41	C	ABSENT	TRI	18.1	9.6	3.0	3.20000	1.88542
647	TU66	41	C	ABSENT	TRI	15.6	8.0	2.0	4.00000	1.95000
648	TU66	30	C	MDR	TRA	14.3	10.2	2.3	4.43478	1.40196
649	TU66	16	C	ABSENT	TRI	20.2	8.4	2.8	3.00000	2.40476
650	TU66	45	C	D	TRA	21.4	8.5	1.9	4.47368	2.51765
651	TU66	32	C	ABSENT	TRI	19.9	10.2	2.2	4.63636	1.95098
652	TU66	22	C	PMDL	TRI	22.5	11.7	4.2	2.78571	1.92308
653	TU66	43	C	P	TRI	15.1	8.8	2.5	3.52000	1.71591
654	TU66	16	C	PML	TRI	20.7	11.3	4.1	2.75610	1.83186
655	TU66	15	C	PMD	TRI	15.2	8.1	2.1	3.85714	1.87654
656	TU66	31	C	PMD	CONVEX	17.2	7.4	2.6	2.84615	2.32432
657	TU66	41	C	PMD	TRI	19.6	8.0	4.4	1.81818	2.45000
658	TU66	69	C	ABSENT	TRI	13.6	7.7	2.1	3.66667	1.76623
659	TU66	65	C	PMD	TRI	19.1	8.1	2.3	3.52174	2.35802
660	TU66	23	C	PMD	CONVEX	21.5	10.3	5.5	1.87273	2.08738
661	TU66	43	C	PMD	CONVEX	17.4	9.0	3.0	3.00000	1.93333
662	TU66	14	C	ABSENT	TRA	15.8	9.2	2.4	3.83333	1.71739
663	TU66	16	C	PMD	TRI	22.7	7.1	3.7	1.91892	3.19718
664	TU66	41	C	PMDL	TRI	22.4	7.8	3.1	2.51613	2.87179
665	TU66	31	C	PMDR	TRI	15.2	8.7	3.0	2.90000	1.74713

(continued)

Table A.2 (continued)

OBS	SITE	FSM	COND	CORTEX	XSECT	LENGTH	WIDTH	THICKNES	WDTH	LWD
666	TU66	15	C	PMD	TRI	16.6	10.1	2.7	3.74074	1.64356
667	TU66	31	C	ABSENT	TRI	23.3	10.2	2.9	3.51724	2.28431
668	TU66	31	C	PMD	TRI	21.1	8.6	2.3	3.73913	2.45349
669	TU66	41	C	PMD	CONVEX	23.4	7.5	3.1	2.41935	3.12000
670	TU66	16	C	PMD	CONVEX	21.2	8.2	3.9	2.10256	2.58537
671	TU66	43	C	D	TRA	19.3	11.3	2.9	3.89655	1.70796
672	TU66	31	C	PMDR	TRI	20.8	9.3	4.1	2.26829	2.23656
673	TU66	16	C	ABSENT	TRI	17.2	9.5	2.5	3.80000	1.81053
674	TU66	45	C	ABSENT	TRI	19.5	8.5	3.3	2.57576	2.29412
675	TU66	39	C	ABSENT	TRI	16.4	8.5	3.2	2.65625	1.92941
676	TU66	30	C	PMD	CONVEX	21.7	8.5	4.2	2.02381	2.55294
677	TU66	41	C	P	TRA	14.1	8.6	2.2	3.90909	1.63953
678	TU66	16	C	ABSENT	TRI	18.5	9.8	4.6	2.13043	1.88776
679	TU66	16	D	ABSENT	TRI	11.8	7.8	2.6	3.00000	1.51282
680	TU66	15	D	D	TRI	12.5	11.3	2.7	4.18519	1.10619
681	TU66	47	M	ABSENT	TRI	13.9	7.7	2.7	2.85185	1.80519
682	TU66	29	M	ABSENT	TRI	12.8	7.3	2.0	3.65000	1.75342
683	TU66	14	M	M	TRI	13.5	8.1	2.5	3.24000	1.66667
684	TU66	14	M	ABSENT	TRI	10.7	8.3	3.3	2.51515	1.28916
685	TU66	41	M	ABSENT	TRI	12.9	7.3	3.9	1.87179	1.76712
686	TU66	44	M	ABSENT	TRI	11.1	12.1	2.2	5.50000	0.91736
687	TU66	44	M	ABSENT	TRI	15.1	8.1	2.5	3.24000	1.86420
688	TU66	19	M	M	TRI	16.5	8.1	4.3	1.88372	2.03704
689	TU66	45	M	ABSENT	TRI	11.8	7.5	2.0	3.75000	1.57333
690	TU66	14	MD	D	TRI	21.2	9.5	4.4	2.15909	2.23158
691	TU66	49	MD	D	TRI	23.5	9.9	3.6	2.75000	2.37374
692	TU66	30	MD	ABSENT	TRI	18.0	8.0	3.4	2.35294	2.25000
693	TU66	16	MD	MD	TRI	21.5	9.1	2.8	3.25000	2.36264
694	TU66	15	MD	D	TRI	17.5	8.7	2.1	4.14286	2.01149
695	TU66	41	MD	MD	TRI	18.0	6.4	3.3	1.93939	2.81250
696	TU66	31	MD	ABSENT	TRI	20.1	6.7	4.8	1.39583	3.00000
697	TU66	23	MD	MD	TRI	13.3	6.2	2.4	2.58333	2.14516
698	TU66	51	MD	D	TRI	19.9	11.6	2.5	4.64000	1.71552
699	TU66	29	MD	M	TRI	16.4	8.6	4.1	2.09756	1.90698
700	TU66	14	MD	MD	TRI	18.0	7.2	2.9	2.48276	2.50000
701	TU66	23	MD	MD	TRI	13.5	8.1	1.9	4.26316	1.66667
702	TU66	41	MD	D	TRI	17.2	7.3	2.5	2.92000	2.35616
703	TU66	16	MD	ABSENT	TRI	16.4	7.4	2.3	3.21739	2.21622
704	TU66	14	MD	MD	TRI	18.5	9.0	3.0	3.00000	2.05556
705	TU66	15	MD	ABSENT	TRI	16.1	8.1	2.6	3.11538	1.98765
706	TU66	44	MD	ABSENT	TRI	12.6	7.5	1.7	4.41176	1.68000
707	TU66	69	MD	ABSENT	TRI	16.1	7.7	2.3	3.34783	2.09091
708	TU66	16	MD	MD	TRI	17.7	7.9	4.1	1.92683	2.24051
709	TU66	29	MD	D	TRA	17.8	9.5	3.2	2.96875	1.87368

(continued)

Table A.2 (continued)

