To the Graduate Council:

I am submitting herewith a thesis written by Daniel S. Amick entitled "Lithic Raw Material Variability in the Central Duck River Basin: Reflections of Middle and Late Archaic Organizational Strategies." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Anthropology.

Walter E. Klippel

Walter E. Klippel, Major Professor

We have read this thesis
and recommend its acceptance:

Michael H. Logan

Accepted for the Council:

C. W. Minkel

The Graduate School

LITHIC RAW MATERIAL VARIABILITY IN THE CENTRAL DUCK RIVER BASIN: REFLECTIONS OF MIDDLE AND LATE ARCHAIC ORGANIZATIONAL STRATEGIES

A Thesis

Presented for the

Master of Arts

Degree

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ABSTRACT

The purpose of this study was to develop a model for understanding prehistoric chipped-stone debris distribution in the central Duck River Basin region located in Middle Tennessee. The model design consists of theoretical and empirical observations which are integrated to form an interpretive framework. Seven lithic assemblages ranging from Middle to Late Archaic periods (ca. 7000 to 3000 years B.P.) in age were analyzed to assess the model.

The first stage of model-building was the development of a theoretical foundation for approaching the problem. A cultural adaptation paradigm is the foundation cornerstone. Understanding cultural process and organization are emphasized. Lithic technology is viewed as an integral part of prehistoric cultural adaptation and lithic remains are regarded as critical indicators of behavioral variability. Environmental variables are stressed in interpreting lithic debris patterning across the landscape.

The second stage of model-building involved the construction of a set of observations on lithic resource types and their distributions in the study area. A regional lithic resource survey was implemented. Several chert types are defined and described. Emphasis is placed on macroscopic identification techniques. Quantification of lithic resource distribution patterns was achieved through a regional gravel study.

Application of the model to archaeological data was the last stage of model-building. Seven Middle-Late Archaic assemblages are compared.

A pilot study of two assemblages initiates the comparison. Results of the interassemblage analysis suggest that Late Archaic settlement systems were more logistically organized and technological systems were less expediently organized than those of Middle Archaic groups. Differences between Middle and Late Archaic adaptations are viewed as responses to regional environmental and demographic trends. Documentation of these trends and their implications for subsistence, settlement, and social organization is considered. Evaluation of the model suggests adequate explanatory ability. The consideration of more assemblages is recommended for improving model accuracy.

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CHAPTER I

INTRODUCTION

Recent evaluations of lithic studies in archaeology allege serious problems within the field (Dunnell 1980:466; Cross 1983). Central to these criticisms is the characterization of lithic studies as strongly empirical and generally atheoretical. Focus on methodological means often proceeds at the expense of theoretical ends. The conduct of lithic studies within a theoretical vacuum results in a lack of integration with general anthropological and archaeological goals. Failure of many previous lithic studies to address theory-building problems has resulted in research trivia and redundancy. The history of lithic analysis since the pioneering work of William Henry Holmes (e.g., 1890, 1893, 1894, 1897, 1919) near the turn of this century has been marked by repeated reinvention of the wheel.

It is intended that this study serve as a departure from these trends. This work represents an effort to place lithic analysis within a general anthropological framework. These comments do not deny substantive contributions by other researchers. The approach developed here acknowledges significant contributions of method and theory and data from many researchers. This study does not intend to erect a programmatic approach to lithic analysis. The growth of lithic studies is encouraged by analytical flexibility. However, it is stressed that the conduct of research within a theoretical milieu is essential for development of the field.

This study is structured as a model-building exercise in the belief that:

> It is model building and testing in the context of comparative studies of patterning and their implied organization characteristics which will greatly expand our knowledge of the past (Binford 1972a:456).

The definition and value of models in archaeological research have been discussed by Clarke (1968:32):

> Essentially, models are hypotheses or sets of hypotheses which simplify complex observations whilst offering a largely accurate predictive framework structuring these observations--usefully separating 'noise' from information. Which aspect is noise and which counts as information is solely dependent upon the frame of reference of the model.
>
> Models and hypotheses succeed in simplifying complex situations by ignoring information outside their frame of reference and by accurate generalization within it.

In addition to model development, emphasis is placed on precise delineation of environmental parameters. Understanding the resource base is critical to accurate understanding of resource utilization patterns. Lithic analysis is too frequently undertaken divorced from raw material considerations. The development of regional lithic resource surveys and typologies should be the first step in any assessment of prehistoric lithic technologies. The differential utilization of raw materials furnishes general information regarding technological organization and provides a baseline for further investigations.

Cross (1983:102) has noted that problems of scale are critical to lithic analysis. The scale of the solutions must equal the scale of the

questions. As an initial exploration into lithic technology systems, very general questions are most appropriate. This approach is intended to develop an informational matrix upon which subsequent research may resolve particular details. Development of a matrix is stressed in this study. Further problems of scale involve the level of measurement employed. Dichotomous nominal attributes and statistical measures of association are emphasized as an exploratory strategy. These tactics are expected to reveal fundamental patterns of assemblage similarities and differences with conservative estimation of statistically significant trends. Finally, the scale of the inferences derived from the lithic analysis is commensurate with general observations.

Chapter II presents the general theoretical orientation of this investigation. The works of Lewis R. Binford have been highly influential in developing an epistemological structure for research. However, it is stressed that interpretation of Binford's writings has resulted in an unique and personal theoretical frame of reference. The potential of lithic studies to contribute to general anthropological goals is also considered in this chapter. Discussion of the study area and research design conclude Chapter II.

The results of a lithic resource survey of the study area are presented in Chapter III. This includes a discussion of regional geologic history, physiography, and drainage patterns. These factors play significant roles in determining the distributional patterns of lithic resources. Geological and archaeological literature searches and field surveys of the study area were employed. A synoptic collection of chert types defined by geologic formation of origin and described by

macroscopic characteristics was formed to serve as the basis for archaeological lithic material identifications.

Chapter IV builds on the lithic resource survey data through the consideration of regional gravel sources. Stream deposited chert forms a significant component of available lithic materials in the study area. Collection and analysis of gravels across regional physiographic zones yields descriptive data on the gravels and provides a quantitative basis for modeling the distribution of lithic resources. Methods and concepts of geological gravel studies are emphasized. Results suggest that gravel studies have substantial value for archaeological lithic resource considerations.

Application of archaeological materials to expectations derived from the theoretical and environmental resource base background is conducted in Chapter V. Two stratified assemblages are compared as a pilot study for model evaluation. These assemblages are from the same location, but differ chronologically. Significant differences are shown to exist between the assemblages. Inferences regarding cultural site formation processes suggest these differences are due to changes in settlement and technological system organization.

Chapter VI presents a seven assemblage consideration of temporal/geographic patterning. This chapter includes descriptions of the additional assemblages and revision of the model. Middle-range theory, hypotheses, test implications, and testing methods are all modified to accommodate the increased sample size and variability. This expansion of the pilot study indicates greater complexity in the data set, but the proposed changes in organizational strategy are supported.

Chapter VII is the final chapter and considers further inferences and explanation for the observed variability. Central to these issues is the question of why cultures change. Local environmental and demographic trends are reviewed. The consequences of these trends for subsistence, settlement, and social organization are discussed. This deeper consideration of theoretical issues indicates that the interassemblage variability inferences are independently supported.

CHAPTER II

THEORETICAL BACKGROUND AND PROBLEM ORIENTATION

The basic paradigms guiding this research are derived primarily from theories of cultural evolution, ecology, materialism, and systemics (see Harris 1968, 1979; Thomas 1979). The general aim of anthropology is considered to be explanation for the origin, maintenance, and change of sociocultural differences and similarities. Variables such as economy, ecology, environment, technology, and demography are assumed to be ultimately causal factors effecting cultural variability and change. In order for archaeologists to contribute to anthropology, they must isolate and seek predictable relationships between these causative factors. Therefore, the proper focus of archaeological investigations should be an attempt to understand culture process (Binford 1962, 1965, 1968a, 1968b, 1977a). Culture process refers to:

> the dynamic relationship (causes and effects) operative among sociocultural systems, to those processes responsible for changes observed in the organization and/or content of the systems, or to the integration of new formal components into the system (Binford 1968a:14).

The locus of cultural process is in the dynamic articulation of environmental and sociocultural subsystems (Binford 1965:198).

Cultural Process and Organization

Culture is regarded as a complex adaptive system by which man adjusts to his internal and external environments (Alland 1970, 1975; Alland and McCay 1973; Binford 1962, 1964, 1965, 1968a, 1968b, 1968c; Blake 1980; Carneiro 1968; Clarke 1968; Kirch 1980). "Basically,

societies adapt to their environment by three means: technological, organizational, and ideational" (Carneiro 1968:552). Among these means, technology is closely related to organization and represents "the most directly adaptive facet of culture," while organization is the means by which behavior is coordinated, integrated, regulated, and directed in adapting to the demands of existence (Carneiro 1968:551-552). Tainter (1977:328-329, emphasis in original) states that within a general systemic framework, "the abstract, composite dimensions that allow for the characterization of a social system are the structure and the organization of the system." Structure refers to the nature of the constituent parts of the system and organization refers to the patterned interaction among these parts. As such, "organization can be considered as the constraints imposed upon the ranges of behavior that may be pursued by the elements of a system" (Tainter 1977:328). Cultural systems are conditioning organizational frameworks within which all events, behaviors, and transactional phenomena transpire (Binford 1981a:201). Human behavior is organized along "relationships between the properties of alternative spatial organizations and the labor and social pressures operative during periods of organized behavior" (Binford 1977a:9).

A processual approach to the archaeological record aims at "explaining demonstrated patterning in the organization of past human systems of adaptation" (Binford 1973:253). Concomitantly,

> we should be seeking to understand cultural systems, in terms of organizational properties, and in turn, to explain differences and similarities among these cultural systems . . . those 'things' of interest from the past are organizational

> properties, which cannot be dug up directly (Binford 1981a: 197, emphasis in original).

Therefore, our ultimate goal is the understanding of the processes which are responsible for change and diversification in the organizational properties of cultural systems (Binford 1977a:7).

This view suggests:

> not only that the archaeological record derives from an adaptation but also that adaptations have all the properties of a system in which various components are responsive to one another in their ongoing operation. The basic elements or components of the system are units of organization rather than discrete elements as viewed by us in the contemporary world (Binford 1978a:3, emphasis in original).

The archaeological record can be expected to reflect: (1) an ordered consequence of levels of adaptive organization; (2) basic organizational constraints and determinants; (3) structural consequences of the operation of a level of organization; and (4) the unit (level of organization) upon which ecological-evolutionary selection operates (Binford 1981a:197-198).

An emphasis on variability is critical to processual studies (Binford 1965:205). Variation in the structure and content of an archaeological assemblage is assumed to be directly related to the form, nature, and spatial arrangement of human activities. Separate activities are the cause of assemblage variability, which may be related to both the social and physical environment, and interrelated in different ways (Binford 1964; Binford and Binford 1966, 1969; S.R. Binford 1968; Binford 1973). In addition, cultural systems are expected to exhibit differential internal organization which should be reflected within archaeological assemblages through the range and nature of the

tasks performed, the size and composition of the social unit performing the tasks, and the length and intensity of occupation. Generally, two kinds of variability are exhibited in the archaeological record, organizational and distributional.

> Organizational variability refers to all the associations and correlations which in the context of repetition permit the recognition of an entity or the association of entities or characteristics having definable structural properties. Distributional variability refers to the patterning manifest when recognized units or characteristics are plotted spatially or across populations isolated independently of the unit or characteristic being studied (Binford 1972b:246).

Variability in the archaeological record should reflect particular adaptive situations of a group through varying activities and their organization.

> Similarities may equally reflect continuities in the character of the acts performed. Differences may arise when the organization of activities varies temporally and/or spatially, resulting in a variety of assemblage types characteristic of the life of a given community (Binford 1972b:264).

Considering the need to understand and explain variation, it is necessary to realize that variability may represent: (1) the normal functioning of internally differentiated cultural systems, (2) evolutionary changes within cultural systems, or (3) changes in content within an essentially stable cultural system (Binford 1968a:26-27).

Binford and Binford (1966:290-291) have noted some particular analytical problems and solutions relating assemblage variability to behavior. The primary problems are the possibility of observed variability being due to sampling error and explaining the significance of assemblage differences and similarities. The first problem can be most effectively controlled by regional designs and statistical tests

(see Binford 1964). The latter problem is best solved by assuming that the form and composition of an assemblage is directly related to the form and composition of human activities at that location and that the minimal organizational principles and social processes of human groups today were operative in the past. Therefore, it can be stated that assemblages should vary in terms of the form of the social unit (e.g., social segments or cooperating groups organized along age and/or sex lines) and the specific tasks performed. The differential distribution of resources and living sites should condition spatial and temporal variability in the form of the social unit and the tasks performed by a given group. Despite an emphasis on variability, processual studies must recognize that:

> Before one can make meaningful statements as to the significance of patterns of observed variability in the archaeological record, he must consider the causal determinants of patterning. Processes vary as organizations vary, forms of patterning vary as processes vary. Organizational variability is one of the major characteristics of cultural variation in general. Investigation of the organizational properties of systems and their processual consequences, archaeologically, is the first step toward an accurate attribution of meaning to observed patterning (Binford 1977b:36).

Lithic Technology and Behavioral Adaptations

The nature of the archaeological record allows archaeologists to make significant advances in anthropological studies of long-term cultural similarities, differences, changes, and processes (Binford 1962; Harris 1968; Plog 1973, 1974). This study focuses on lithic technology among prehistoric hunter-gatherers over a period of approximately 4000 years (ca. 7000 to 3000 years B.P.). The relevance

of hunter-gatherer research to anthropology is based upon their almost direct adaptation to the environment (Netting 1971:4) and the long-term evolutionary success of this adaptation (Lee and DeVore 1968:3). Environment is not considered a determining factor of culture and technology, rather it is emphasized that environment circumscribes the variation of behavioral adaptations (Kirch 1980:124). In addition, hunter-gatherer lithic technologies represent an integral part of this adaptation and can be used to monitor systemic readjustments or adaptive changes within a broader cultural context (Collins 1974, 1975; Hassan 1975a; Sheets 1975). Lithic technology systems are based on the acquisition and reduction of raw materials (Collins 1975:16) and represent one of man's most direct exploitive interfaces with the environment. Lithic materials often form a major part of archaeological assemblages and can serve as "common denominators" reflecting behavioral variability (Raab et al. 1979:168; also see Collins 1974, 1975). Therefore, diachronic long-term studies of hunter-gatherer lithic technologies represent basic and significant contributions to anthropology from archaeological data.

Raw material variability in this study refers to the patterns of lithic material procurement and utilization. This term is used in a general manner and is not equated with the discussion of specific lithic reduction systems. Particularly important is the evaluation of differential use of various lithic resources. Emphasis is placed on the by-products of lithic tool manufacture (debitage) since these artifacts are generally discarded at the production site and can be considered the

best indicators of the activities represented by an assemblage (Binford 1973:244; Collins 1974:3-5, 1975:17-19).