OBS	SITE	FSM	COND	CORTEX	XSECT	LENGTH	WIDTH	THICKNES	WDTH	LWD
710	TU66	29	MD	D	TRI	15.0	7.3	2.0	3.65000	2.05479
711	TU66	12	MD	ABSENT	TRI	18.3	11.0	3.6	3.05556	1.66364
712	TU66	38	MD	D	TRA	18.7	8.1	3.1	2.61290	2.30864
713	TU66	31	MD	MD	TRI	17.4	8.0	4.6	1.73913	2.17500
714	TU66	38	MD	ABSENT	TRI	21.1	10.8	3.0	3.60000	1.95370
715	TU66	15	P	ABSENT	TRI	15.3	10.1	1.9	5.31579	1.51485
716	TU66	44	P	ABSENT	TRI	11.1	8.7	2.5	3.48000	1.27586
717	TU66	16	P	ABSENT	TRI	9.4	7.2	1.8	4.00000	1.30556
718	TU66	12	P	ABSENT	TRI	8.0	7.3	1.8	4.05556	1.09589
719	TU66	41	P	ABSENT	TRI	12.1	7.2	2.0	3.60000	1.68056
720	TU66	12	P	ABSENT	TRI	11.9	9.6	2.2	4.36364	1.23958
721	TU66	17	P	ABSENT	TRA	9.3	8.8	1.9	4.63158	1.05682
722	TU66	12	P	ABSENT	TRI	12.0	8.1	1.3	6.23077	1.48148
723	TU66	29	P	P	TRI	13.0	11.3	3.0	3.76667	1.15044
724	TU66	26	P	ABSENT	TRI	11.0	9.8	2.1	4.66667	1.12245
725	TU66	15	P	ABSENT	TRI	15.3	12.3	2.6	4.73077	1.24390
726	TU66	41	P	ABSENT	TRI	12.2	9.5	3.2	2.96875	1.28421
727	TU66	18	P	ABSENT	TRI	8.1	13.1	2.9	4.51724	0.61832
728	TU66	35	PM	PM	TRA	21.1	9.0	3.1	2.90323	2.34444
729	TU66	16	PM	M	TRI	16.6	8.3	2.3	3.60870	2.00000
730	TU66	15	PM	PM	TRA	15.1	6.5	2.4	2.70833	2.32308
731	TU66	14	PM	P	TRI	15.8	7.7	1.8	4.27778	2.05195
732	TU66	23	PM	M	CONVEX	15.3	8.4	1.7	4.94118	1.82143
733	TU66	24	PM	P	TRI	15.3	8.9	2.6	3.42308	1.71910
734	TU66	52	PM	PM	TRI	12.3	9.5	2.4	3.95833	1.29474
735	TU66	31	PM	ABSENT	TRI	15.6	8.8	1.8	4.88889	1.77273
736	TU66	48	PM	PM	TRI	19.1	9.2	3.0	3.06667	2.07609
737	TU66	24	PM	ABSENT	TRI	17.8	9.0	2.2	4.09091	1.97778
738	TU66	29	PM	ABSENT	TRI	12.0	7.8	2.4	3.25000	1.53846
739	TU66	38	PM	ABSENT	TRI	12.2	8.3	1.9	4.36842	1.46988
740	TU66	44	PM	ABSENT	CONVEX	13.6	6.7	1.8	3.72222	2.02985
741	TU66	14	PM	PM	IRR	12.5	9.8	2.7	3.62963	1.27551
742	TU66	16	PM	ABSENT	TRI	17.	9.1	4.3	2.11628	1.90110
743	TU66	44	PM	P	TRI	19.1	8.0	4.7	1.70213	2.38750
744	TU66	51	PM	ABSENT	IRR	13.8	11.4	1.6	7.12500	1.21053
745	TU66	14	PM	PM	TRI	13.0	10.7	3.2	3.34375	1.21495

Table A.3 Key

MORPH - morphological category for reduction trajectory:

STAGE1 - Group 1 in classification typology

STAGE2 - Group 2 in classification typology

COND - breakage condition

Condition and Cortex attributes the same for Table A.2; ND - no data.

XSECT - medial cross-section:

TRI - triangular
RHO - rhomboidal
TRA - trapezoidal
BICON - biconvex
ND - no data

MAXLENGT - maximum length

MAXWIDTH - maximum width

MAXTHICK - maximum thickness

Table A.3. Unfinished Bit-tool Attributes

OBS	SITE	FSM	CATALOGN	MORPH	COND	CORTEX	XSECT	MAXLENGT	MAXWIDTH	MAXTHICK	WEIGHT
1	HA15	22	5	STAGE2	D	ND	TRI	17.7	8.3	[illegible]	[illegible]
2	HA7	46	8	STAGE1	MD	ND	RHO	20.5	9.6	5.3	[illegible]
3	HA7	46	6	STAGE2	M	ND	RHO	11.2	9.8	6.0	[illegible]
4	HA7	49	8	STAGE2	MP	P	TRI	13.9	9.7	3.6	0.6
5	HA7	46	7	STAGE2	MP	ND	RHO	14.4	8.5	4.0	[illegible]
6	HA8	123	1	STAGE1	MP	MP	ND	22.2	10.7	7.2	1.4
7	HA8	256	1	STAGE1	P	ND	ND	20.3	10.5	4.4	[illegible]
8	HA8	189	3	STAGE2	M	ND	ND	19.0	10.4	3.2	0.6
9	HA8	189	4	STAGE2	MD	MD	ND	20.5	10.3	5.4	[illegible]
10	HA8	189	5	STAGE2	M	ND	ND	12.0	9.3	3.2	0.3
11	HA8	189	6	STAGE2	M	M	ND	16.1	11.2	3.5	0.5
12	HA8	142	1	STAGE2	MP	ND	ND	18.5	9.9	6.4	[illegible]
13	HA8	259	1	STAGE2	MP	ABSENT	ND	22.2	7.9	[illegible]	[illegible]
14	HA8	109	2	STAGE2	MD	D	ND	14.4	8.7	2.3	[illegible]
15	HA8	54	1	STAGE2	M	ND	ND	17.2	8.7	[illegible]	[illegible]
16	HA8	267	2	STAGE2	MP	ND	ND	19.7	10.5	[illegible]	[illegible]
17	HA92	32	16	STAGE1	C	P	TRI	34.3	9.8	8.0	2.6
18	HA92	28	3	STAGE1	D	ND	TRI	15.4	12.3	[illegible]	[illegible]
19	HA92	37	11	STAGE1	MP	ND	TRI	25.0	9.5	7.0	[illegible]
20	HA92	23	9	STAGE1	MP	ND	BICON	22.2	11.3	8.3	[illegible]
21	HA92	22	3	STAGE1	D	ND	TRA	11.1	13.1	6.1	1.2
22	HA92	8	16	STAGE2	M	ND	ND	13.7	6.2	3.0	[illegible]
23	HA92	21	17	STAGE2	D	ND	TRI	19.5	7.3	4.5	[illegible]
24	HA92	11	22	STAGE2	M	M	BICON	16.4	9.3	5.9	[illegible]
25	HA92	22	16	STAGE2	D	ND	TRI	15.3	11.2	5.5	[illegible]
26	HA92	45	5	STAGE2	M	ND	TRI	22.7	10.3	7.2	[illegible]
27	TUM5	1	13	STAGE2	MP	P	RHO	19.9	10.1	4.8	[illegible]
28	TU2	15	6	STAGE1	M	ND	BICON	15.8	11.9	4.2	[illegible]
29	TU2	4	6	STAGE2	M	ND	TRI	17.1	9.4	4.0	[illegible]
30	TU2	28	2	STAGE2	M	ND	RHO	16.6	8.9	[illegible]	[illegible]
31	TU2	5	2	STAGE2	MP	P	BICON	15.4	9.4	[illegible]	[illegible]
32	TU2	3	5	STAGE2	MP	ND	TRA	11.7	6.3	2.6	0.2
33	TU259	8	34	STAGE1	D	ND	TRI	16.4	10.6	6.0	[illegible]
34	TU259	16	3	STAGE1	M	M	ND	21.3	8.3	6.5	[illegible]
35	TU259	8	30	STAGE1	M	ND	ND	12.2	10.2	4.5	[illegible]
36	TU259	6	30	STAGE1	MP	ND	ND	12.9	9.0	4.9	[illegible]
37	TU259	5	27	STAGE1	MP	P	ND	18.3	.	5.5	[illegible]
38	TU259	6	33	STAGE1	M	ND	ND	13.4	8.8	[illegible]	[illegible]
39	TU259	5	22	STAGE1	M	ND	BICON	15.6	11.0	[illegible]	[illegible]
40	TU259	8	32	STAGE1	P	P	ND	12.6	11.6	[illegible]	[illegible]
41	TU259	16	7	STAGE2	P	P	TRI	12.8	11.9	[illegible]	[illegible]
42	TU259	6	34	STAGE2	M	ND	ND	15.1	.	.	[illegible]
43	TU259	8	31	STAGE2	M	ND	BICON	12.7	6.9	2.5	[illegible]
44	TU259	12	23	STAGE2	M	ND	ND	24.9	11.1	[illegible]	[illegible]
45	TU346	9	10	STAGE1	M	ND	ND	8.1	9.3	[illegible]	[illegible]
46	TU346	9	11	STAGE2	M	ND	ND	11.4	8.1	[illegible]	[illegible]

Table A.3 (continued)

OBS	SITE	FSM	CATALOGN	MORPH	COND	CORTEX	XSECT	MAXLENGT	MAXWIDTH	MAXTHICK	WEIGHT
47	TU346	9	1	STAGE2	MP	P	BICON	16.7	10.7	4.1	0.7
48	TU346	9	2	STAGE2	MP	P	BICON	22.1	10.2	4.1	0.9
49	TU56	28	7	STAGE1	M	M	RHO	23.1	12.5	11.0	2.6
50	TU56	22	13	STAGE2	MP	P	RHO	15.5	8.3	4.6	0.8
51	TU59	1	6	STAGE1	M	ND	TRI	18.1	10.4	4.9	1.0
52	TU62	1	2	STAGE1	MP	P	RHO	17.9	10.4	5.7	0.9
53	TU65	8	11	STAGE1	M	ND	TRI	16.0	6.5	5.9	0.5
54	TU65	9	16	STAGE1	M	ND	ND	18.7	8.0	5.7	0.8
55	TU65	1	25	STAGE2	M	ND	BICON	14.9	8.9	3.2	0.4
56	TU65	16	35	STAGE2	MD	M	BICON	15.4	9.4	2.7	0.5
57	TU66	61	1	STAGE1	M	ND	TRI	20.2	6.8	9.2	1.1
58	TU66	14	3	STAGE1	M	ND	RHO	14.8	10.6	8.0	1.3
59	TU66	22	2	STAGE1	M	M	BICON	19.5	9.6	5.7	1.1
60	TU66	29	4	STAGE1	M	ND	ND	15.7	7.6	5.6	0.7
61	TU66	44	39	STAGE1	MP	MP	RHO	23.8	9.4	7.2	1.7
62	TU66	39	4	STAGE1	MP	M	ND	25.5	10.0	8.6	1.3
63	TU66	39	5	STAGE1	MD	D	BICON	20.8	.	3.3	0.5
64	TU66	39	6	STAGE1	MP	P	BICON	17.9	11.6	4.3	[illegible]
65	TU66	44	3	STAGE2	MD	ND	TRI	19.4	10.5	5.4	[illegible]
66	TU66	29	2	STAGE2	M	ND	RHO	10.5	8.4	4.4	[illegible]
67	TU66	44	5	STAGE2	M	ND	BICON	15.5	7.4	3.8	[illegible]
68	TU66	41	42	STAGE2	M	ND	TRI	20.6	8.5	5.0	0.9
69	TU66	22	7	STAGE2	MP	P	TRI	20.3	11.2	5.2	[illegible]
70	TU66	39	3	STAGE2	MP	P	RHO	20.4	8.4	4.8	[illegible]
71	TU66	15	33	STAGE2	MP	ND	TRI	22.8	9.4	6.2	1.3
72	TU66	69	32	STAGE2	P	ND	BICON	13.9	10.4	7.3	1.1
73	TU66	45	4	STAGE2	MP	ND	TRI	21.4	8.1	5.3	1.0
74	TU66	1	4	STAGE2	D	ND	BICON	13.4	8.6	3.9	0.4
75	TU66	45	29	STAGE2	P	ND	BICON	16.7	10.7	3.9	0.7
76	TU66	45	28	STAGE2	P	ND	RHO	20.5	11.4	6.5	1.2
77	TU66	31	17	STAGE2	MP	ND	BICON	17.3	9.9	4.5	0.8
78	TU66	49	4	STAGE2	M	ND	TRI	17.6	9.2	7.2	[illegible]
79	TU66	45	5	STAGE2	P	ND	BICON	12.6	8.0	3.3	[illegible]
80	TU66	16	36	STAGE2	M	ND	ND	13.4	.	3.3	[illegible]
81	TU66	31	5	STAGE2	M	ND	BICON	9.3	10.2	4.2	[illegible]
82	TU66	39	7	STAGE2	MP	ND	TRI	17.1	13.4	[illegible]	[illegible]

Table A.4 Key

MORPH1 - classification subtype and group:

- BICON 1 - biconvex, group-1
- BICON 2 - biconvex, group-2
- CYLIND - cylindrical
- BLDUNFL - blade with unifacial, lateral retouch
- BIFACFLK - bifacial flake
- BLDUNFD - blade with unifacial, distal (end) retouch
- FLAKEBIF - bifacially retouched flake
- FLAKUNIF - unifacially retouched flake

MORPH2 - classification type (blade/flake; fragment)

Condition attributes the same as for preceding tables

XSECT - cross-section of bit:

- R - rhomboidal
- C - cylindrical
- T - triangular
- B - biconvex
- ND - no data

USE-WEAR:

- DH - dry hide
- SWKD - shell, weak linkage; drill
- SMD - shell, moderate linkage; drill
- SWD - shell, well-developed; drill
- BD - bone; drill
- BG - bone graver
- SBD - shell/bone; drill
- SBG - shell/bone; graver
- SMG - shell, moderate linkage; graver
- SWKG - shell, weak linkage; graver
- SMDG - shell, moderate linkage; drill/graver
- SWKDG - shell, weak linkage; drill/graver
- SBDG - shell/bone; drill/graver

Table A.4 Key (cont.)