Lithic technologies are sequential subtractive systems which are well suited to activity analysis. Debitage populations can be used to infer specific and more general reduction activities represented by an assemblage (Monet-White 1963; Frison 1968; Muto 1971; Schneider 1972; Collins 1974, 1975; Ahler 1975, 1977; Raab et al. 1979; Wright 1980; Johnson and Raspet 1980; Johnson 1981a; Jefferies 1982a; Ahler and Christensen 1983). The relationship between debitage assemblages and specific tool manufacturing stages (especially in the case of biface manufacture) is also well recognized (Binford and Quimby 1963; Sharrock 1966; Muto 1971; Newcomer 1971; Knudson 1973; Collins 1974; Ahler 1975; Christenson 1977; Callahan 1979; Johnson 1979, 1981a; Johnson and Raspet 1980; Futato 1980; Wright 1980; Magne and Pokotylo 1981; Stahle and Dunn 1982; Ahler and Christensen 1983). The tendency for lithic reduction to be accomplished in discrete stages which can be recognized by distinctive debitage assemblage compositions indicates that studies of raw material variability can lead to the identification of differential activity sets and strategies among assemblages.

Spatial incongruence of resources is perceived as a major factor leading to activity differentiation and assemblage variability (Binford and Binford 1966, 1969; Binford 1972b, 1978b, 1979, 1980). Lithic assemblage variability can monitor settlement system differences effected by resource distribution differences (Lourandos 1977; McBryde 1977; O'Connell 1977; Hayden 1978; Straus 1980; Mazel and Parkington 1981). Previous studies of raw material variability have indicated that

organizational properties of technologies, settlement-subsistence systems, and social organizations can be inferred for prehistoric populations. Patterns of territorial utilization, spatial extent, and mobility have generally been emphasized when inferring settlement-subsistence organization (Winters 1969; Ahler 1975; Hassan 1975a; Hester and Grady 1977; Reher and Frison 1980; Ebert 1979; Goodyear 1979; Francis 1980; Gramly 1980; Perlman 1981; Tippitt and Marquardt 1982). Social organization studies have stressed task group structure (Ahler 1975, 1977) and degree of egalitarianism (Young and Sheets 1975; Perlman 1981). Interrelated settlement-subsistence and social organization parameters such as boundary conditions, interaction rates, and group cohesion/integration have also been addressed in the context of raw material variability (Knudson 1973; Wilmsen 1973, 1974; Wobst 1974, 1976; Ahler 1975, 1977; Hassan 1975a). Technological organization is generally subsumed by settlement-subsistence and social organization studies due to the close relationship among these variables.

Although the characterization of hunter-gatherer band level societies can be directly assessed by ethnographers, relating static archaeological facts to the dynamics of culture poses particular analytical problems for the archaeologist. Recognition of this important leap has inspired much recent research concerning site formation processes. Especially valuable to this study will be organizational principles regarding hunter-gatherer procurement (Binford 1979), technology (Binford 1977), and settlement-subsistence systems (Binford 1980, 1982; Wiessner 1982).

Research Problem

This study represents an investigation of organizational variability among Middle and Late Archaic hunter-gatherer populations through the assessment of raw material variability patterns. Seven lithic assemblages from open alluvial settings in the central Duck River Basin and upper Buffalo River Basin are employed in this analysis (see Table 2.1 and Figure 2.1). As Spaulding (1960a) has noted, archaeological integration takes place along the dimensions of time, space, and form-- all of which are represented in this study.

The methodology used in this analysis involves the construction and testing of a model of raw material variability for this particular temporal-spatial framework. The model building is structured along generally well recognized methods (e.g., Binford 1968a, 1972a, 1972b, 1977a, 1981b; Hill 1972; Zubrow 1973; Collins 1974, 1975; Thomas 1979). The general and middle-range theoretical background serves as the paradigm or "warranting argument" of this research indicating theoretical orientation and bias. In order to properly assess raw material variability, a geologic model or set of observations on lithic resource distribution must be developed before the deduction of testable hypotheses. These hypotheses are stated as the relationships of independent and dependent variables (Brim and Spain 1974:6) expected from theoretical and real world considerations. Organizational principles are used as independent variables which are tested by the deduction of implications derived from the dependent variables. The relationship between the deductive variables and test implications is

Table 2.1. Characteristics of the assemblages employed in this study.

Site	Period[a]	Phase	Radiocarbon Date(s)[b]	Physiographic Location[c]	Nearest Chert-Bearing Formation
Topsy (40WY204)	LA	Ledbetter/Wade	---	BRB-HR	Fort Payne
Clay Mine-Area 2 (40MU347)	LA	Ledbetter	3215±125 (UGa-3350)	CDRB-IB	Ridley
Leftwich (40MU262)	LA	Benton/Ledbetter	4130±130 (A-2553) 4190±260 (A-2366)	CDRB-IB	Ridley
Clay Mine-Area 1 (40MU347)	MA	Sykes/White Springs	6240±500 (A-2367)	CDRB-IB	Ridley
Cedar Creek (40MU432)	MA	Sykes/White Springs Eva/Morrow Mountain	6375±215 (GX-8822)	CDRB-IB	Ridley
Cave Spring (40MU141)	MA	Eva/Morrow Mountain	6540±110 (UGa-3753) 6885±90 (UGa-3752) 7250±350 (A-2362)	CDRB-IB	Ridley
Bench (40MU433)	MA	Eva/Morrow Mountain	8885±360 (GX-8821)	CDRB-IB	Carters

[a] LA = Late Archaic, MA = Middle Archaic

[b] Dates are expressed as radiocarbon years before present.

[c] BRB-HR = Buffalo River Basin-Highland Rim, CDRB-IB = Central Duck River Basin-Inner Basin.

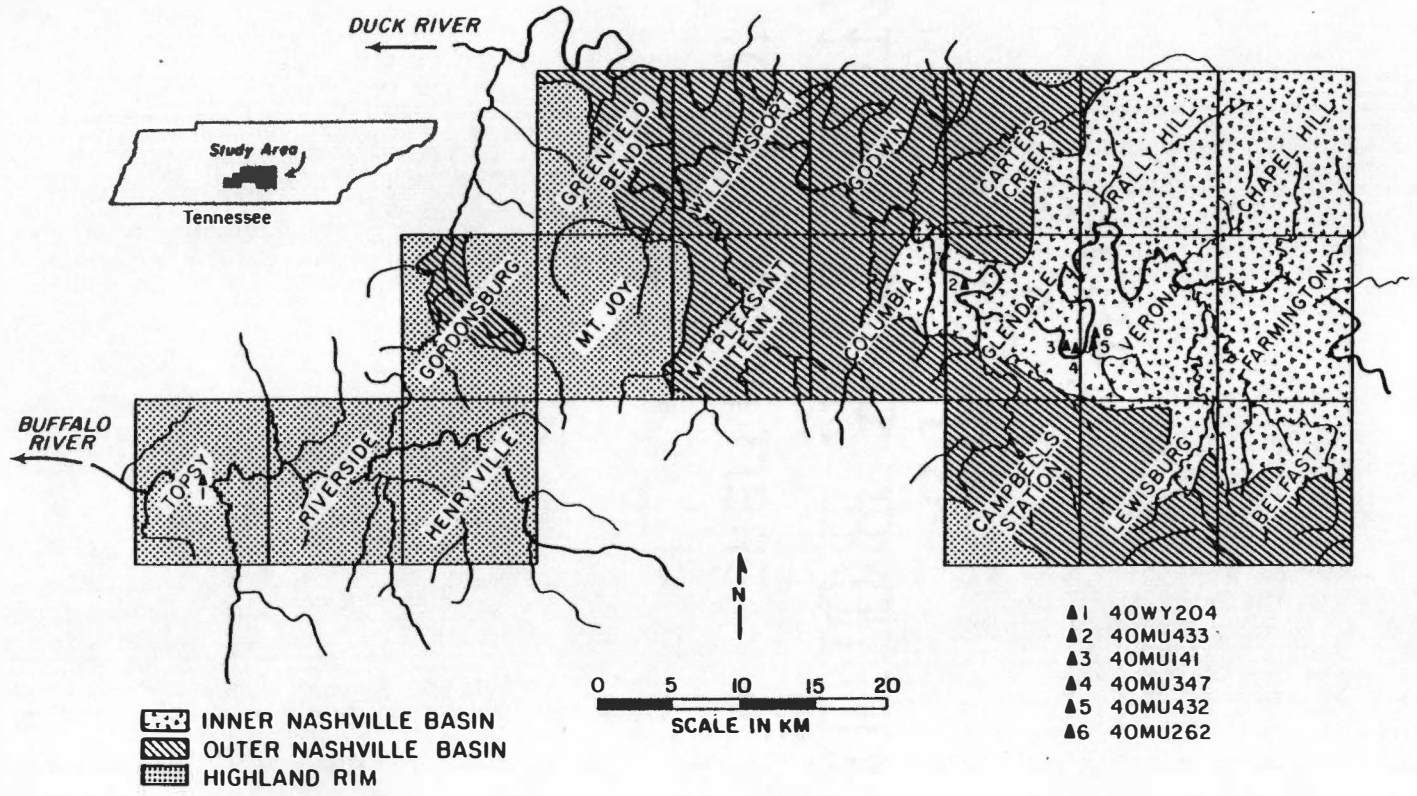

Figure 2.1. Location of sites employed in this study. Sites are superimposed on Geologic Quadrangles with shading representing physiographic/geological sections.

established by bridging arguments based primarily on the geologic model of resource distributions and principles of lithic reduction sequences.

Evaluation of the model is based on the expected patterns compared to observed patterns of variability of the actual archaeological data. These comparisons are expressed in terms of statistical probabilities and predictions. Contingency analysis and similarity indices (e.g., Spaulding 1960b; Sokal and Rohlf 1969) provide the major statistical tools for comparison of the assemblages. Upon evaluation of the hypotheses, the model is reviewed. Feedback and modification at any level of the model may be required. New observational data may then be compared to the refined model in a continuous cycle which should lead to higher resolution, predictability, and reliability.

As Binford (1977a:5-6) notes, statistical statements and probabilities describe patterning, but do not explain it. Nonetheless, these descriptions are complex empirical facts and projection from these facts requires an assumption that systems will remain unchanged. Once distributional patterning has been demonstrated, it can be shown that: "(a) an organizational difference has been isolated and (b) the dynamics of organizational process was existentially independent" (Binford 1972a:248). Products of patterning must be explained in terms of the processes causing change and diversification in organization (Binford 1977a:6). Within the integrative dimensions of archaeology:

> time is the conventional referent for evaluating the dynamics of transformations occurring within or among organizations. Space is the normal referent for evaluating the disposition of systemic processes and functions (Binford 1972b:247; cf. Spaulding 1960a).

The framework of the data set is expected to reveal organizational variability for several reasons. Previous investigations of regional geology have indicated significant patterned spatial variability of lithic resources (Amick 1981). These patterns suggest that varying organizational strategies were required to cope with this spatial variability. Further evidence suggesting potential variability in the data set is derived from environmental conditions of demographic and climatic change recognized for this temporal period. Population appears to have increased throughout the Archaic period in Eastern North America (Ford 1974, 1979; Cohen 1977; Brose 1979; Stoltman 1979), however, this trend differs through Archaic times in the Inner Basin - central Duck River Basin (Klippel and Turner 1983). There also appears to have been a trend toward increased sedentism over this time period (Muller 1978; Stoltman 1979). Subsistence economies evidence change during this span as well (e.g., Cleland 1976; Ford 1977; Stoltman 1979). Perhaps the most significant of these environmental changes is a shift from warm-dry to contemporary cool-moist climatic conditions during this period (Stoltman 1979; Klippel and Parmalee 1982; Brakenridge 1982, 1984). It is assumed that these general environmental differences should create both temporal and spatial variability within the archaeological record which will be reflected by differential procurement and utilization of lithic raw materials.

CHAPTER III

LITHIC RESOURCE SURVEY OF THE CENTRAL DUCK RIVER BASIN AREA

The accurate definition of the geologic and geographic parameters of chert resource distribution is considered to be critical to meaningful investigations of lithic procurement and utilization strategies (Ahler 1977:132-133). In fact, an accurate understanding of the variability and spatial incongruence of lithic resources is necessary for understanding both lithic technology and settlement system adaptations. It is naive to suggest that lithic resource distribution was the primary factor affecting the organization of prehistoric settlement systems. Food resources are clearly more critical. However, foodstuffs are notoriously susceptible to poor or differential preservation. Lithic materials are durable and prolific among archaeological remains. The differential procurement, reduction, use, and discard of lithic materials forms the most complete record of prehistoric adaptations to the environment. In addition, chert resource distributions tend to be fixed in space and stable relative to biotic resources. This property makes lithic resources particularly amenable to resource exploitation and adaptation modeling. This is especially helpful regarding diachronic studies where the distribution of lithic resources may be considered as essentially constant.

Before lithic studies can become credible, the resource base must be defined and described. The following represents an attempt to define and describe the relevant geological resources from the perspective of the central Duck River drainage. First, environmental factors which

include geologic history, physiography, and drainage patterns are presented. The chert resource survey follows. This includes methodological considerations, literature search, fieldwork, and chert identification procedures. The macroscopic characteristics and regional distribution patterns of the various chert types recognized by the survey are then discussed. All too often, lithic analyses are divorced from the natural resource base or chert resource surveys fall short of archaeological application. The work here is descriptive and intended to provide a geological and geographical baseline for interpretation of archaeological lithic materials in a portion of the central Duck River Basin.

Environmental Background

Geologic History

Middle Tennessee is located almost entirely within the Interior Low Plateau physiographic province. Fenneman (1938:413-414) has noted that within this province there is a close relationship of geological stratigraphy and structure to variations in physiography and topography. These relationships are so profound that explanation of surface forms requires constant reference to the underlying rocks. A discussion of regional geological history is the best point of departure in developing an understanding of present-day geologic and geographic parameters of Middle Tennessee. Reference to the generalized chart of time and rock units (Figure 3.1) is essential.

During the Ordovician Period, tectonic stresses operative in Appalachia caused vertical uplift of a dome-like structure known as the

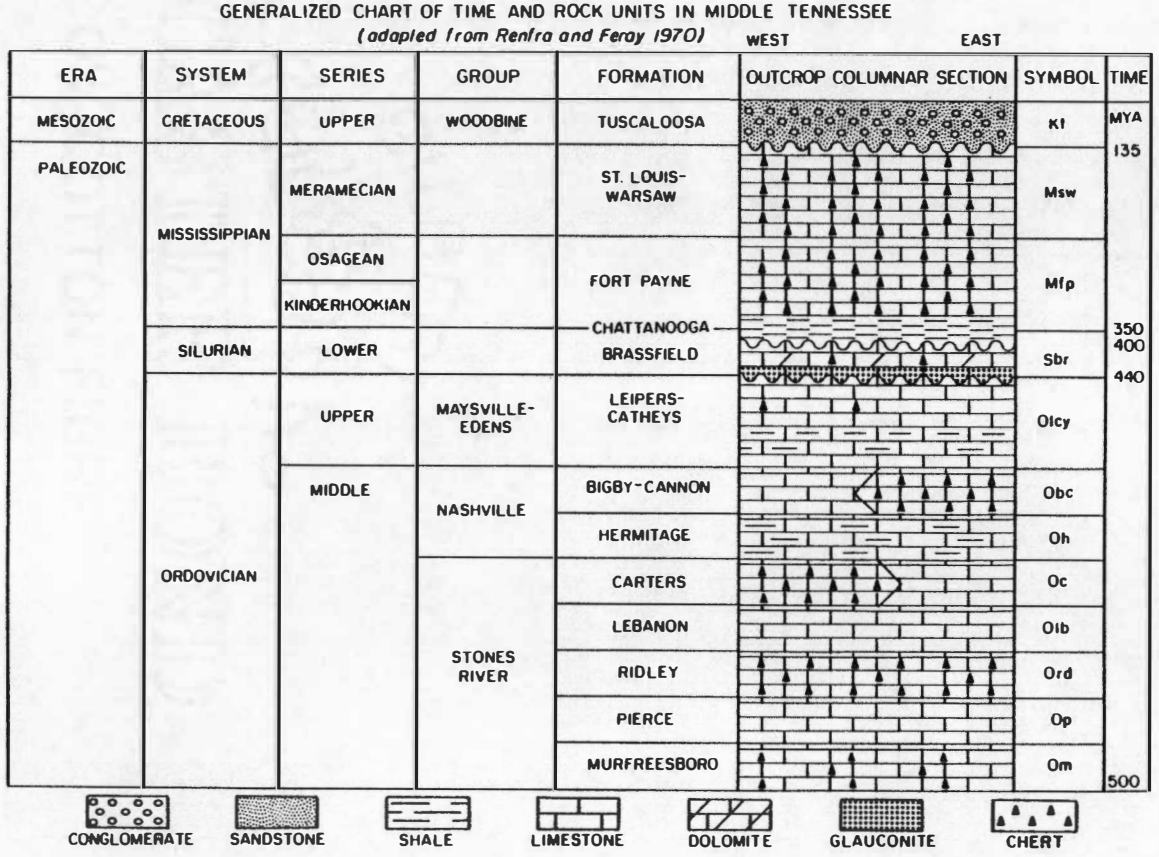

Figure 3.1. Generalized chart of time and rock units in Middle Tennessee.