SWKI - shell, weak linkage; indeterminate action
SI - shell, indeterminate action
SBI - shell/bone; indeterminate action
W/H - wood/hide; indeterminate action
WM - wood; medial fragment
WP - wood/fiber; proximal fragment, haft wear
S/WG - shell/wood; graver
IG - indeterminate; graver action
ID - indeterminate; drill action
I - indeterminate
ND - no data

Table A.4. Bit-tool Morphological and Functional Attributes

OBS	SITE	FSM	CATALOGN	MORPH1	MORPH2	COND	XSECT	USE-WEAR
1	HAM6	19		BLDUNFL	BLADE	C	R	DH
2	HAM8	11	4	BICON 2	BLADE	C	C	SMD
3	HA7	33	3	TRIANGLE	FLAKE	P	C	SWKI
4	HA7	49	9	BICON 2	BLADE	MP	R	SWKD
5	HA7	49	10	BICON 2	BLADE	C	R	SWKD
6	HA7	46	5	CYLIND	BLADE	C	C	SWKD
7	HA7	50	7	FRAGMENT	FRAGMENT	MP	ND	BD
8	HA8	189	1	BICON 2	BLADE	C	T	SWKD
9	HA8	189	2	TRIANGLE	FLAKE	MP	R	SWKD
10	HA8	123	2	BIFACFLK	FLAKE	MP	ND	SBG
11	HA8	209	1	CYLIND	BLADE	D	C	SWD
12	HA8	270	1	BICON 2	BLADE	MP	R	SWKD
13	HA8	256	2	BICON 1	BLADE	C	T	SWKD
14	HA8	75	1	BICON 2	BLADE	MP	R	SWKD
15	HA8	91	2	BICON 1	BLADE	C	T	SWKG
16	HA8	267	1	BICON 2	BLADE	MP	R	SWD
17	HA8	233	1	CYLIND	BLADE	MD	R	SWD
18	HA8	262	1	BICON 2	BLADE	MP	R	SWKI
19	HA8	27	1	CYLIND	BLADE	C	R	SWKD
20	HA8	270	2	BLDUNFD	BLADE	C	T	W/H
21	HA8	118	1	TRIANGLE	FLAKE	C	B	I
22	HA8	91	1	FLAKUNIF	FLAKE	C	R	SWD
23	HA92	22	12	CYLIND	BLADE	C	C	SWKD
24	HA92	25	13	TRIANGLE	FLAKE	MP	B	BG
25	HA92	13	9	TRIANGLE	FLAKE	MP	C	SWKD
26	HA92	16	33	FLAKEBIF	FLAKE	C	C	SWD
27	HA92	4	9	FLAKEBIF	FLAKE	C	C	SBD
28	HA92	43	13	BICON 2	BLADE	C	C	BD
29	HA92	31	15	FLAKEBIF	FLAKE	C	C	SWKG
30	HA92	11	21	CYLIND	BLADE	MP	ND	IG
31	HA92	7	5	FRAGMENT	FRAGMENT	MP	ND	WP
32	HA92	36	12	BICON 1	BLADE	MD	C	SBD
33	HA92	46	6	BICON 2	BLADE	MP	C	SBD
34	HA92	1	10	FRAGMENT	FRAGMENT	M	C	SWKD
35	HA92	17	9	FRAGMENT	FRAGMENT	P	ND	WP
36	HA92	22	14	CYLIND	BLADE	C	C	SMD
37	HA92	40	6	BLDUNFL	BLADE	C	R	ND
38	HA92	32	19	BICON 1	BLADE	C	T	SMG
39	TU2	15	5	BICON 1	BLADE	MP	C	SWKI
40	TU2	19	1	FRAGMENT	FRAGMENT	C	C	SBD
41	TU2	3	3	BICON 2	BLADE	MP	R	SWKD
42	TU2	13	3	BICON 1	BLADE	MD	C	SWKD
43	TU2	35	5	BICON 2	BLADE	MP	R	WP

(continued)

Table A.4 (continued)

OBS	SITE	FSM	CATALOGN	MORPH1	MORPH2	COND	XSECT	USE-WEAR
44	TU2	11	1	FRAGMENT	FRAGMENT	MD	B	SI
45	TU259	12	27	BICON 2	BLADE	C	C	SMD
46	TU259	5	21	BICON 1	BLADE	MP	ND	SWKD
47	TU259	12	26	CYLIND	BLADE	M	T	SWD
48	TU259	13	28	CYLIND	BLADE	P	ND	SMDG
49	TU259	12	25	CYLIND	BLADE	MP	ND	I
50	TU259	8	27	CYLIND	BLADE	D	C	SWD
51	TU259	8	28	TRIANGLE	FLAKE	MD	C	SWD
52	TU259	14	26	FLAKUNIF	FLAKE	MP	C	SMD
53	TU259	12	24	CYLIND	BLADE	MP	R	SWKI
54	TU259	5	20	FLAKUNIF	FLAKE	C	B	SG
55	TU346	10	1	TRIANGLE	FLAKE	MP	C	ID
56	TU346	17	1	TRIANGLE	FLAKE	C	C	SWKD
57	TU346	7	4	BICON 2	BLADE	C	C	SWD
58	TU346	7		FRAGMENT	FRAGMENT	MD	B	SMG
59	TU398	3	1	CYLIND	BLADE	MD	C	SWD
60	TU46	8	11	CYLIND	BLADE	C	C	SMD
61	TU46	14	5	BICON 1	BLADE	C	T	IG
62	TU46	14	2	FRAGMENT	FRAGMENT	MD	B	DH
63	TU48	CC		CYLIND	BLADE	MD	T	SWD
64	TU58	CC	6	BICON 2	BLADE	MP	R	SMD
65	TU58	CC	14	FRAGMENT	FRAGMENT	MD	T	I
66	TU62	1	1	FRAGMENT	FRAGMENT	MP	ND	ND
67	TU65	1	28	CYLIND	BLADE	C	C	SWD
68	TU65	6	18	FRAGMENT	FRAGMENT	M	ND	SWKD
69	TU66	1	6	TRIANGLE	FLAKE	C	B	I
70	TU66	16	33	TRIANGLE	FLAKE	MP	B	SWKG
71	TU66	51	5	TRIANGLE	FLAKE	MP	B	SBDG
72	TU66	31	11	TRIANGLE	FLAKE	C	C	SWD
73	TU66	44	22	BICON 2	BLADE	C	R	SWKD
74	TU66	45	27	BICON 2	BLADE	MP	C	SWKD
75	TU66	38	13	BICON 1	BLADE	MP	C	SWKD
76	TU66	43	13	BICON 2	BLADE	C	C	SWKD
77	TU66	42	9	BICON 2	BLADE	C	C	ID
78	TU66	17	6	BICON 2	BLADE	MP	C	SWKD
79	TU66	68	6	BICON 1	BLADE	C	C	SWKD
80	TU66	13	5	BICON 2	BLADE	MD	C	SBD
81	TU66	44	21	FLAKEBIF	FLAKE	C	C	SWD
82	TU66	14	21	BICON 2	BLADE	MP	C	SBD
83	TU66	17	3	BICON 2	BLADE	P	ND	SWKI
84	TU66	21	6	CYLIND	BLADE	C	C	SWKDG
85	TU66	45	16	BICON 1	BLADE	MP	C	SWD
86	TU66	14	20	CYLIND	BLADE	M	ND	WM
87	TU66	47	16	BICON 2	BLADE	M	ND	WP
88	TU66	65	16	FRAGMENT	FRAGMENT	M	C	SBI
89	TU66	49	12	CYLIND	BLADE	MP	ND	WP

(continued)

Table A.4 (continued)

OBS	SITE	FSM	CATALOGN	MORPH1	MORPH2	COND	XSECT	USE-WEAR
90	TU66	45	15	FRAGMENT	FRAGMENT	MD	C	SWKD
91	TU66	41	34	FRAGMENT	FRAGMENT	MD	C	SBD
92	TU66	30	18	BICON 1	BLADE	MD	R	BD
93	TU66	31	13	CYLIND	BLADE	D	C	SBD
94	TU66	24	4	FRAGMENT	FRAGMENT	MD	C	SBD
95	TU66	69	33	BICON 1	BLADE	MP	R	SWKD
96	TU66	30	19	BICON 1	BLADE	MD	R	SWKD
97	TU66	43	18	TRIANGLE	FLAKE	MP	ND	ND
98	TU66	49	19	FLAKEBIF	FLAKE	C	R	SBD
99	TU66	45	22	TRIANGLE	FLAKE	P	ND	SWKD
100	TU66	47	11	BICON 1	BLADE	MD	T	SMD
101	TU66	16	29	FRAGMENT	FRAGMENT	MD	B	I
102	TU66	65	2	FRAGMENT	FRAGMENT	MD	B	IG
103	TU66	15	3	BICON 1	BLADE	C	T	S/WG
104	TU66	16		FLAKEBIF	FLAKE	MD	R	W/H
105	TU66	49	23	FLAKUNIF	FLAKE	C	T	DH

Table A.5 Key

MAXLENGTH - maximum length

MAXWIDTH - maximum width

MAXTHICK - maximum thickness

Table A.5. Bit-tool Metric Attributes

OBS	SITE	FSM	CATALOGN	MAXLENGTH	MAXWIDTH	MAXTHICK	WEIGHT
1	HAM6	19		23.1	7.2	3.7	1.0
2	HAM8	11	4	26.8	7.7	5.4	1.0
3	HA7	33	3	12.4	14.4	4.0	0.5
4	HA7	49	9	14.1	9.7	3.8	0.4
5	HA7	49	10	18.3	8.4	4.5	0.5
6	HA7	46	5	20.4	6.0	5.1	0.6
7	HA7	50	7	21.6	8.0	5.1	0.9
8	HA8	189	1	24.7	9.4	6.0	1.1
9	HA8	189	2	16.3	13.5	4.2	0.7
10	HA8	123	2	27.3	10.3	7.0	1.6
11	HA8	209	1	14.6	6.6	4.9	0.5
12	HA8	270	1	17.1	10.1	5.4	0.8
13	HA8	256	2	21.2	6.6	4.6	0.6
14	HA8	75	1	21.5	8.2	3.4	0.5
15	HA8	91	2	22.3	7.4	4.3	0.6
16	HA8	267	1	26.1	8.8	3.9	0.8
17	HA8	233	1	18.5	7.4	5.3	0.6
18	HA8	262	1	17.1	9.2	4.8	0.8
19	HA8	27	1	27.0	6.5	5.1	0.7
20	HA8	270	2	25.0	9.7	5.1	1.3
21	HA8	118	1	21.0	13.3	4.9	1.0
22	HA8	91	1	19.4	7.7	3.1	0.6
23	HA92	22	12	20.5	7.7	4.0	0.8
24	HA92	25	13	16.9	9.3	2.9	0.5
25	HA92	13	9	13.6	9.8	4.1	0.3
26	HA92	16	33	16.6	10.6	4.9	0.7
27	HA92	4	9	15.2	8.9	4.0	0.5
28	HA92	43	13	16.2	8.1	4.0	0.4
29	HA92	31	15	17.2	8.5	2.9	0.4
30	HA92	11	21	17.5	8.5	7.3	0.8
31	HA92	7	5	18.4	7.1	5.7	0.6
32	HA92	36	12	22.1	6.8	3.9	0.6
33	HA92	46	6	23.3	10.0	4.5	1.1
34	HA92	1	10	10.3	8.6	3.6	0.3
35	HA92	17	9	13.6	7.4	3.6	0.3
36	HA92	22	14	34.4	7.5	4.8	1.0
37	HA92	40	6	25.7	8.0	4.6	1.4
38	HA92	32	19	25.1	6.8	4.4	0.8
39	TU2	15	5	25.5	7.1	3.9	0.7
40	TU2	19	1	13.9	8.4	4.5	0.4
41	TU2	3	3	15.8	8.5	2.9	0.4
42	TU2	13	3	15.5	7.2	4.1	0.3
43	TU2	35	5	19.0	9.4	4.3	0.8
44	TU2	11	1	11.5	8.0	3.4	0.3
45	TU259	12	27	21.7	11.0	4.4	0.8

(continued)

Table A.5 (continued)

OBS	SITE	FSM	CATALOGN	MAXLENTH	MAXWIDTH	MAXTHICK	WEIGHT
46	TU259	5	21	21.3	6.3	4.6	0.6
47	TU259	12	26	12.7	5.3	4.5	0.3
48	TU259	13	28	15.1	7.0	4.6	0.5
49	TU259	12	25	18.7	7.1	5.1	0.6
50	TU259	8	27	13.5	5.9	4.1	0.4
51	TU259	8	28	13.3	10.3	3.7	0.4
52	TU259	14	26	14.2	7.4	2.8	0.2
53	TU259	12	24	20.7	7.4	4.6	0.7
54	TU259	5	20	22.0	10.9	4.9	1.1
55	TU346	10	1	16.5	11.9	3.1	0.5
56	TU346	17	1	20.1	11.7	6.1	1.2
57	TU346	7	4	17.5	10.3	4.4	0.6
58	TU346	7		11.6	10.5	3.4	0.5
59	TU398	3	1	20.0	5.8	3.7	0.5
60	TU46	8	11	17.0	6.4	5.1	0.5
61	TU46	14	5	24.3	10.8	5.7	1.4
62	TU46	14	2	16.1	12.7	4.9	1.0
63	TU48	CC		21.6	6.4	5.0	0.7
64	TU58	CC	6	22.1	8.4	4.1	0.6
65	TU58	CC	14	16.7	5.2	4.7	0.5
66	TU62	1	1	19.0	9.2	6.0	1.2
67	TU65	1	28	18.2	6.5	5.0	0.6
68	TU65	6	18	15.9	6.7	3.2	0.5
69	TU66	1	6	17.3	11.7	3.6	0.6
70	TU66	16	33	19.6	13.7	4.7	0.7
71	TU66	51	5	17.7	12.0	3.0	0.4
72	TU66	31	11	17.2	14.7	3.5	0.5
73	TU66	44	22	20.9	9.2	4.2	0.5
74	TU66	45	27	14.9	9.0	3.1	0.4
75	TU66	38	13	17.2	7.5	3.9	0.4
76	TU66	43	13	19.7	8.8	3.1	0.4
77	TU66	42	9	22.2	9.5	3.3	0.6
78	TU66	17	6	23.2	8.3	4.9	0.7
79	TU66	68	6	24.9	7.4	5.2	0.9
80	TU66	13	5	19.6	7.7	4.0	0.5
81	TU66	44	21	15.7	8.7	4.4	0.5
82	TU66	14	21	20.2	8.1	3.9	0.6
83	TU66	17	3	13.1	8.7	3.6	0.4
84	TU66	21	6	28.2	6.6	4.4	0.8
85	TU66	45	16	21.0	7.0	5.0	0.6
86	TU66	14	20	19.5	5.3	4.1	0.5
87	TU66	47	16	12.4	8.2	5.1	0.6
88	TU66	65	16	17.5	8.5	4.8	0.7