Nashville Dome (Wilson 1935:464-467). This dome occupied Middle Tennessee and trended southwest-northeast. The Nashville Dome is actually part of a larger structure called the Cincinnati Arch or geanticline. The Cincinnati Arch, in turn, is part of a larger system of belt structures between Appalachia and the Rocky Mountains (Wilson 1939:586). Throughout its history, the Nashville Dome has been subjected to periods of tectonic stress causing minor shifting of the geosyncline axis and repeated uplift episodes.

Shallow inland seas occupied Middle Tennessee during Ordovician times and the Nashville Dome formed a barrier reef ("Curdsville Island") protecting the Appalachian shoreline (Wilson 1962:495). The seas west of the dome were much rougher than those between the dome and Appalachia. The combination of geosynclinal axis shifting, water-depth changes, and variability in sea rugosity led to the deposition of four different limestone facies which vary from west to east (Wilson 1962:482). In order of increasing frequency from west to east, these facies are: (1) laminated argillaceous limestone; (2) granular phosphatic limestone; (3) dove-colored limestone; and (4) "normal" eastern limestone with varying amounts of silt (Wilson 1962:482). These facies are divided among formations of the Stones River Group and the Nashville Group of the Chickamauga Supergroup (Milici 1969:119). Due to changing environmental factors during their deposition, the Middle and Upper Ordovician formations in Middle Tennessee exhibit some west-east variability and discontinuity.

Following the deposition of Ordovician sediments across the Nashville Dome, Silurian and Devonian Period seas invaded. The deposits

from these seas left a complex group of limestone and chert formations which are regionally discontinuous from northwest to southeast (Luther 1977:24). Upwarping of the Nashville Dome continued during these periods resulting in erosion of Silurian and Devonian deposits from higher elevations and local unconformities. These formations are generally best developed on the western side of the dome. Marcher (1962a:831) has noted that the thickening of these formations to the northwest indicates the beginning of a period of subsidence.

During the Mississippian Period, subsidence accelerated which led to a radical change in environment (Marcher 1962a, 1962b). Fort Payne Formation deposits from this time suggest a change from a near shore (shale) to a deep tranquil sea floor (chert) environment. Milici et al. (1979:11-12) have recognized that the Fort Payne Formation contains several lithologies and facies, but that the stratigraphy of the formation has not been studied in detail on a regional scope. Overall, the formation thickens to the north and northwest. Four major facies are recognized for the Fort Payne Formation: (1) upper cherty facies, lower siltstone facies; (2) silicastone facies; (3) basal crinoidal limestone; and (4) cherty carbonate siltstone and shale (Milici et al. 1979:12). Facies (1) is distributed across the southern end of the dome and on the southwestern flank. Facies (2) is distributed across the southern end of the dome with a finger extending to the eastern flank. Facies (3) is rather spotty in distribution with the major occurrences at the extreme southern and northern ends of the dome and smaller patches present along the eastern flank. Facies (4) is present on the eastern and northwestern flanks of the dome. The greatest number of

overlapping facies is present on the southcentral part of the dome. Consequently, this is the area of greatest stratigraphic complexity and lithologic diversity for the Fort Payne Formation.

Subsequent to Fort Payne deposition, the seas became more turbulent and shallow. Warsaw Formation deposits from these times suggest an open shelf shoal environment (Marcher 1962a:831-832, 1962b:34-35). St. Louis limestone deposits followed the Warsaw. Silica precipitation in the form of chert nodules indicate increasing stability of the shelf and less turbulent conditions. However, St. Louis deposits are more heterogeneous than preceding Warsaw sediments which may reflect less equable environments.

Later Mississippian and Pennsylvanian Period formations are largely absent from Middle Tennessee. Pennsylvania rocks remain on the Cumberland Plateau between Middle and East Tennessee. These formations may have covered all of Middle Tennessee at one time, but this is difficult to determine since there appears to have been a massive erosional episode prior to Cretaceous times (Marcher 1962b:36; Luther 1977:26). This erosion certainly suggests renewed crustal upwarping of the Nashville Dome to elevations above sea level.

Following this long erosional period, Cretaceous Tuscaloosa sediments were deposited along the western flank of the Nashville Dome (Marcher and Stearns 1962). The Tuscaloosa sea covered Middle Tennessee with a shoreline along the western part of the dome. The Tuscaloosa Formation is composed of western and eastern gravel conglomerate facies (Marcher and Stearns 1962:1371-1379). The western facies was derived from Ordovician, Devonian, and Mississippian cherts and indurated

sandstones. These gravels were deposited by alluvial sources draining the Pascola Dome centered over northwestern Tennessee and southeastern Missouri. The eastern facies was derived from Pennsylvania siltstones, quartz, and quartzites to the north or south. This facies represents gravel deposited by long-shore movement. Post-Cretaceous deposits were restricted to the Mississippi Embayment in West Tennessee (Stearns and Marcher 1962:1393). Another long erosional period ensued in Middle Tennessee on the Nashville Dome from this time until the present.

This latest erosional episode has led to the creation of the present topography and physiography of the region. Fenneman (1938:416-433) and Luther (1977:36-42) give excellent accounts of the processes involved and the resulting physiographic patterns. Continued upwarping of the Nashville Dome caused cracking and erosion. Local widening, broadening, and coalescence of stream valleys (especially the Cumberland River) resulted in erosion from the top of the dome. This stream erosion undercut the protective cherty Mississippian limestone formations and proceeded rapidly through the more soluble (softer) underlying Ordovician limestones. The process of "sapping," or breaking-off of overlying resistant rocks which form talus slopes in the valley bottoms, led to the formation of a characteristically "bowl-shaped" basin. Erosion continued to scoop out a basin equal in depth to the streams to the south and west (Tennessee River).

This basin, known as the Central or Nashville Basin, has approximately the same areal dimensions as the former dome. Figure 3.2 illustrates the present extent of the Nashville Basin. The basin is roughly ellipical in shape and approximately 130 km long (southwest-

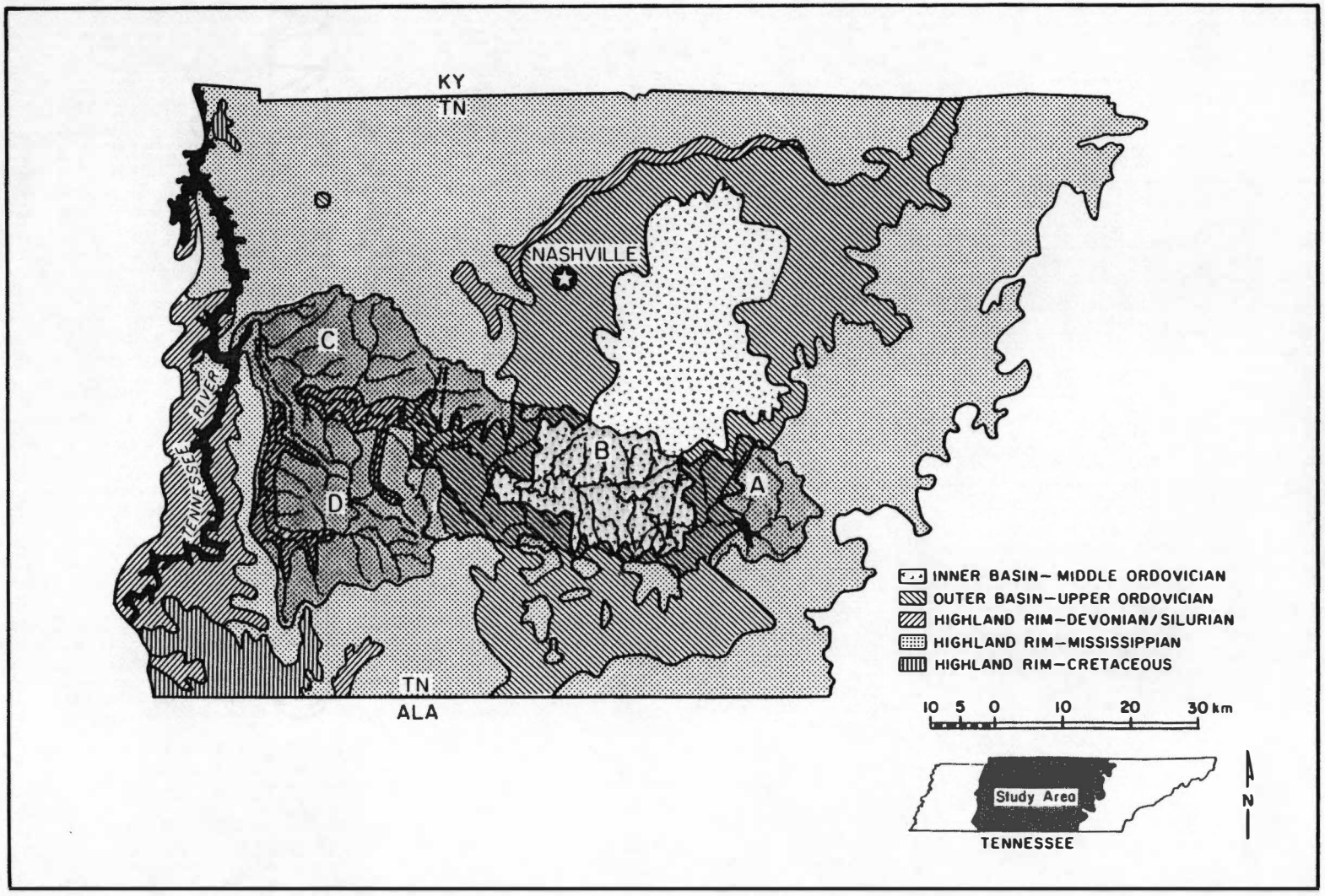

Figure 3.2. Physiographic/geologic section map.

northeast) by 80 km wide (southeast-northwest) and covers about 8000 km². Figure 3.3 is a generalized cross-section of the basin which shows the location of the topographical Nashville Basin upon the structural Nashville Dome. The depth of the basin is about 150 m below the surrounding resistant Mississippian rocks which form an elevated collar around the Nashville Basin known as the Highland Rim.

Luther (1977:37) has likened the Nashville Basin to a "bull's-eye center." The placement of an erosional basin on a structural dome leads to the beveling of geologic formations which dip away from the crest of the dome. The greatest amount of erosion has taken place in the center of the basin and the oldest rocks are exposed there. This center is located approximately 50 km southeast of Nashville, Tennessee. As one proceeds outward, successively younger and higher rocks form concentric rings around the center point. This pattern generally accounts for the present topography. The center of the Nashville Basin is marked by a low rolling plain topography. Moving toward the Highland Rim, there is a gradual increase in the undulating character of the topography and the frequency of residual knobs. Highland Rim remnants are also common along the major river divides in the Nashville Basin. Monadnocks are present along Duck Ridge which separates the Cumberland and Duck River drainages and along Elk Ridge which separates the Duck and Elk River drainages. The remnants are so numerous on Elk Ridge and within the Elk River Basin that its inclusion within the Nashville Basin is often considered questionable (Theis 1936:15; Fenneman 1938:433).

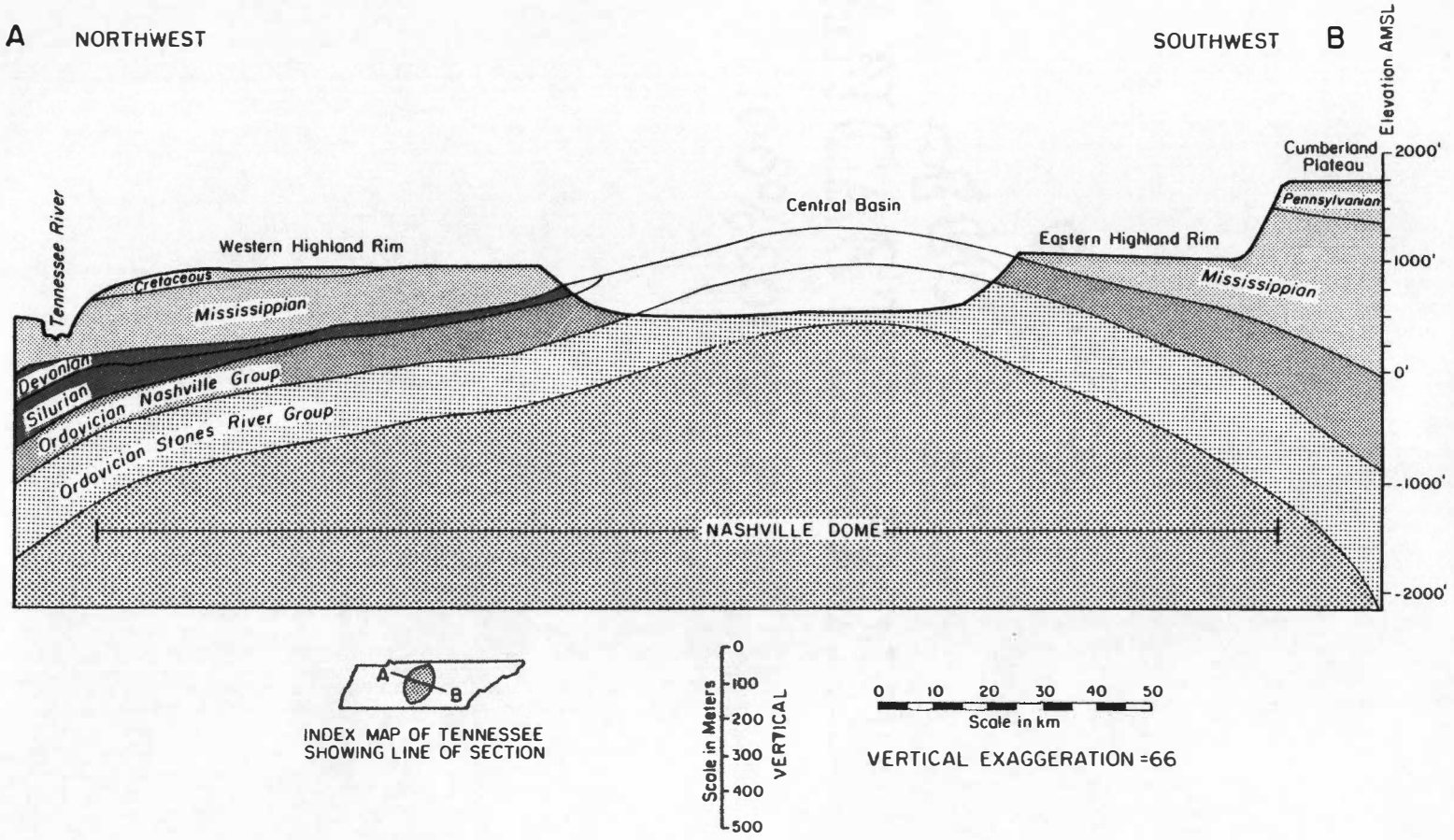

Figure 3.3. Generalized structural/topographic cross-section of the Nashville Basin.