(continued)

Table A.5 (continued)

OBS	SITE	FSM	CATALOGN	MAXLENGTH	MAXWIDTH	MAXTHICK	WEIGHT
89	TU66	49	12	19.1	8.3	5.6	0.9
90	TU66	45	15	22.0	11.3	4.1	0.9
91	TU66	41	34	16.1	8.4	3.6	0.4
92	TU66	30	18	16.2	6.8	3.7	0.4
93	TU66	31	13	16.9	7.3	5.0	0.6
94	TU66	24	4	12.8	9.1	3.2	0.3
95	TU66	69	33	17.4	7.7	4.4	0.6
96	TU66	30	19	17.7	7.5	4.7	0.6
97	TU66	43	18	15.5	11.2	5.2	0.8
98	TU66	49	19	13.9	9.7	3.8	0.5
99	TU66	45	22	16.7	12.0	7.7	1.1
100	TU66	47	11	17.6	9.6	3.8	0.8
101	TU66	16	29	13.5	8.9	3.1	0.4
102	TU66	65	2	14.9	.	4.4	0.5
103	TU66	15	3	22.8	10.4	8.0	1.2
104	TU66	16		21.0	12.6	3.4	0.8
105	TU66	49	23	19.3	8.5	4.4	0.7

Table A.6 Key

DISTLENG - distal length

DISTWIDT - distal width

DISTTHIC - distal thickness

PROXLENG - proximal length

PROXWIDT - proximal width

PROXTHIC - proximal thickness

Table A.6. Bit-tool Metric Attributes - Distal and Proximal

OBS	SITE	FSM	CATALOGN	DISTLENG	DISTWIDT	DISTTHIC	PROXLENG	PROXWIDT	PROXTHIC
1	HAM6	19		.	.	3.3	.	6.5	3.1
2	HAM8	11	4	8.3	3.7	3.1	18.5	7.7	5.4
3	HA7	33	3	2.6	3.3	3.1	9.8	14.4	4.0
4	HA7	49	9	7.1	4.5	3.8	7.0	9.7	2.5
5	HA7	49	10	7.0	4.7	3.2	11.3	8.4	4.5
6	HA7	46	5	11.6	5.6	5.1	8.8	6.0	3.0
7	HA7	50	7	.	.	.	.	.	.
8	HA8	189	1	7.0	3.0	2.0	17.7	9.4	6.0
9	HA8	189	2	.	3.1	2.4	9.4	13.5	4.2
10	HA8	123	2	7.2	3.3	2.4	20.1	10.3	7.0
11	HA8	209	1	.	.	.	.	.	.
12	HA8	270	1	.	.	.	.	10.1	5.4
13	HA8	256	2	7.2	3.6	2.8	14.0	6.6	4.6
14	HA8	75	1	.	3.5	3.0	15.3	8.2	2.7
15	HA8	91	2	11.1	3.0	3.0	11.2	7.4	4.3
16	HA8	267	1	.	3.6	3.1	12.0	8.8	3.9
17	HA8	233	1	7.0	3.8	4.0	.	.	.
18	HA8	262	1	.	5.7	4.1	.	.	.
19	HA8	27	1	15.3	4.4	3.4	11.7	6.5	5.1
20	HA8	270	2	9.3	6.0	4.0	15.7	9.7	5.1
21	HA8	118	1	17.7	6.7	4.9	3.3	13.3	4.0
22	HA8	91	1	7.5	3.5	2.5	11.9	7.7	3.1
23	HA92	22	12	8.8	5.9	4.2	11.7	7.7	3.9
24	HA92	25	13	12.2	5.0	2.5	4.7	9.3	2.9
25	HA92	13	9	7.0	3.3	2.9	6.6	9.8	4.1
26	HA92	16	33	10.5	8.5	3.5	6.1	10.6	4.9
27	HA92	4	9	5.3	3.9	2.7	9.9	8.9	4.0
28	HA92	43	13	5.7	3.9	3.1	10.5	8.1	4.0
29	HA92	31	15	12.0	4.9	2.6	5.2	8.5	2.9
30	HA92	11	21	.	.	.	.	.	.
31	HA92	7	5	.	.	.	.	.	.
32	HA92	36	12	11.8	3.4	2.6	.	.	.
33	HA92	46	6	.	.	.	.	.	.
34	HA92	1	10	.	2.7	2.9	.	.	.
35	HA92	17	9	.	.	.	.	.	.
36	HA92	22	14	10.3	5.2	4.4	24.1	7.5	4.3
37	HA92	40	6	7.7	4.5	3.3	18.0	8.0	4.6
38	HA92	32	19	9.2	5.1	2.9	15.9	4.5	3.7
39	TU2	15	5	7.7	3.5	2.9	17.8	7.1	3.9
40	TU2	19	1	6.0	4.0	3.4	7.9	8.4	4.5
41	TU2	3	3	7.5	5.5	2.9	8.3	8.5	[illegible]
42	TU2	13	3	7.3	2.9	2.7	.	.	.
43	TU2	35	5	.	.	.	.	.	.
44	TU2	11	1	4.4	2.8	2.2	.	.	.

(continued)

Table A.6 (continued)

OBS	SITE	FSM	CATALOGN	DISTLENG	DISTWIDT	DISTTHIC	PROXLENG	PROXWIDT	PROXTHIC
45	TU259	12	27	6.5	3.8	2.7	15.2	11.0	4.4
46	TU259	5	21	14.1	5.7	3.8	7.2	6.3	4.6
47	TU259	12	26	.	.	.	.	.	.
48	TU259	13	28	.	.	.	.	.	.
49	TU259	12	25	.	.	.	.	.	.
50	TU259	8	27	.	4.1	3.3	.	.	.
51	TU259	8	28	6.8	3.8	2.4	.	.	.
52	TU259	14	26	.	.	.	8.2	7.4	2.8
53	TU259	12	24	.	.	.	.	.	.
54	TU259	5	20	.	5.5	2.8	.	10.9	4.0
55	TU346	10	1	6.2	2.6	2.5	10.3	11.9	3.1
56	TU346	17	1	8.2	7.0	4.6	11.9	11.8	6.0
57	TU346	7	4	5.8	3.0	2.7	11.7	10.3	4.4
58	TU346	7		5.0	4.2	2.7	.	.	.
59	TU398	3	1	12.1	5.1	3.6	7.9	5.8	3.7
60	TU46	8	11	.	.	.	.	.	.
61	TU46	14	5	13.5	5.3	4.0	10.8	10.8	3.3
62	TU46	14	2	8.5	7.0	4.0	.	.	.
63	TU48	CC		12.1	4.5	4.2	9.5	6.4	5.0
64	TU58	CC	6	12.9	4.2	2.8	9.2	8.4	4.1
65	TU58	CC	14	.	3.3	4.0	.	.	.
66	TU62	1	1	.	.	.	.	.	.
67	TU65	1	28	.	.	.	.	.	.
68	TU65	6	18	.	.	.	.	.	.
69	TU66	1	6	10.1	4.6	2.2	7.2	11.7	3.6
70	TU66	16	33	12.2	4.4	2.2	7.4	13.7	4.7
71	TU66	51	5	8.8	3.0	2.0	8.9	12.0	3.0
72	TU66	31	11	9.3	3.3	2.7	7.9	14.7	3.5
73	TU66	44	22	10.6	3.6	3.1	10.3	9.2	4.2
74	TU66	45	27	4.2	2.8	2.4	10.7	9.0	3.1
75	TU66	38	13	10.9	3.9	2.9	6.3	7.5	3.9
76	TU66	43	13	6.9	3.3	2.8	12.8	8.8	3.1
77	TU66	42	9	5.9	3.1	2.9	16.3	9.5	3.3
78	TU66	17	6	11.6	4.6	3.2	11.6	8.3	4.9
79	TU66	68	6	8.7	4.4	3.3	16.2	7.4	5.2
80	TU66	13	5	8.0	4.0	3.5	11.6	7.7	4.0
81	TU66	44	21	7.5	3.2	3.1	8.2	8.7	4.4
82	TU66	14	21	4.8	3.6	3.1	15.4	8.1	3.5
83	TU66	17	3	.	.	.	.	8.7	3.6
84	TU66	21	6	14.6	4.2	3.2	13.6	6.6	4.4
85	TU66	45	16	9.4	4.1	3.4	11.6	7.0	5.0
86	TU66	14	20	.	.	.	.	.	.
87	TU66	47	16	.	.	.	.	.	.
88	TU66	65	16	.	.	.	.	.	.
89	TU66	49	12	.	.	.	.	.	.
90	TU66	45	15	9.2	3.1	3.1	.	.	.
91	TU66	41	34	9.5	3.2	2.4	.	.	.

(continued)

Table A.6 (continued)

OBS	SITE	FSM	CATALOGN	DISTLENG	DISTWIDT	DISTTHIC	PROXLENG	PROXWIDT	PROXTHIC
92	TU66	30	18	.	.	.	.	.	.
93	TU66	31	13	.	4.4	3.6	.	.	.
94	TU66	24	4	5.3	3.8	2.3	.	.	.
95	TU66	69	33	.	.	.	.	.	.
96	TU66	30	19	.	.	.	.	.	.
97	TU66	43	18	.	.	.	6.1	11.2	4.5
98	TU66	49	19	2.7	2.5	3.3	11.2	9.7	3.2
99	TU66	45	22	.	.	.	.	.	.
100	TU66	47	11	11.1	5.4	3.3	.	.	.
101	TU66	16	29	6.3	3.5	2.5	.	.	.
102	TU66	65	2	2.2	2.5	2.0	.	.	.
103	TU66	15	3	.	3.1	2.5	.	10.4	8.0
104	TU66	16		10.5	3.9	2.7	.	.	.
105	TU66	49	23	4.7	2.8	1.5	14.6	8.5	4.4

Table A.7 Key

WDTH - width/thickness

LWD - length/width

DWDTH - distal width/thickness

DLWD - distal length/width

PWDTH - proximal width/thickness

PLWD - proximal length/width

Table A.7. Bit-tool Metric Ratio Attributes

OBS	SITE	FSM	CATALOGN	WDTH	LWD	DWDTH	DLWD	PWDTH	PLWD
1	HAM6	19		1.94595	3.20833	.	.	2.09677	.
2	HAM8	11	4	1.42593	3.48052	1.19355	2.24324	1.42593	2.40260
3	HA7	33	3	3.60000	0.86111	1.06452	0.78788	3.60000	0.68056
4	HA7	49	9	2.55263	1.45361	1.18421	1.57778	3.88000	0.72165
5	HA7	49	10	1.86667	2.17857	1.46875	1.48936	1.86667	1.34524
6	HA7	46	5	1.17647	3.40000	1.09804	2.07143	2.00000	1.46667
7	HA7	50	7	1.56863	2.70000	.	.	.	.
8	HA8	189	1	1.56667	2.62766	1.50000	2.33333	1.56667	1.88298
9	HA8	189	2	3.21429	1.20741	1.29167	.	3.21429	0.69630
10	HA8	123	2	1.47143	2.65049	1.37500	2.18182	1.47143	1.95146
11	HA8	209	1	1.34694	2.21212	.	.	.	.
12	HA8	270	1	1.87037	1.69307	.	.	1.87037	.
13	HA8	256	2	1.43478	3.21212	1.28571	2.00000	1.43478	2.12121
14	HA8	75	1	2.41176	2.62195	1.16667	.	3.03704	1.86585
15	HA8	91	2	1.72093	3.01351	1.00000	3.70000	1.72093	1.51351
16	HA8	267	1	2.25641	2.96591	1.16129	.	2.25641	1.36364
17	HA8	233	1	1.39623	2.50000	0.95000	1.84211	.	.
18	HA8	262	1	1.91667	1.85870	1.39024	.	.	.
19	HA8	27	1	1.27451	4.15385	1.29412	3.47727	1.27451	1.80000
20	HA8	270	2	1.90196	2.57732	1.50000	1.55000	1.90196	1.61856
21	HA8	118	1	2.71429	1.57895	1.36735	2.64179	3.32500	0.24812
22	HA8	91	1	2.48387	2.51948	1.40000	2.14286	2.48387	1.54545
23	HA92	22	12	1.92500	2.66234	1.40476	1.49153	1.97436	1.51948
24	HA92	25	13	3.20690	1.81720	2.00000	2.44000	3.20690	0.50538
25	HA92	13	9	2.39024	1.38776	1.13793	2.12121	2.39024	0.67347
26	HA92	16	33	2.16327	1.56604	2.42857	1.23529	2.16327	0.57547
27	HA92	4	9	2.22500	1.70787	1.44444	1.35897	2.22500	1.11236
28	HA92	43	13	2.02500	2.00000	1.25806	1.46154	2.02500	1.29630
29	HA92	31	15	2.93103	2.02353	1.88462	2.44898	2.93103	0.61176
30	HA92	11	21	1.16438	2.05882	.	.	.	.
31	HA92	7	5	1.24561	2.59155	.	.	.	.
32	HA92	36	12	1.74359	3.25000	1.30769	3.47059	.	.
33	HA92	46	6	2.22222	2.33000	.	.	.	.
34	HA92	1	10	2.38889	1.19767	0.93103	.	.	.
35	HA92	17	9	2.05556	1.83784	.	.	.	.
36	HA92	22	14	1.56250	4.58667	1.18182	1.98077	1.56250	3.21333
37	HA92	40	6	1.73913	3.21250	1.36364	1.71111	1.73913	2.25000
38	HA92	32	19	1.54545	3.69118	1.75862	1.80392	1.21622	3.53333
39	TU2	15	5	1.82051	3.59155	1.20690	2.20000	1.82051	2.50704
40	TU2	19	1	1.86667	1.65476	1.17647	1.50000	1.86667	0.94048
41	TU2	3	3	2.93103	1.85882	1.89655	1.36364	2.93103	0.97647
42	TU2	13	3	1.75610	2.15278	1.07407	2.51724	.	.
43	TU2	35	5	2.18605	2.02128	.	.	.	.
44	TU2	11	1	2.35294	1.43750	1.27273	1.57143	.	.