Physiography

Variability between and within physiographic sections in Middle Tennessee is directly related to distribution and variability of the underlying geologic formations. Two major physiographic sections are recognized: the Highland Rim and the Nashville Basin. The Nashville Basin can be further subdivided into the Inner Nashville Basin and Outer Nashville Basin. These physiographic areas form roughly concentric ovals trending southwest-northeast.

The Inner Nashville Basin lies within the center of the concentric ovals. It is distinguished from the Outer Nashville Basin on the basis of underlying geologic formations. The boundary of the Inner and Outer Basins is considered to be the base of the Hermitage Formation (Theis 1936:14; Harmon et al. 1959:2). Consequently, the Inner Nashville Basin is comprised of Stones River Group rock formations. This includes the Murfreesboro, Pierce, Ridley, Lebanon, and Carters Formations. Relief is lowest in this area and soils are typically shallow with frequent bedrock outcrops. Bedrock outcrops and shallow soils have encouraged the development of patchy vegetation and xeric cedar glades communities (Freeman 1933; Quarterman 1950a, 1950b) in the Inner Nashville Basin. Primary ecological variability in the Inner Basin stems from the increased relief and soil depth encountered with higher underlying geologic formations (e.g., Carters) closer to the surrounding Outer Basin. Cedar glade patches tend to be restricted to Lebanon and Ridley Formation bedrocks. The bottomland forests tend to be more homogeneous and stable than upland forests within the Inner Basin (Shaver and

Denison 1928:8-12; Crites 1983:64-65). This is probably the result of greater soil depth and moisture on the floodplains.

The Outer Nashville Basin is composed of rocks above the base of the Hermitage Formation and below Silurian aged formations. This includes the Upper Ordovocian Hermitage, Bigby-Cannon, and Leipers-Catheys Formations, as well as limited exposures of later Ordovician Richmond Group rocks (Wilson 1949:201-239). The Outer Basin encircles the Inner Basin and is characterized by greater relief and soil depth; deciduous forest is more homogeneous and less patchy than comparable Inner Basin uplands. Variability within the Outer Basin is primarily east versus west. This undoubtably has resulted from differing environmental conditions east and west of the Nashville Dome during deposition of Upper Ordovician formations. On the eastern side of the Outer Basin, Upper Ordovician formations tend to be cherty (Fenneman 1938:432). On the western side of the Outer Basin, the Upper Ordovician formations (and soils derived from them) tend to be less cherty and highly phosphatic (Smith and Whitlatch 1940; Hardeman and Miller 1959). The high phosphate content of Western Outer Basin soils make the area extremely fertile and attractive for agricultural purposes (in contrast to the Inner Nashville Basin).

The Highland Rim physiographic section surrounds the Nashville Basin. The Highland Rim in this report is considered to be composed of Silurian, Devonian, and Mississippian rocks, and the Cretaceous Tuscaloosa Formation. This definition differs somewhat from Fenneman (1938:415) in that Silurian formations are included. The similarity of Silurian and Devonian distribution and lithology serves as the basis of

this decision. The Highland Rim is characterized as a dissected upland with slight undulations (Fenneman 1938:423). Major variability within the Highland Rim is due to differences in rock units of the eastern and western portions. A lesser degree of variability is present due to the decreasing thickness of formations to the south (Marcher 1962b; Milici et al. 1979; Thomas 1979). The boundary of Outer Nashville Basin and Highland Rim sections in the east is marked by a minor escarpment (Luther 1977:44). As one moves westward, this boundary becomes less abrupt, this is probably related to the major drainages flowing from east to west across the erosion resistant beds of Fort Payne chert.

The Eastern Highland Rim is about 50 m higher than the Western Highland Rim. The Eastern Highland Rim can be considered to have three separate components. Along the face of the Cumberland Plateau escarpment (approximately 300 m high) and its remnants, some higher Mississippian formations crop out (e.g., Bangor, Hartselle, Monteagle, Ste. Genevieve). Although some of these formations are chert-bearing, outcrops are limited due to the steep beveling of the escarpment. The second component is along the eastern portion of the Highland Rim plateau surface proper. This area is underlain by St. Louis and Warsaw Formations and is characterized by rich fertile soils. The third component is along the western margin of the rim. This area is slightly lower than the St. Louis-Warsaw section and is underlain by the Fort Payne Formation. Chert occurs in beds and nodules throughout the western margin and soils are generally poor. Infertile soils in combination with poor drainage led to the development of treeless prairie expanses in this area, known as "The Barrens" (Luther 1977:46).

Trees can become established in this area; but if destroyed by fire, reforestation would occur slowly (Luther 1977:46). Relief is more rugged in the northern part of the Eastern Highland Rim. Silurian and Devonian formations are generally absent.

The Western Highland Rim is maturely dissected and deeply weathered (Marcher 1962a:819). The Ste. Genevieve Formation is present in the extreme northern parts of the Western Highland Rim, but the St. Louis-Warsaw and Fort Payne Formations provide the vast majority of bedrock. St. Louis-Warsaw tends to be restricted to the higher elevations toward the north. On the Southwestern Highland Rim, the St. Louis is weathered and tripolitic (Miser 1921:24). Deposits of Tuscaloosa gravel are present on scattered higher elevations across the Western Highland Rim (Marcher and Stearns 1962). Several Silurian and Devonian formations crop out along the Western Tennessee River Valley and along the Duck and Buffalo Rivers on the Southwestern Highland Rim. The primary variation within the Western Highland Rim section seems to be north-south.

It should be emphasized that the differences used to distinguish between and within physiographic sections are clinal in nature. The greatest differences are between the Highland Rim and Nashville Basin and between the Inner Nashville Basin and the Western Outer Nashville Basin. The transition from one environmental or geographic area to another is also blurred by gradational erosional processes across the landscape which have left erosional remnants and talus slopes of higher formations behind. Nonetheless, these general differences form a basis for stratifying the distribution of resources across the landscape.

Drainage Patterns

Another important factor in developing empirically based regional research units is hydrology. Watershed morphology and drainage patterns are particularly useful. Basically, Middle Tennessee is drained by two major river basins, the Cumberland and the Tennessee (Figure 3.4). The major drainage pattern is from east to west as part of the larger Mississippi River system.

The Cumberland River originates in the Appalachian Plateau section of southeastern Kentucky. From there it makes a slight southerly loop into Middle Tennessee before heading northwest to the Ohio River. Passing through Middle Tennessee, the Cumberland drains the northern parts of the Highland Rim and cuts through the northern margin of the Nashville Basin. The Cumberland River drains the northern half of the Nashville Basin largely by its tributaries, the Stones and Harpeth Rivers.

The southern half of the Nashville Basin is drained by the Tennessee River system. The Tennessee River originates far to the east along the Appalachian Mountains. It flows through the Great Valley of East Tennessee toward the southwest and then cuts westward across northern Alabama and Mississippi before abruptly changing course to the north on its way to the Ohio River. The Tennessee River effectively separates the Western Highland Rim (Middle Tennessee) from the Mississippi Embayment (West Tennessee). The Elk and Duck Rivers are the major Tennessee River system tributaries draining Middle Tennessee and the Nashville Basin. The Elk River originates in the Southeastern Highland Rim and passes through the southern margin of the Nashville

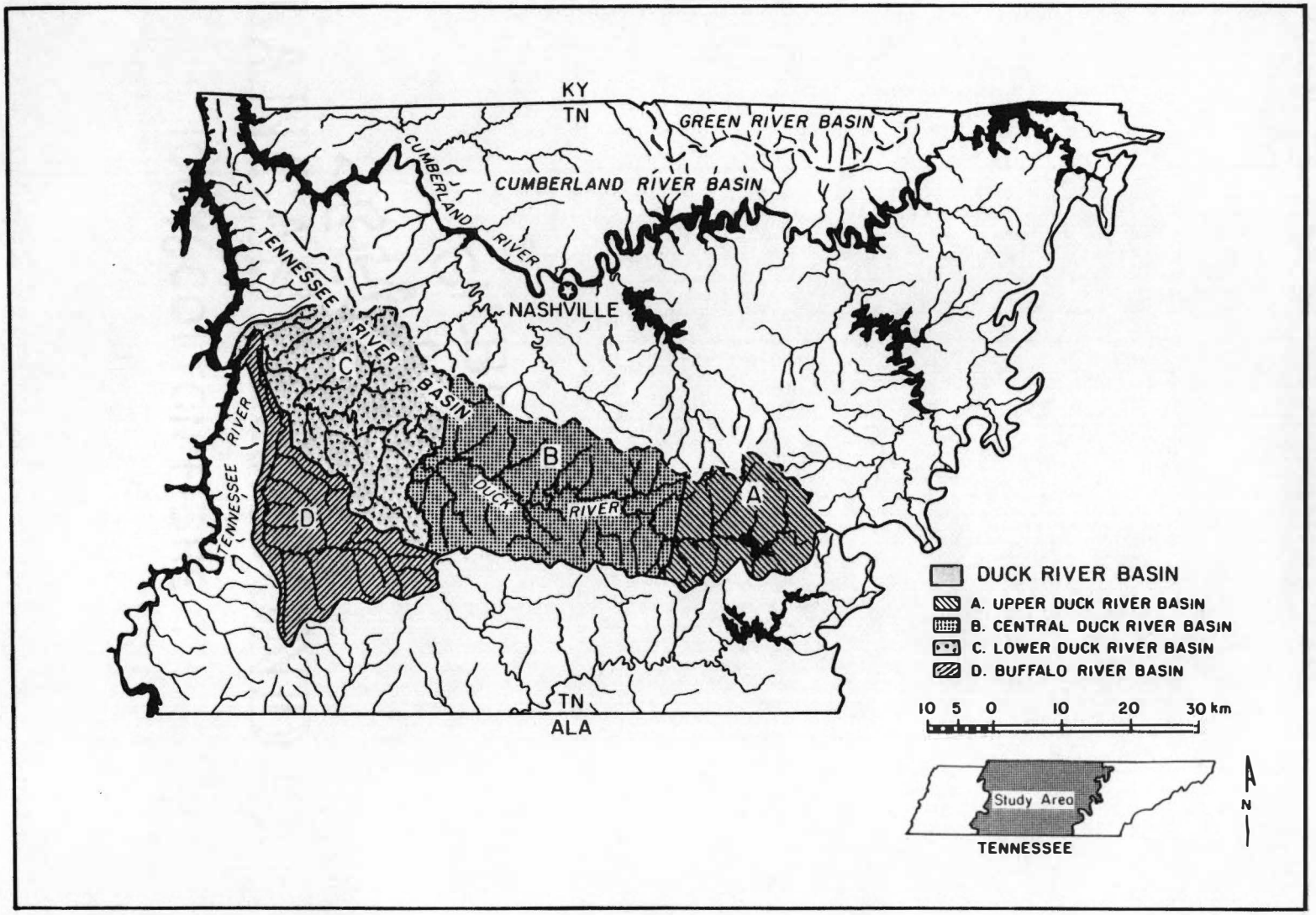

Figure 3.4. Duck River watershed divisions.

Basin. As noted earlier, the Elk River might be more properly considered a region distinct from both the Highland Rim and Nashville Basin due to its unique admixture of characteristics from both provinces.

The Duck River marks the boundary of the Tennessee and Cumberland River Basins in Middle Tennessee. The Duck originates in the Eastern Highland Rim and passes through the Nashville Basin and Western Highland Rim before entering the Tennessee. Since the Duck River system is the major focus of this research, it has been divided into four distinct regions (Figure 3.4). These regions generally correspond to the physiographic sections the Duck transects on its way westward to the Tennessee. The upper Duck River Basin consists of the section of the river that passes through the Eastern Highland Rim. The central Duck River Basin is considered to be that portion of the river that crosses the Nashville Basin. It would seem appropriate to subdivide the central Duck River Basin into Eastern and Western Outer Nashville Basin and Inner Nashville Basin portions. The lower Duck River Basin is the section that passes through the Western Highland Rim. The Buffalo River Basin is technically a part of the lower Duck River section. However, since it is wholly confined to the Southwestern Highland Rim, it is somewhat distinct from the rest of the Duck River system. In essence, the Duck River system represents a transect across the major physiographic sections of Middle Tennessee.

Chert Resource Survey

Methodological Statement

Organization of a chert resource survey for the central Duck River Basin has proceeded along several stages. The first consideration is the definition of a chert type. May (1981) has noted that there are two typological systems available, geological chert types and source areas or archaeological chert types and source areas. These systems may be isomorphic or independent. May (1981:114) has argued that geological classification limits the range of hypotheses which can be addressed in chert exploitation studies and has urged the adoption of independent archaeological classification methods. A major difficulty with this approach is the selection of proper attributes needed to develop an archaeological classification. In fact, May's suggestion flirts with an attempt to identify ideational and cognitive modes of extinct peoples. As Binford (1967:234) has noted, archaeologists are poorly equipped to become "paleopsychologists" and the illusive understanding of extinct cognitive systems is quite unlikely to contribute to understanding the processes causing cultural differences and similarities. The chert type classification employed in this study reflects the underlying theoretical stance of an environmental and ecological approach to understanding resource exploitation. This classification system is necessarily a geological one isomorphic with archaeological classification. Geological chert types are equated with chert from a single geologic formation or a part of that formation and as such, reflect an objective reality grounded in natural processes of chert

genesis (Luedtke 1979:745). Geological chert types and source areas are critical in developing resource distribution patterns necessary for modeling exploitation strategies. After defining chert types equivalent to geological reality, a literature search was conducted, and appropriate fieldwork, collection, and identification procedures were established.

Literature Search

The literature search focused on regional geological and archaeological accounts of chert type diversity. The geological literature revealed which geologic formations were recognized to be chert-bearing and the general distributional patterns of these cherts and formations. These accounts are acknowledged below in the chert type descriptions. Primary sources on Middle Tennessee stratigraphy and petrology are Bassler (1932) and Wilson (1949) for the Nashville Basin and Marcher (1962a, 1962b), Marcher and Stearns (1962), and Milici et al. (1979) for the Highland Rim. In addition, the study of 7.5 minute Geologic Quadrangle maps (scale equals 1:24,000) and Mineral Resource Summaries available from the Tennessee Division of Geology was undertaken (Table A.1, Appendix A). The major problem with geological accounts of chert are based on its economic unimportance. State-wide geological surveys are generally conducted to determine the distribution and quality of economically important minerals. Consequently, accounts of chert deposits and chert morphologies are often inaccurate and inadequate for the purposes of archaeological chert type descriptions.

Several archaeological accounts of chert type diversity are available for Middle Tennessee. The cornerstone of these accounts has been the Normandy Lithic Resource Survey in the upper Duck River Basin (Faulkner and McCollough 1973; Penny 1974; Penny and McCollough 1976; Prescott 1978). Understanding lithic resource distributions upstream is critical to understanding lithic resource distributions in the central Duck River Basin. Faulkner and McCollough (1973:52-61) identified 14 chert types in the upper Duck area. Penny (1974) lists 20 different chert types, and Penny and McCollough (1976) list 18 chert types in the upper Duck. A major problem with these chert types is that they were often not referenced to a parent geologic formation. Incomplete geological mapping of the western Cumberland Plateau escarpment is partially at fault. These chert types were given morphological names based on color, fossil inclusions, and other structural characters. An attempt is made to correlate these types with the geologic chert type descriptions below. For the most part, lithic resource use in the upper Duck River Basin suggested that proximity to source was the most influential factor guiding procurement strategies (Prescott 1978:425). This probably reflects the general abundance of chert throughout the Eastern Highland Rim section. Work by Kline (1978:55-68) in the Caney Fork drainage of the Eastern Highland Rim suggests similar conclusions regarding localized procurement of abundant chert sources. McCluskey (1974, 1976) has conducted a pilot study on defining chert type variability in the central Duck River Basin. He lists 21 chert types, 9 of these are referable to the Normandy types. McCluskey's work suffers primarily from attempts to define morphological chert types from

archaeological collections without adequate resource survey fieldwork; consequently, many of his types are of limited utility.

Fieldwork

Following literature survey, it was decided that lithic resource survey fieldwork was required in the central Duck River area. The purpose of this fieldwork was to develop a chert collection from known proveniences (preferably from known geologic formation outcrops) and to make observations on chert type distributions and modes of occurrence in the area. Foremost emphasis was placed on the development of a synoptic chert collection referenced by geologic formation which reasonably represented morphological variability within the formations. The literature search was helpful in determining which formations were chert-bearing, but the Geologic Quadrangle Maps were critical to implementing a fieldwork collection and observation program. The Geological Quadrangles display all the usual features of topographic quadrangles as well as geologic formation distributions and historic quarrying and mining locations. A series of quadrangles transecting the Inner Nashville Basin--Outer Nashville Basin--Southwestern Highland Rim were the focus of intensive study in the laboratory and the field (Figure 3.5 and Table A.1, Appendix A). In addition, the larger scale (1:250,000) Geologic Map of Tennessee, West-Central Sheet (Miller et al. 1966) was helpful in consideration of greater regional scale patterns.

A total of 82 outcrops were formally examined for chert deposits. These outcrops encompassed all of the local formations from Murfreesboro through Fort Payne (see Table A.2, Appendix A). Historic quarries and

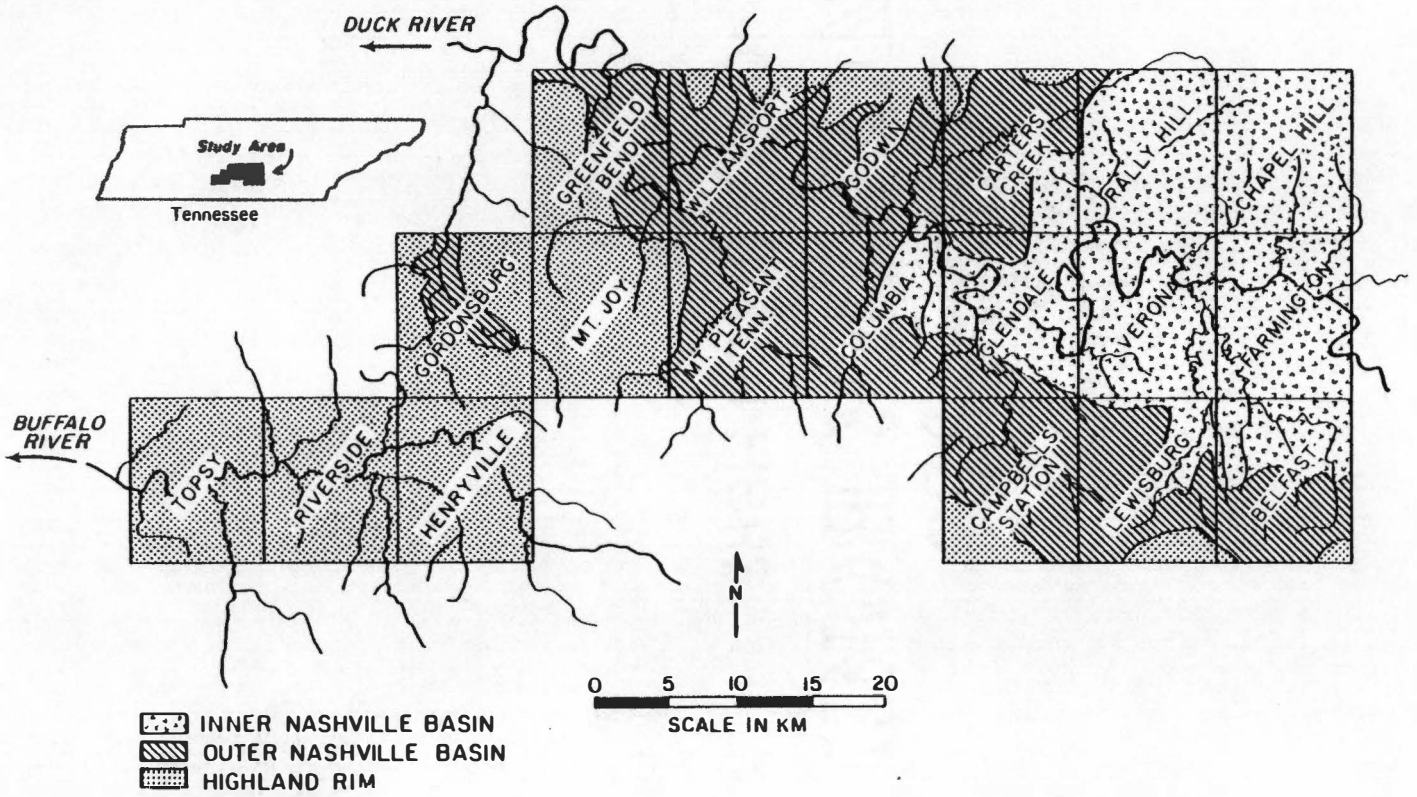

Figure 3.5. Geologic Quadrangles (7.5 minute) employed in the chert resource survey.

road-cuts formed the majority of observed outcrops. However, natural surface rock outcrops, bluffs, and caves were also examined. An attempt was made to observe outcrops of all relevant formations regardless of geological literature reports of chert. Since geological reports were often superficial where chert is concerned, it was suspected that some unreported chert-bearing formations and geographically patterned variability might exist. Chert collected from these documented formation exposures formed the nucleus of a large comparative chert collection housed at The University of Tennessee, Department of Anthropology, Knoxville.

In addition to chert collected from bedrock context, collections were made from secondary depositional settings. It is estimated that nearly 150 other locations were examined and/or collected during the lithic resource survey. These locations represent surface residual, talus deposits, terrace gravels, and recent alluvial gravels. Remarks concerning the distributions and modes of occurrence of various chert types are included in the chert type descriptions below.

Chert Identification

Before proceeding to the chert type descriptions, a statement should be made regarding chert identification procedures. Increasing technical sophistication of chert type identification has been a marked trend over the last decade. This is particularly exemplified by trace-element studies (e.g., Sieveking et al. 1972; Luedtke 1978). This trend toward technical sophistication is related to criticisms of less technically sophisticated macroscopic visual identification. Luedtke

(1979:745) summarizes these problems as: (1) a greater chance of error; (2) requirement of expertise in chert discrimination; and (3) low replicability. Consequently, she has advocated the trace-element technique of chert identification. Blakeman (1977:72-75) has also compared macroscopic techniques of identification to trace-element techniques, but has come to an opposing conclusion. His main objections to the trace-element approach are: (1) time consumption; (2) cost; (3) special expertise requirements; and (4) sampling requirements which make it ill-suited to large assemblage processing. In essence, Blakeman (1977:84) feels that technical sophistication is being substituted for the more critical methodological sophistication required in chert identification. He suggests (1977:74-75) that the proper methodological sophistication can only result from a solid geological and geographical assessment of regional resources. Luedtke (1979:452-455) has compared macroscopic and trace-element techniques by concensus agreement analysis. Although her trace-element techniques yielded as high as 87.5% "correct classification," visual inspections yielded as high as 73.9% "correct classification." The major problem of the macroscopic technique is that greater significance is assigned to some attributes than to others and criteria for type definition varies from one type to another (Luedtke 1979:745). Invariably, expertise results from experience with the technique. This problem could be resolved through the development of a classificatory key, but the application of this technique to items with variable states of numerous overlapping attributes is difficult and often inaccurate. Nonetheless, nearly 75% "correct classification" is quite acceptable, particularly in light of

the statistical probability method of lithic analysis in general (cf. Collins 1975: 15).

Blakeman (1977:72) has noted that:

> classification of chert via macroscopic examination is dependent upon criteria which are visible either to the naked eye or under low magnification. These characteristics include color, texture, fossil inclusions, transluency, and bedding and fracture patterns.

Of these criteria, it is suggested that color may be the least reliable (Kellberg 1963:1). Emphasis on classification of central Duck River cherts is placed on internal sedimentary structures. Geologists (Biggs 1957:2, 11; Pettijohn 1957:94, 157-228) have used this term to refer to bedding laminations, oolites, fossils, and clastic textures. Geologic formations are divided on the basis of structural differences and it seems appropriate that cherts which are recognized to be lithologically similar to their host rock (Biggs 1957:7) should reflect these differences also. The use of internal sedimentary structures as the prime criteria of archaeological chert classification has been advocated by Leonoff (1970:8) and Young and Syms (1980:207).

Chert Type Descriptions and Distributions

Ordovician Murfreesboro (Om)

Murfreesboro Formation outcrops are relatively rare in the Nashville Basin. It is the oldest exposed Ordovician formation in the basin and is generally found only in deeply incised river channels. There is a small bluff exposure in the central Duck River Basin between river miles 186 and 188 (Om #1, Table A.2, Appendix A). In addition, relict meander scars expose the Murfreesboro Formation in the upper

parts of the Stones River drainage (Rutherford County). Milici (1969:115) reports chert from the Murfreesboro Formation in the Sequatchie Valley at the southern end of the Cumberland Plateau. Wilson (1949:30) has noted that:

> The presence of abundant chert is a prominent feature of most exposures of the upper part of the Murfreesboro limestone. The chert occurs as lens-like stringers, nodules, blebs, and irregular masses and is either along bedding planes or within a stratum. Where fresh the stringers, nodules, and blebs are commonly black or dark brown in color, but upon weathering an outer zone of leached chert with much light color is developed. This process continues until the original dense black chert is completely leached. The irregular masses are white to cream and buff in color.

Chert from this formation was collected at the bluff exposure on the Duck River at Wilhoite Mills. This chert occurred in small (approx. 2.5 cm thick) flattened nodules with frequent incipient fracture planes. The very fissile nature of this chert imparts a tendency toward crumbling into small cubes (approx. 5 mm^3) when flaking is attempted. Murfreesboro chert is characteristically fine-grained brownish gray and contains numerous inclusions (Figure B.1, Appendix B). In order of greatest frequency, these inclusions are: (1) small reddish brown spots, greater than 2 mm in diameter; (2) black specks, greater than 2 mm in diameter; (3) small light blue spots and streaks, about 0.5 mm wide; and (4) large reddish brown-blue-gray mottlings, about 3 to 10 mm in diameter. The most distinctive features of Murfreesboro chert are the small irregular nodule shape and size, the numerous fracture planes, and the brownish gray color with frequent inclusions.

Although Mufreesboro chert is fine-grained, its extremely small nodule size and fissile nature cause it to be poorly suited for the

production of chipped-stone implements. Exposures of this formation are also extremely limited, leading to a relatively low sediment/residual contribution compared to other regional formations. Perhaps better quality chert and larger exposures are present within the Sequatchie Valley, but Murfreesboro chert is expected to be unimportant to Middle Tennessee chipped-stone technologies.

Ordovician Pierce (Op)

The Pierce Formation outcrops are similar to the Murfreesboro. It is generally found in deeply incised meander scars. This formation is very thin and often grouped with the Murfreesboro on geologic maps (Opm). No chert has been reported from the Pierce Formation (Wilson 1949:32-34). Limited outcrops are in the Lillard Mill area, but surveys there revealed no chert presence.

Ordovician Ridley (Ord)

The Ridley Formation crops out in extensive areas in the Inner Nashville Basin. The formation is massive bedded and erosion results in a flat or only slightly rolling topography. Flat bedrock outcrops are common and lead to establishment of distinctive cedar glades vegetation "patches" referred to earlier. There is some tendency for the Ridley to develop karst features; this is particularly evident in the Farmington and Verona Quadrangles (Figure 3.5, page 40; Table A.1, Appendix A). Wilson (1949:36-37) has noted that:

> Chert is a common feature of the Ridley limestone. Two types may be found: (1) stringers, nodules, and blebs of dense black or dark-brown chert that is found in fresh exposures . . . as well as in weathered exposures and (2) irregular masses of brown to light-brown or white chert coinciding with zones of

> concentrated fossils, the localization of these masses probably resulting from secondary chertification of the fossils.

Mineral Resource Summaries (Table A.1, Appendix A) for quadrangles in which Ridley crops out uniformly state that "thin lenses of chert are present locally." Ridley chert typically occurs in a flattened nodule shape about 10 to 20 cm in diameter and 5 to 7 cm thick. Incipient fracture planes are common and transect the nodules perpendicular to the bedding causing the chert to split into small blocks and wedges. Ridley chert displays considerable diversity but is invariably gray or irregularly mottled with a variety of gray shades. Common structural features are: (1) "rods" (discussed below); (2) quartz and calcite filled vugs, about 1 to 8 mm in diameter; (3) minute black specks, less than 0.5 mm in diameter; (4) small white flecks, about 1 mm long; and (5) dark-gray black sugary textured, irregularly shaped, mottlings 0.5 to 2.0 cm in diameter. Most of these structural features are common to Carters chert (see below), and Ridley may sometimes be difficult to distinguish from gray phases of Carters and Fort Payne. Fortunately, the structural "rods" in Ridley seem to be an exclusive characteristic. These "rods" are fossil inclusions, probably a small cylindrical ramose bryozoan form (Wilson 1949:38). These branching tendinous invertebrate animals once inhabited the Ridley seas. They are now oriented parallel to the bedding plane and commonly appear as circular or elongated oval spots within the Ridley chert (see Figures B.2 and B.3, Appendix B). The structural detail and frequency of "rods" vary considerably. Usually no structural detail of the "rod" itself is noticeable in these cross-sections, but occasionally, a swirling spiral can be observed.

"Rods" may be darker or lighter gray than the surrounding matrix and can usually be detected by contrasting saturation.