(continued)

Table A.7 (continued)

OBS	SITE	FSM	CATALOGN	WDTH	LWD	DWDTH	DLWD	PWDTH	PLWD
45	TU259	12	27	2.50000	1.97273	1.40741	1.71053	2.50000	1.38182
46	TU259	5	21	1.36957	3.38095	1.50000	2.47368	1.36957	1.14286
47	TU259	12	26	1.17778	2.39623	.	.	.	.
48	TU259	13	28	1.52174	2.15714	.	.	.	.
49	TU259	12	25	1.39216	2.63380	.	.	.	.
50	TU259	8	27	1.43902	2.28814	1.24242	.	.	.
51	TU259	8	28	2.78378	1.29126	1.58333	1.78947	.	.
52	TU259	14	26	2.64286	1.91892	.	.	2.64286	1.10811
53	TU259	12	24	1.60870	2.79730	.	.	.	.
54	TU259	5	20	2.22449	2.01835	1.96429	.	2.72500	.
55	TU346	10	1	3.83871	1.38655	1.04000	2.38462	3.83871	0.86555
56	TU346	17	1	1.91803	1.71795	1.52174	1.17143	1.96667	1.00347
57	TU346	7	4	2.34091	1.69903	1.11111	1.93333	2.34091	1.13592
58	TU346	7		3.08824	1.10476	1.55556	1.19048	.	.
59	TU398	3	1	1.56757	3.44828	1.41667	2.37255	1.56757	1.36207
60	TU46	8	11	1.25490	2.65625	.	.	.	.
61	TU46	14	5	1.89474	2.25000	1.32500	2.54717	2.84211	1.00000
62	TU46	14	2	2.59184	1.26772	1.75000	1.21429	.	.
63	TU48	CC		1.28000	3.37500	1.07143	2.68889	1.28000	1.48438
64	TU58	CC	6	2.04878	2.63095	1.50000	3.07143	2.04878	1.09524
65	TU58	CC	14	1.10638	3.21154	0.82500	.	.	.
66	TU62	1	1	1.53333	2.06522	.	.	.	.
67	TU65	1	28	1.30000	2.80000	.	.	.	.
68	TU65	6	18	2.09375	2.37313	.	.	.	.
69	TU66	1	6	3.25000	1.47863	2.09091	2.19565	3.25000	0.61538
70	TU66	16	33	2.91489	1.43066	2.00000	2.77273	2.91489	0.54015
71	TU66	51	5	4.00000	1.47500	1.50000	2.93333	4.00000	0.74167
72	TU66	31	11	4.20000	1.17007	1.22222	2.81818	4.20000	0.53741
73	TU66	44	22	2.19048	2.27174	1.16129	2.94444	2.19048	1.11957
74	TU66	45	27	2.90323	1.65556	1.16667	1.50000	2.90323	1.18889
75	TU66	38	13	1.92308	2.29333	1.34483	2.79487	1.92308	0.84000
76	TU66	43	13	2.83871	2.23864	1.17857	2.09091	2.83871	1.45455
77	TU66	42	9	2.87879	2.33684	1.06897	1.90323	2.87879	1.71579
78	TU66	17	6	1.69388	2.79518	1.43750	2.52174	1.69388	1.39759
79	TU66	68	6	1.42308	3.36486	1.33333	1.97727	1.42308	2.18919
80	TU66	13	5	1.92500	2.54545	1.14286	2.00000	1.92500	1.50649
81	TU66	44	21	1.97727	1.80460	1.03226	2.34375	1.97727	0.94253
82	TU66	14	21	2.07692	2.49383	1.16129	1.33333	2.31429	1.90123
83	TU66	17	3	2.41667	1.50575	.	.	2.41667	.
84	TU66	21	6	1.50000	4.27273	1.31250	3.47619	1.50000	2.06061
85	TU66	45	16	1.40000	3.00000	1.20588	2.29268	1.40000	1.65714
86	TU66	14	20	1.29268	3.67925	.	.	.	.
87	TU66	47	16	1.60784	1.51220	.	.	.	.

(continued)

Table A.7 (continued)

OBS	SITE	FSM	CATALOGN	WDTH	LWD	DWDTH	DLWD	PWDTH	PLWD
88	TU66	65	16	1.77083	2.05882	.	.	.	.
89	TU66	49	12	1.48214	2.30120	.	.	.	.
90	TU66	45	15	2.75610	1.94690	1.00000	2.96774	.	.
91	TU66	41	34	2.33333	1.91667	1.33333	2.96875	.	.
92	TU66	30	18	1.83784	2.38235	.	.	.	.
93	TU66	31	13	1.46000	2.31507	1.22222	.	.	.
94	TU66	24	4	2.84375	1.40659	1.65217	1.39474	.	.
95	TU66	69	33	1.75000	2.25974	.	.	.	.
96	TU66	30	19	1.59574	2.36000	.	.	.	.
97	TU66	43	18	2.15385	1.38393	.	.	2.48889	0.54464
98	TU66	49	19	2.55263	1.43299	0.75758	1.08000	3.03125	1.15464
99	TU66	45	22	1.55844	1.39167	.	.	.	.
100	TU66	47	11	2.52632	1.83333	1.63636	2.05556	.	.
101	TU66	16	29	2.87097	1.51685	1.40000	1.80000	.	.
102	TU66	65	2	.	.	1.25000	0.88000	.	.
103	TU66	15	3	1.30000	2.19231	1.24000	.	1.30000	.
104	TU66	16		3.70588	1.66667	1.44444	2.69231	.	.
105	TU66	49	23	1.93182	2.27059	1.86667	1.67857	1.93182	1.71765

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