Wilson (1949:38-39) has stated that "residual chert is not a prominent feature of soil derived from Ridley limestone." Contrary to this opinion, the present survey suggests that residual chert is indeed a prominent feature of Ridley derived soils. Flat upland expanses and valley slopes in the central Duck River Basin frequently display Ridley chert "floaters" on the surface and throughout the soil profile to Ridley bedrock. Residual cherts are released from the bedrock by chemical weathering of the softer limestone matrix. Various mechanical processes (e.g., freeze-thaw, soil erosion) then move this residual toward the surface. Ridley residual chert may be present wherever Ridley bedrock underlies the soil or is exposed. Ridley residual typically occurs as grainy-textured small blocks or wedges (Figure B.4, Appendix B--also note dark-gray black sugary structural mottlings). The pieces may have been procured by surface gathering or shallow digging. These blocks were commonly sheared along natural incipient fracture planes to reduce the piece to a relatively homogeneous mass. Reduction then proceeded with blows parallel to the bedding plane and perpendicular to the incipient fracture planes which served as striking platforms (Figure B.5, Appendix B).

Recent central Duck River alluvial gravels contain some water-worn Ridley cobbles (Amick 1981:590). Ridley chert can also be found adhering to limestone matrix in natural outcrops (e.g., bluffs, caves). There seems to be some tendency for Ridley gravels and cave sources to be more fine-grained than residual sources. This is probably a function

of more severe weathering at residual locations. Figure B.6 (Appendix B) shows an exceptionally fine-grained Ridley nodule, note that "rods" are infrequent and difficult to distinguish, but that minute black specks are common. In general, Ridley chert should be characterized as grainy small residual blocks frequent in low Inner Basin upland areas.

Ordovician Lebanon (Olb)

Despite the fact that Wilson (1949:41) notes localized chert presence in the Lebanon Formation, no chert was observed during this survey. None of the Geologic Quadrangles or Mineral Resource Summaries studied mention chert-bearing Lebanon deposits. It appears that chert is absent from the Lebanon Formation in the central Duck River Basin. The thin-bedded nature of the Lebanon Formation often results in surface and stream liberation of flat limestone plates (approx. 30 x 15 x 3 cm). These plates may have been important raw materials for the production of limestone implements (e.g., hoes, grubbing implements).

Ordovician Carters (Oc)

The Carters Formation marks the highest formation in the Inner Nashville Basin. It is similar to the Ridley Formation in bed thickness and chert presence. Topography on the Carters is more rolling and soils are deeper, however. The Carters Formation is recognized to have distinct upper and lower members (Wilson 1949:45). Wilson (1949:51) notes that:

> At most exposures of Lower Carters limestone it contains lens-like stringers and nodules of white to dark-gray chert, the long dimension of which is parallel to the bedding. The chert, which is often banded concentrically with different

> shades of gray, may occur along a bedding plane or within a stratum.

Milici (1969:118) has noted the presence of irregular 5-7.5 cm dark-gray chert layers weathering to a yellowish brown with fossil inclusions common in Carters exposures as far east as the Sequatchie Valley.

The Geologic Quadrangles and Mineral Resource Summaries (Table A.1, Appendix A; and Figure 3.5, page 41) state that the Carters Formation contains "thin lenses of chert locally" in the lower member. This chert is similar to Ridley in size and shape, but displays more variability in these attributes. Carters chert ranges from thin platy lenses (approx. 3 cm thick) to moderate rounded masses and contorted cylinders (approx. 15 cm thick). Like Ridley chert, the Carters chert is epigenetically derived by silica replacement (see Biggs 1957 for an excellent discussion of replacement cherts). Replacement cherts are often formed along thin bedding planes and within fossil castings. Carters chert exemplifies these tendencies with several characteristic structural forms. These forms all have a common characteristic inclusion; Carters chert displays scattered white flecks (approx. 1 mm long) throughout. Unfortunately, this characteristic is not restricted to Carters; Fort Payne or Ridley may sometimes appear similar. Carters is also like Ridley in coloration which ranges from white to medium gray. Quartz and calcite filled vugs are common.

The most prevalent form of Carters chert found is a flattened nodule 20 to 30 cm in diameter and 10 to 20 cm thick. These nodules tend to be more spherical than similar Ridley nodules. Incipient fracture planes are common, but more widely spaced than in the Ridley

chert. Gross irregular gray-brown mottlings characterize this Carters form (Figure B.7, Appendix B; also note white flecks). Other inclusions seem to be present within Carters chert, but they are often too indistinct to characterize. A somewhat related form of Carters chert occurs in long winding cylinders about 5-10 cm in diameter. These cherts appear to have replaced structurally weaker limestones along former burrows of bottom dwelling animals in the lower Carters sea. Coloration and inclusions are similar to the nodular forms, but these cylinder cherts are characterized by concentric banding (Figure B.8, Appendix B).

Another distinctive form of Carters chert occurs in lenses (approx. 5 cm thick). This form displays fine darker gray banding parallel to the bedding plane (Figures B.9 and B.10, Appendix B). McCary (1963:4) has termed this pattern "pseudo-bedding." This form can be confused with a similarly patterned Fort Payne chert noted below. One more form of Carters chert has been observed, but it appears to be quite rare. This unusual form occurs as small nodules (approx. 5 cm diameter) that are fine-grained and homogeneously gray with white flecks.

In general, Carters chert is comparable to Ridley in size and quality. There may be a similar reduction strategy for Carters chert, but this is inconclusive at the present. Carters tends to be grainy and blocky like Ridley and is most commonly found as surface residual. The Carters Formation typically forms relatively steep slopes and bluffs at interstream divides (Wilson 1949:56-56). Residual Carters chert is present on these slopes and bluffs as well as in the talus deposits. Consequently, Carters chert may often be found on the lower lying

Lebanon Formation outcrops. Carters chert also occurs within the central Duck River alluvial gravels (Amick 1981:50).

Ordovician Hermitage (Oh)

The base of the Hermitage Formation forms the boundary of the Inner and Outer Nashville Basins. One convenient reason for this is the distinctive lithologic character of the Hermitage. Several intergradational facies are recognized for this formation, usually slight variations in limestone lithology and fauna account for these facies. Chert has been reported from the Hermitage Formation in the Mt. Pleasant Quadrangle (Table A.1, Appendix A; and Figure 3.5, page 40), but investigations by the author failed to locate any Hermitage chert deposits. It is possible that the chert reported was derived from hillslope erosion of overlying Fort Payne deposits which are common to the Mt. Pleasant area.

Within the Inner Nashville Basin, Hermitage Formation remnants often cap interstream divides (Wilson 1949:56). A classic expression of this topography is recognized to cut north-south across the central Duck River Basin along the Fountain and Negro Creek drainages (approx. R.M. 148). The Hermitage Formation possesses a distinctive rock referred to as "siltstone." This rock is actually the weathered laminated argillaceous limestone facies of the formation (Wilson 1949:88, 1962:485). Siltstone slabs litter the surface of the Fountain Creek-Negro Creek ridge and are washed into the Duck River where they decompose quite rapidly. Siltstone is similar to sandstone; however, the individual grains are within the smaller silt size range. This

property lends siltstones a finer texture and weaker structure than sandstones. Nonetheless, Hermitage siltstone would have been a locally accessible source of abrading stone in the central Duck River Basin.

Ordovician Bigby-Cannon (Obc)

The Bigby-Cannon Formation is composed of three distinct contemporary facies which laterally intergrade (Wilson 1949:80, 107). The Bigby facies thins from west to east and the Cannon facies thins from east to west, the Dove-colored facies separates the Bigby and Cannon. Wilson (1949) has reported several chert zones within the Bigby-Cannon Formation. Between the middle and upper zones of the Bigby facies, a cherty massive limestone is reported in Maury County (Wilson 1949:114).

> The Bigby facies weathers to a brown phosphatic soil with many scattered plates of phosphate. Generally, chert is not a conspicuous feature in the soil, but where the limestone has been thoroughly leached, as it has in the phosphate pits near Mt. Pleasant, Maury County, considerable secondary chert does occur (Wilson 1949:120).

Smith and Whitlatch (1940:21-22) have also described this occurrence of chert:

> The two main varieties of chert are: a porous yellow form, derived from the fossiliferous lenses, that is composed largely of silicified shells; and a dense, compact platy flint or chert, usually non-fossiliferous, that is yellow on the outside but often white or light-bluish inside. This latter variety often assumes curious forms, at some places, rising in the rock into conical or mushroom-like shapes. The chert derived from the Bigby formation can usually be distinguished from that of the underlying Hermitage formation by the presence of the silicified Dalmanella shells in the latter.

Wilson (1949:124) has also noted that "chert is locally common in the upper lentils of the Dove-colored facies, as for example in the

Dove-colored member at Nashville." Chert was also noted in the upper 6 to 10 meters of the Cannon facies by Wilson (1949:127). Finally, Milici (1969:119) has stated that within the Cannon facies in the Sequatchie Valley:

> medium-dark gray to dark-gray chert occurs parallel to the bedding as irregular masses up to 1-foot long and 6-inches thick near the top of the formation and in 1-inch balls and lenses in some limestones in the lower half of the formation.

Despite these numerous geological references to chert within the Bigby-Cannon Formation, the present survey has failed to locate any Bigby-Cannon chert in situ in the central Duck River Basin. A small unconsolidated siliceous bleb was found in the Campbell Station Quadrangle at Obc #1 (see Table A.2, Appendix A). This piece resembled what is commonly referred to as gray-banded chert in the archaeological literature (Faulkner and and McCollough 1973:53-54; Penny and McCollough 1976:155-165). Gray-banded chert is recognized to originate in the upper half of the Cannon facies on the Eastern Outer Nashville Basin (Penny and McCollough 1976:160). Adequate descriptions of this chert (referred to herein as Bigby-Cannon) have been published previously (Faulkner and McCollough 1973:53-54; Penny 1974:16-35; Penny and McCollough 1976:155-164). Particularly noteworthy considerations are the high tractability and moderate subspherical nodule size of this near vitreous chert (Figure B.11, Appendix B). Bigby-Cannon chert was a highly attractive raw material for prehistoric groups in the upper Duck River Basin. Distance-decay distributions of Bigby-Cannon frequency in the upper Duck (Penny and McCollough 1976:155-157; Prescott 1978: 423) suggest that sources may be restricted at least to the Eastern Outer

Nashville Basin. This seems quite reasonable considering the general east-west lithological variability of the Ordovician rocks of the Nashville Basin and the Bigby-Cannon Formation in particular. Further evidence for this interpretation is provided by the observation of Bigby-Cannon alluvial cobbles within the Duck River watershed. Penny and McCollough (1976:157) noted that gray-banded chert was infrequent in the upper Duck River gravels (about 0.1%). Amick (1981:50) has noted a similar low frequency in the central Duck River gravels (less than 0.07%). However, terrace gravels representing pre-Pleistocene downcutting of the Duck contain abundant amounts of Bigby-Cannon (Amick 1981:49). This may reflect considerable headward erosion of a cherty Cannon facies which was once present farther to the west.

Bigby-Cannon chert is present in the central Duck River Basin in the form of ancient terrace gravels as noted above. Due to considerable weathering of these gravels, some distinctive varieties of Bigby-Cannon chert are available in the central Duck River Basin. As the lustrous Bigby-Cannon weathers, it becomes sugary and dull in appearance (Figure B.12, Appendix B). It further weathers to a tenacious quartzitic texture and alters to a brownish color (Figure B.13, Appendix B). McCluskey (1976:704) recognized this form as "brown-banded chert." The weathered varieties of Bigby-Cannon chert respond very well to thermal alteration, turning deep maroon in color and often regaining the lustrous qualities of fresh gray-banded. The quartzitic tenaciousness of the brown-banded Bigby-Cannon and the rounded cobble form it assumes in terrace gravels impart desirable characteristics for knapping hammerstones. It is suspected that this quality may enhance the

desirability of brown-banded Bigby-Cannon for this functional artifact class.

Ordovician Leipers-Catheys (Olcy)

The Leipers and Catheys Formations are actually separate unconformable units, but the lithological similarities of these formations makes them difficult to distinguish from each other (Wilson 1949:156). Consequently, they are usually mapped together on the Geologic Quadrangles. Milici (1969:119) has reported "medium-gray chert in irregular nodules up to 6-inches long and 2-inches across" in Catheys Formation outcrops in the Sequatchie Valley. Otherwise, chert has not been reported from these formations.

The present chert survey located chert at a Leipers-Catheys outcrop in the Campbell Station Quadrangle (Olcy #1; Table A.2, Appendix A). This chert resembled Murfreesboro chert in size and fissility. Figure B.14 (Appendix B) illustrates this chert. Numerous fossiliferous inclusions are present (typically bryozoan species) in a grainy light-gray brown matrix. Like the Murfreesboro chert, it is suggested that the limited occurrence and poor quality of Leipers-Catheys chert makes it an unattractive raw material for chipped-stone industries.

Silurian and Devonian Systems

Wilson (1949:240-314) has reported chert from several Silurian and Devonian formations which crop out along the major river valley bluffs in the Western Highland Rim. Since these formations are not directly relevant to considerations of raw material use in the Nashville Basin, they are excluded from discussion. These formations are the Silurian

Beech River, Bob, Lobelville, Decatur, Ross, and Harriman Formations, and the Devonian Camden and Pegram Formations. One chert-bearing Silurian formation is important to central Duck River Basin considerations, the Silurian Brassfield Formation.

Silurian Brassfield (Sbr)

The Brassfield Formation occurs in thin outcrops along the boundary of the Western Highland Rim and Nashville Basin. Wilson (1949:240) has noted that:

> It (the Brassfield Formation) is usually cherty . . . . The Brassfield limestone nearly everywhere contains lenses, beds, or nodules of light-gray to dark-gray or black chert that averages between 1 and 3 inches in thickness. In the southern counties of the Western Valley the chert is not as common as to the north and east . . . . Where both chert and glauconite are prominent in one section, the upper part is cherty, the lower glauconitic.

Flattened nodules about 4 to 7 cm thick and 10 cm in diameter have been collected from the Columbia Quadrangle (Sbr #1; Table A.2, Appendix A) during this survey. Brassfield chert is typically fine-grained and highly tractable. It possesses a wide variety of inclusions and colors. There appears to be two distinctive characters to Brassfield chert: (1) a compact, smooth, cream-colored cortex (about 5 mm thick) and (2) faint maroon tintings which often form a thin subcortex band (Figure B.15, Appendix B). Generally, Brassfield is gray and tan mottled with some occasional blue-gray patches. Inclusions are numerous although not very distinct, they are usually lighter in color than the surrounding matrix. White flecks (approx. 1 mm long) are common. Some larger bryozoan-like structures are scattered throughout (Figure B.16, Appendix B). Brassfield is a difficult chert to characterize because of the wide

variety of color mottling and inclusion patterns present. It is this lack of clear sedimentary pattern, fine-texture, and maroon tinting with white flecks which usually combine to form a diagnostic set of attributes.

The Brassfield Formation is very limited in its distribution. It is a thin formation and outcrops are confined to a few areas within the Western Outer Nashville Basin. Nodgrass Hill in the Columbia Quadrangle and the Snow and Knob Creek drainages in the Godwin Quadrangle contain the major sources of Brassfield in the area (Table A.1, Appendix A; Figure 3.5, page 40). Also, some minor exposures of Brassfield are present within the Buffalo River Basin. Brassfield chert may have been a desirable raw material due to its fine flaking qualities. But the small nodule size and extremely limited distribution of the formation tend to lessen its potential contribution to local chipped-stone industries.

Mississippian Fort Payne (Mfp)

Fort Payne chert has been recognized as a major source of raw material for prehistoric chipped-stone tool production throughout the Middle South (e.g., Faulkner and McCollough 1973; McCluskey 1976; Penny and McCollough 1976; Kline 1978; Johnson 1981a). These investigators have also despaired at the great variability in Fort Payne color and structure. Not only is the chert morphologically variable, but the vertical and lateral distribution of Fort Payne varieties form a complex mosaic across the Middle South landscape. Geological understanding of the variability within this massive ubiquitous formation is admittedly

poor (Milici et al. 1979:11). Attempts at characterization of variability by trace-elements have also been futile (Hoffman 1981). Lithic resource survey in the central Duck River Basin has suggested that five different structural categories may be discernable: quartz geodes, laminated, pepper-and-salt speckled, crinoidal, and fibrous. These categories are not necessarily mutually exclusive and single specimens may exhibit more than one structural configuration. The primary reason for devising a scheme of Fort Payne varieties has been to facilitate recognition of macroscopic structural variability. The ultimate goal of this endeavor is to develop an understanding of Fort Payne variability across the landscape.

Quartz geodes. The presence of quartz geodes within the Fort Payne Formation is well recognized by geologists (Miser 1921:133-134; Marcher 1962b:12; Chowns and Elkins 1974; Milici et al. 1979:11; Thomas 1979:8). The best account of these geodes is given by Chowns and Elkins (1974:889). They note that the geodes are easily distinguished by their distinctive "cauliflower shape." The outer shell of the geode is composed of chalcedony while euhedral quartz lines the inside. The geodes can attain a maximum diameter of 15 cm in the Fort Payne Formation. Quartz geodes are also present within the Warsaw Formation where they range up to 60 cm in maximum diameter. Since the Fort Payne and Warsaw are contiguous formations on the Highland Rim, the origin and distribution of quartz geodes is generally restricted to the lower margins of the Highland Rim. Alluvial gravels constitute a minor source of this material throughout Middle Tennessee. It seems likely that the

Fort Payne/Warsaw quartz geodes may be the source of vein quartz/chalcedony raw materials previously recognized among Eastern Highland Rim archaeological assemblages (Faulkner and McCollough 1973:57-58; Penny and McCollough 1976:181-183; Kline 1978:57-59).

Laminated Fort Payne. Most other Fort Payne types show characteristics which are suggestive of this typical structure. Marcher and Stearns (1962:1372) have perceived this structure as imparting a distinctive banded appearance to the chert. Laminated Fort Payne is more commonly referred to as the "bedded" chert lithofacies of the Fort Payne Formation (Marcher 1962a, 1962b). Marcher (1962a:821; 1962b:12) states that "the bedded chert lithofacies consists of layers of chert 4 inches to 1 foot thick (10 to 30 cm)." Observations of the present survey suggest these layers may be up to one meter thick in some localities. This variety of Fort Payne chert has been described as follows:

> Chert, which occurs as persistent beds or irregular nodules in the limestone, is nearly everywhere brownish black to olive black. Because of its dense and brittle character the chert fractures along irregular planes, producing angular pieces of all sizes. Under magnification the chert is very fine grained and fairly uniform in texture, much like the limestone. The silica is mostly cryptocrystalline, but small amounts of chalcedonic silica are present. Most of the chalcedonic silica occurs as irregularly-shaped spherulites randomly scattered through the rock. Brownish organic matter and finely disseminated iron oxides are abundant, much more so than in the limestone. Small carbonate rhombs are present but are rare. Small cubes and irregular masses of unaltered pyrite also occur, but most of them have been more or less oxidized (Marcher 1962b:13-14).

The characteristic thinly laminated appearance of this bedded Fort Payne chert is imparted by the "presence of finely disseminated saprolitic material" (Marcher 1962a:822). This saprolitic material composed of

fine irregular black flakes concentrates along irregular discontinuous planes creating lens-like layers and a semi-banded or laminated appearance. The laminae roughly approximate the bedding plane orientation. A typical example of laminated Fort Payne chert is illustrated in Figure B.17 (Appendix B).

Archaeological literature has generally referred to laminated Fort Payne chert as "blue-gray and tan" chert (Faulkner and McCollough 1973:53; Penny and McCollough 1976:151-157; Kline 1978:59-66). It is important to note that although geological literature usually refers to this chert as brownish black to olive black, a great deal of color variability is present. Miser (1921:24) has characterized Fort Payne as dark-gray, yellow, and dark bluish-gray. Thomas (1979:8) refers to blue-gray and smokey chert. Bassler (1932:153) describes Fort Payne as a yellow chert. Although nearly every description of Fort Payne chert suggests a different coloration, there are some modal patterns apparent. Blue-gray and tan is perhaps the best overall characterization. The combination of a variety of blue, gray, and tan hues lead to the diversity of Fort Payne coloration. Several laminated Fort Payne varieties have been recognized during the present survey. Blue-gray and tan chert in various color proportions forms the most commonly occurring type. This variety seems to be distributed throughout the Fort Payne Formation. Blue and blue-gray is also a common variety. A blue-black laminated Fort Payne is frequent in the Buffalo River area. Within the central Duck River area, a yellow variety seems distinctive. This yellow Fort Payne may be related to tan varieties. It occurs frequently within the recent alluvial gravels and along the crest of Elk Ridge. A

gray-blue mottled variety of Fort Payne laminated (Figure B.18, Appendix B) is also particular to the Elk Ridge area. Although a thorough consideration of Fort Payne color variability would greatly aid the development of Fort Payne distributional studies, the poor understanding of Fort Payne variability at this time precludes further discussion. It is certainly beyond the scope of this project to undertake such a monstrous problem, but it is hoped that the few comments provided here may aid in the understanding of Fort Payne distributional variability.

Pepper-and-salt speckled Fort Payne. A particular structural variety of Fort Payne chert herein referred to as "pepper-and-salt speckled" was first recognized by Penny and McCollough (1976:178). They had suggested that this variety might be associated with the lower portion of the Fort Payne Formation. This chert is characterized by black, gray, and white intermingled small flecks (Figure B.19, Appendix B). Small siliceous crinoid fragments (less than 3 mm) are commonly included.

For the most part, pepper-and-salt speckled Fort Payne is grainy in texture and apparently desilicified. This variety is extremely common throughout the central Duck River Basin. It is usually found capping the Highland Rim remnant hills and monadnocks along Duck Ridge, and throughout the Western Outer Nashville Basin, and on the Western Highland Rim escarpment. The presence of pepper-and-salt speckled chert at these highly eroded locations lends support to the notion that this is a leached form of previously dense bedded Fort Payne chert. Some examples have been noted which still retained remnant laminae (Figure

B.20, Appendix B); these pieces can be readily confused with pseudo-bedded Carters chert (Figure B.15, Appendix B). Since weathering of chert generally proceeds from the outer surface toward the interior, fine-grained texture is sometimes present within the deeper interior portions of a block or nodule. Remnant laminae and increased porosity toward the exterior also suggest that pepper-and-salt speckled is merely a deeply weathered variety of Fort Payne. This chert rarely occurs among archaeological assemblages in southwest Middle Tennessee. It is suspected that the extreme graininess of pepper-and-salt speckled Fort Payne made it unsuitable for chipped-stone tool production.

Crinoidal Fort Payne. Crinoid fragments (less than 3 mm) are common inclusions in Fort Payne chert. Occasionally these crinoids fail to silicify or are leached out. This results in a distinctive vesicular appearance (Figure B.21, Appendix B). This may be what Marcher (1962a:823; 1962b:15) has referred to as the "scraggy" Fort Payne lithofacies. Crinoidal Fort Payne chert is characterized by a spongy yellow appearance. Faint laminae are present which suggest a relationship to laminated Fort Payne. Crinoidal Fort Payne is fairly common to the Elk Ridge area. Due to the high porosity of this chert, controlled fracture is virtually impossible to maintain and it is worthless to chipped-stone industries.

Fibrous Fort Payne. Fibrous fossiliferous chert has been tentatively assigned to the Fort Payne Formation in this study. This chert is characterized by numerous fossil inclusions and a tendency toward multicoloration (Figure B.22, Appendix B). Blue, yellow, green,

and white are the most frequent colors. Fibrous Fort Payne chert may be related to the "fossiliferous chert" described from the upper Duck River Basin (Faulkner and McCollough 1973:54-55; Penny and McCollough 1976:176-178). Fossiliferous chert was suggested to originate in the Warsaw Formation, but similarities to Fort Payne were noted. Marcher (1962a:824-826; 1962b:18) describes a similar chert from the Warsaw Formation. He noted the presence of numerous fossils (e.g., crinoid ossicles, bryozoan debris, pieces of brachispod shells, small horn coral fragments, threadlike algae) which were oriented parallel to the bedding plane giving an irregular laminated appearance to Warsaw chert. Marcher (1962a:827-828; 1962b:21) also recognized a similar fossiliferous chert from the St. Louis Formation.

The primary reasons that this chert has been assigned to the Fort Payne Formation in this report are: (1) its great similarity to laminated Fort Payne structure and (2) its frequency in the Fountain Creek headwater gravels. The similarity to laminated Fort Payne may be merely superficial, but uniformly colored specimens (especially yellow) with a lower fossil content suggest a relationship with Fort Payne structure (Figure B.23, Appendix B). The occurrence of fibrous chert in the Fountain Creek headwaters suggests a Fort Payne origin because Warsaw deposits are not present there. The generally deflated condition of Fort Payne deposits in the Fountain Creek headwaters (Elk Ridge) implies an absence of Warsaw deposits. Regardless of the geologic origin of fibrous chert, it seems to be restricted to the Fountain Creek drainage and the Duck River below Fountain Creek. It may also be available on the Highland Rim at higher elevations. Faulkner and

McCollough (1973:55) noted that fossiliferous chert was a rare constituent of upper Duck River area lithic assemblages. This also appears to be true in the central Duck River area. The reason for this is not quite clear since fibrous Fort Payne is generally a fine-grained nearly vitreous chert. It is highly tractable and responds well to thermal alteration, the numerous fossil inclusions cause only slight irregularity of fracture surfaces.

Fort Payne summary. Fort Payne chert is quite variable in color and texture. Most color variability can be related to a basic blue-gray and tan form. Texture can range from nearly vitreous to gritty or desilified chalky or almost quartzitic. Three inclusions seem quite common: geodes, chalcedonic specks, and crinoids. The geodes are quartz or calcite and may occur as independent globular masses or vug linings within chert blocks. The chalcedonic specks are usually light-blue and less than 2 mm long, they occur in nearly all forms of Fort Payne. Crinoid fragments are particularly common to Fort Payne chert, they may be silicified or leached.

The Fort Payne Formation ranges from about 25 to 80 m thick on the Highland Rim (Milici et al. 1979:11); and 25 to 50% of the formation is composed of massive chert beds and nodules (Marcher 1962b:12). This constitutes the most significant chert-bearing formation in Middle Tennessee. Fort Payne chert is available as angular blocky fragments throughout the Highland Rim and on high remnant hills and ridges within the Nashville Basin. The residual Fort Payne in the Nashville Basin is usually grainy or desilicified. Elk Ridge is capped by a great variety

of Fort Payne cherts which are often fine-grained. Alluvial Fort Payne chert gravels are present throughout the Duck River Basin and in Highland Rim contexts. These gravels are present in the active river bed load and on higher terraces as lag gravel deposits. These gravels are considered in more detail below.

Mississippian St. Louis-Warsaw (Msw)

The St. Louis and Warsaw Formations are both Highland Rim chert-bearing units and are grouped here because geologic maps do not usually distinguish between them. The Warsaw Formation contains quartz geodes and fossiliferous chert. These forms were discussed previously in the Fort Payne section. The Warsaw fossiliferous chert is often recognized as porous and spongy and heavily weathered (Marcher 1962a:824, 1962b:18; Milici et al. 1979:15). This chert is not suspected to be isomorphic with fibrous Fort Payne chert.

The St. Louis Formation contains three distinctive chert varieties: fossiliferous, semibanded, and cannonball (Marcher 1962a; 1962b). The fossiliferous variety is porous and spongy and resembles the fossiliferous Warsaw chert (Marcher 1962a:827, 1962b:21). The semibanded St. Louis chert tends to resemble the laminated Fort Payne structure, but differs by the inclusion of various fossils (Marcher 1962a:830, 1962b:21-22). The third variety, cannonballs, are spherical balls and dolls of dense pale-blue to bluish-gray chert ranging from 4 to 10 cm in diameter (Milici et al. 1979:16). "The interior . . . is dense cryptocrystalline silica and has very little internal structure except for poorly developed concentric layering" (Marcher 1962a:830).

> 'Cannonballs' are the most distinctive variety of chert found in residuum from the St. Louis Limestone. The few 'cannonballs' that have been found in place occur in fine-to medium-grained calcarenite. The 'cannonballs' have a thin white tripolitic rind, but the interior generally is dusky yellowish-brown or nearly black. Most of the 'cannonballs' are dense in texture and show no internal structure, although a few are concentrically layered. None show radiating internal structure (Marcher 1962b:22).

Archaeological descriptions of St. Louis cannonballs generally refer to "blue-green nodular" (Faulkner and McCollough 1973:56-57), "gray nodular" (Penny and McCollough 1976:178-180), and/or "blue-gray nodular" (Kline 1979:63-64). St. Louis cannonballs are generally within the blue-green-gray scheme and contain white specks (about 1 mm or less), milky white subcortex bands (concentrically arranged), and pyrite inclusions (less than 1 mm). Cannonballs are extremely fine-grained or vitreous and homogeneous and have a thin hard white cortex.

St. Louis chert is available primarily in residual context on the higher portions of the Highland Rim. Faulkner and McCollough (1973:57) and Penny and McCollough (1976:178-180) indicate that St. Louis chert is not present within the upper Duck River drainage but is abundant in the upper reaches of the Elk River. St. Louis chert is also available on the northern parts of the Highland Rim (Marcher 1962b; Milici et al. 1979), but is weathered and tripolitic on the Southwestern Highland Rim (Miser 1921:24). St. Louis chert was apparently highly utilized during Paleo-Indian and Early Archaic times in the central Duck River Basin. This dense fine-grained material often develops an opaque milky patina. Prescott (1978:430) noted a high frequency of patinated Paleo and Early Archaic specimens in the upper Duck River Basin. The use of St. Louis chert by pre-Middle Archaic groups in the central Duck River Basin

suggests a high degree of residential mobility for these populations because sources are so distant. Goodyear (1979) has noted a similar pattern of high quality lithic resource use by early populations across Eastern North America.

Cretaceous Tuscaloosa (Kt)

Tuscaloosa Formation deposits are restricted to the Western Highland Rim. They are generally composed of chert and quartzite pebbles cemented by a limonite matrix (Marcher and Stearns 1962; Luther 1977:29-33). The quartzite pebbles are well-suited for use as percussion hammers. The limonite matrix may have been a source of hematite or red ochre for pigment, but hematite is not an infrequent constituent of limestone and chert formations and may have been available at other localities.

Quartzite cobbles have been observed at various gravel sources in the Western Outer Nashville Basin which probably resulted from Tuscaloosa let-down. The frequent occurrence of quartzite hammerstones in the central Duck River Basin suggests procurement from sources to the west.

Chert Resource Summary

Physiographic and geologic patterns in Middle Tennessee form a basis for natural stratification of chert resource distribution. In addition, watershed morphologies cross-stratify the research universe. The Highland Rim and Nashville Basin are the major physiographic sections and are transected by the Duck River.

The Highland Rim is characterized as a chert resource rich zone. Chert resources on the Highland Rim are abundant, readily accessible, and high quality (large size, fine texture). Chert types available on the Highland Rim consist of St. Louis and especially Fort Payne. The upper Duck, lower Duck, and Buffalo River Basins are located within the Highland Rim section.

The central Duck River Basin is located within the Nashville Basin. The Nashville Basin is characterized as a chert resource poor zone. Chert resources are available within the Nashville Basin, but they are poor quality (small size, grainy texture). The Nashville Basin is divided into Inner and Outer portions. The poorest quality cherts are available in the Inner Basin (Ridley, Carters). Higher quality cherts are available in the Outer Basin (Bigby-Cannon, Fort Payne alluvial gravels).

In general, the relationship of chert resources between the lowest parts of the Basin and highest parts of the Rim should be viewed as a cline from resource poor to resource rich. Nonetheless, underlying geologic formations appear to be the best criteria of regional resource stratification. Despite the work provided here which attempts to develop natural chert resource strata, differences have been limited to subjective qualitative description. Jochim (1979:99-101) has recognized the measurement problems involved in developing environmental resource models. In an attempt to overcome the problems of qualitative descriptions, an alluvial gravel study was initiated to quantify chert resource distribution parameters.

CHAPTER IV

APPLICATION OF GRAVEL STUDIES TO LITHIC RESOURCE SURVEYS

The study of alluvial gravel sources can profit archaeological research in several aspects. The emphasis of this particular study centers on considerations of lithic technology systems, but geologists have long recognized the value of gravel studies for investigating regional geomorphic processes (Campbell 1929). In regions where chert gravels are available and are known to have been exploited prehistorically, gravel studies can greatly enhance accuracy in modeling the lithic resource base and procurement and utilization strategies. Middle Tennessee fulfills both desirable conditions of successfully implementing a gravel study. Chert-bearing formations are numerous and all but the smallest streams contain gravel deposits. It has been well established that gravel chert sources were important to chipped-stone industries across the Midsouth (e.g., Faulkner and McCollough 1973:53; Penny and McCollough 1976:153; Kline 1978:68; Gatus 1983; Johnson and Raspet 1980; Johnson 1983; Amick 1982:30). This has been particularly true of the ubiquitous Fort Payne chert, although the Yellow Creek upland quarries in northeast Mississippi (Johnson 1981a, 1981b, 1982) are a notable example of matrix/residual Fort Payne chert exploitation.

Despite recognition of gravel deposits as an important source of chert for prehistoric lithic technologies, few archaeological investigations have considered the potential of gravel analysis. However, several recent archaeological studies have attempted to systematically examine gravel chert sources (Gatus 1983; Amick 1981;

Bass 1981; Ray 1982). These works will be discussed in turn, except Amick (1981) which will be considered later.

Archaeological Approaches

Gatus (1983) focused on the distribution patterns of chert gravels in the lower Cumberland and Tennessee River valleys. He collected grab samples of gravel from 34 streams in the area. The sample criteria were loosely defined by collecting: (1) the largest cobbles; (2) a range of pebble to cobble sizes; and (3) a diversity of cobbles representing extreme variability. The cobbles were then fractured and compared to a synoptic collection. This information suggested patterns of chert gravel diversity across the landscape. The gravels were further assessed for suitability in tool production. The potential of gravels to produce tools greater than 10 cm in length was the criterion of "suitability." Distribution of suitable gravel sources was then considered. Gatus (1983) has developed a valuable model of lithic resource distribution based on gravel sources for the lower Cumberland and Tennessee River valleys. However, lack of methodological rigor during sampling and suitability determination is problematical.

Bass (1981) has also exploited the potential of gravel studies for developing resource distribution models. Her research focused on Pleistocene terrace gravels available near the Poverty Point site. A series of historic gravel quarries was examined for relative abundance of gravel and macroscopic comparison to the Poverty Point assemblage. A four liter bucket of gravel was collected from 17 locations which were classified by distance and direction from Poverty Point. These gravel

samples were weighed and sieved through a 1.27 cm^2 mesh, then weighed again. The ratio in weights was considered to represent "richness" of a particular source. It was expected that procurement efforts from Poverty Point would focus on "richer" sources to the west. This expectation was borne out, but may have been biased by an overrepresentation (47%) of western samples in the quarry study. Bass' major contributions were: (1) demonstration of small local gravel use at Poverty Point; (2) quantifying source "richness;" and (3) developing models of procurement distance and orientation.

Ray (1982) has evaluated the quality and quantity of chert gravels available at a single location in southwest Missouri. Surface gravels larger than 10 x 3 x 3 cm were collected from ten 1 x 1 m squares randomly sampled from a larger 5 x 5 m grid. The reason for this sampling method is not given, but generally this type of sampling is employed to reduce bias and achieve representativeness. The size restriction was based on technological considerations. The gravels were then flaked by hard-hammer percussion and classified by material type and quality. The quality of a nodule was ranked according to a set of subjective criteria based on knappability. The relative abundance and quality of various material types was then compared which yielded a general profile of gravel characteristics at this location and suggested that certain materials may have been selected because of higher quality. Major emphasis in Ray's (1982) study was placed on developing a method of gravel sampling and assessing quality of chert types. Unfortunately, gravel resources from only one location are considered with concomitant low sample size. The implication that a single gravel bar sample may

adequately characterize a resource base ignores the much more important considerations of regional resource distribution patterns upon which technological systems are based. Understanding regional resource distribution patterns is critical to understanding technology and settlement system adaptations to those patterns and consequent assemblage variability.

Geological Approaches

Although the preceding studies have demonstrated the potential of gravel analysis to archaeological concerns regarding lithic resources, they ignore a large body of relevant geological literature. This literature includes theoretical aspects of gravel bar formation and movement, general characteristics of gravel bars, considerations of gravel sampling methodology, and patterns of longitudinal downstream gravel change. These topics will be discussed using examples from the Duck River Basin. Particular attention is focused on the central Duck River Basin, but consideration of the watershed as a whole is necessary for interpretation of the patterns.

Gravel Bar Formation and Characteristics

The behavior of gravel bars is described by kinematic wave theory. Lighthill and Whitham (1955a, 1955b) proposed kinematic wave theory as an alternative to Newtonian dynamic theory. They suggested that this theory of movement was particularly applicable to typical pool and bar river flow patterns (1955a), as well as traffic flow on long crowded roads (1955b). Leopold et al. (1964:212) state that "a kinematic wave

is a wave consisting of a concentration of units, particles or individuals, but through which these units may move." As such, a gravel bar is regarded as a kinematic wave in the traffic of clastic debris. Langbein and Leopold (1968:1) note that:

> the form of ripple, dune, or bar exists independently of the grains which compose them and may move upstream, downstream, or remain stationary in the channel though the particles move into and out of it in their more rapid downstream progress.

This phenomenon was empirically realized by the Seneca Creek painted cobble study (Leopold et al. 1964:208-209; Leopold et al. 1966:209). Surface debris on a gravel bar was painted and observed after several high-water periods. The position of the bar and the size distribution and density of cobbles remained stable, but the painted cobbles were transported to other gravel bars downstream. Langbein and Leopold (1968:1) state that continual downstream particle trading is accomplished whenever stream flow is greater than 75% bankfull. This stage is usually reached at least once a year in the Duck River system.

Leopold et al. (1964:212) have noted that the analysis of kinematic waves depends on: (1) flux or transportation rate defined by the number of units passing a point in a given time and (2) linear concentration on the mean grain density. Local perturbations increase linear concentration and lead to bar formation and "any initial grouping of rocks, as in a gravel bar, tends to preserve the concentration of rocks and thus promotes the formation of a gravel bar" (Leopold et al. 1964:214). At a more elementary level, "gravel bars owe their existence to the fact that particles in juxtaposition are less easily moved by flowing water than when widely separated" (Leopold et al. 1966:209). Of

course, as the rate of feed (linear concentration) increases, group size (wave or gravel bar) increases and average particle speed decreases (Langbein and Leopold 1968:5). This trend would continue until a jam formed and all motion was halted.

Although gravel bars exist in a highly dynamic environment, they are generally recognized to be extremely stable in form and position (Leopold et al. 1964:214; Leopold et al. 1966:207; Bradley et al. 1972:1267). The rate of gravel bar pattern change is suggested to be directly related to the amount of bed load (Fahnestock 1963:61). Leopold et al. (1964:203) note that all perennial channels which carry bed material larger than coarse sand are characterized by an alternating pool and riffle pattern. The sequence of pools and riffles is measured by: (1) pool length as a function of the riffle length and (2) average riffle spacing as a function of the bankfull channel mean width. Leopold et al. (1964:207) and Langbein and Leopold (1968:1) have suggested that gravel bars or riffles are commonly irregularly spaced at distances of 5 to 7 channel widths. Determining the frequency and size of gravel bars in a given region would be helpful in developing lithic resource distribution models, however the variability of lithologic catchments and drainage densities and drainage textures (dissection) makes this consideration difficult (see Strahler 1957). Some subjective opinions based on fieldwork and map study of the Duck River Basin may be offered. The relatively high drainage density and texture of the Outer Nashville Basin and Highland Rim suggest larger and more frequent gravel bars than in the Inner Nashville Basin.

Gravel bars are typically classified as central or lateral depending on their relative location within the channel and are generally lobate in shape. Evolution of riffle to gravel bar to island and/or lateral terrace accretion is common. Establishment and spatial succession of vegetation plays an important role in this evolutionary sequence (Dietz 1952:253). Growth results from successive particle addition to the downstream end and lateral margins (Leopold and Wolman 1957:44; Leopold et al. 1964:284). Gravel bars possess several typical characteristics including: (1) presence of the coarsest sediments at the upstream tip; (2) presence of the finest sediments at the downstream end; (3) a central ridge and a slough which parallel stream flow; and (4) a tendency for lateral shifting and ancillary bar formation (Dietz 1952:253; Leopold and Wolman 1957:42-43; Leopold et al. 1964:285-288). Gravel bars in all stages of development are evident throughout the Duck River Basin.

In addition to patterned particle size variability on the bar itself, particle size varies through the local sequence of pools and riffles. Grain size increases gradually from the pool toward the riffle bar, although this pattern is more subtle in channels carrying cobbles or fine gravel (Leopold et al. 1964:203-204). Also, there is a tendency for coarse fragments to collect in the deepest parts of pools where outcrops provide a ready source of coarse material in or near a reach (Leopold et al. 1964:204). This has been observed in the central Duck River Basin where large Ridley cobbles are occasionally found in pools. The largest size class of gravel is always found at the surface of the bed rather than below (Leopold et al. 1964:211; Leopold et al.

1966:204). This phenomenon is caused by intergranular dispersive stress which forces larger particles to the surface by differential stress (Leopold et al. 1964:211). In summary, the coarsest fraction of the bed load will invariably be found at the surface of the upstream tip of a gravel bar. Since vegetation is lowest and gravels are largest and frequently renewed at the upstream tip, it is suspected that this would be the locus of the most intensive prehistoric gravel procurement efforts.

Gravel Sampling

In the course of geological gravel studies, several sampling methods have been devised. Wolman (1954:955) has noted that the sampling method can be designed to suit the problem at hand. Leopold et al. (1964:189) state that:

> ideally a sample of a stream bed would cover a representative surface area of the bed perhaps one grain diameter thick. It is usual to combine or to composite surface samples taken at a number of different points.

The collection of only the coarsest fraction is recognized as "defensible and common practice" (Bradley et al. 1972:1270), but investigators should realize that longitudinal trends are often size grade specific (Sneed and Folk 1958:115). Five basic strategies of gravel sampling have been discerned in the literature: (1) largest clast search; (2) sieved bulk; (3) Wolman traverse; (4) areal-grid; and (5) downstream transect. Some combinations of these methods have also been devised.

The largest clast search is the least frequently used method. Bradley (1970:63) implemented this design with a 1-2 hour search for the

50 largest clasts on a gravel bar. The technique used by Gatus (1983) noted earlier would appear to be a version of this method. The major problem with the largest clast search is the lack of methodological rigor.

The sieved bulk method is more commonly applied to terrace gravel samples. A volume of gravel is scooped and sieved by size grade proportions. McCammon (1961:74-75) and Plumley (1948:539) employed this strategy in geomorphological terrace gravel studies and Bass' (1981) collection methods noted earlier fit this description. Krumbein (1940:645) used sieved bulk sampling on alluvial gravels and Knighton (1980:57) used a combination of both sieved bulk and Wolman traverse sampling on alluvial gravels. An advantage of sieving is that it allows rapid processing into size graded proportions without requiring collection.

The Wolman traverse method is generally the most common approach of geological gravel sampling. The method was designed by Wolman (1954:951) as a more expedient alternative to sieve bulk sampling. A traverse across the stream bed is paced and 100 pebbles are arbitrarily collected and measured by their intermediate axis. Grade classes of dimensions are used to establish frequency distributions. This work is accomplished in the field. Brush (1961:148-150), Fahnestock (1963:24), and Knighton (1980:57) have employed the Wolman traverse method. Brush (1961:148-150) suggests that only 60 pebbles are necessary as a sample size per traverse. The advantage of this method is the ability to conduct it rapidly in the field, but lack of methodological rigor weakens the approach.

The areal-grid method relies on collection of gravel from a specified surface area. Usually there is a limit on the number of particles or size of particles to be collected. Sneed and Folk (1958:116) collected 50 pebble sets from one square yard areas. Whittel (1979:206) collected 100 pebble sets from one meter square areas. Ray's (1982:6-8) method noted earlier operated within areal-grids in a similar fashion, but with a particle size limit rather than a numerical limit. The use of the areal-grid method without numerical restrictions can provide measures of relative abundance per unit area and is fairly rigorous methodologically. However, the size and location of areal-grid unit(s) on the gravel bar can potentially affect the sample.

The final approach is the downstream transect. This method is similar to the Wolman traverse, but gravel is collected parallel rather than perpendicular to stream flow. Bradley et al. (1972:1268-1269) have employed the downstream traverse collecting 100 clasts at 0.5 foot intervals. Gustavson (1974:377) collected gravel along a 30 m transect originating at the head of the gravel bar. The advantage of the downstream transect is that it compensates for downstream sorting of the gravel.

Longitudinal Gravel Change

Some of the more important aspects of alluvial gravel studies involve systematic downstream change. As gravel moves downstream, size decreases and sphericity increases. Sorting of the gravel also improves downstream; that is, the statistical dispersion of the size distribution decreases and gravels downstream tend to be more nearly equal in size.

Additionally, contamination of the gravels by new sources entering the stream affects lithologic content of the gravels. Lithologic content can vary by differential selective transport and weathering/abrasion between raw materials. Aspects of longitudinal gravel change are most important to archaeological concerns of lithic resource modeling.

Chert Gravel Resources of the Central Duck River Basin

In recognition of the importance of alluvial gravels to lithic technologies and the role it could play in elucidating and quantifying lithic resources, a gravel study was implemented during the course of the lithic resource survey of the central Duck River Basin. Gravel was collected from 13 locations within the Duck River system (Figure 4.1; Table C.1, Appendix C). A sampling methodology was devised and size and lithologic observations were recorded. The methodology and results of this study are presented below.

Methods

A pilot study of central Duck River gravels has been reported by Amick (1981). Collection of additional gravel samples with methodological modifications suggest that a review of the previous study and its incorporation into the present study are warranted. The pilot study included 6 gravel collections from the Inner Nashville Basin portion of the Duck River (Table C.2, Appendix C). These locations were chosen to monitor the effect of major tributaries in the central Duck River Basin.

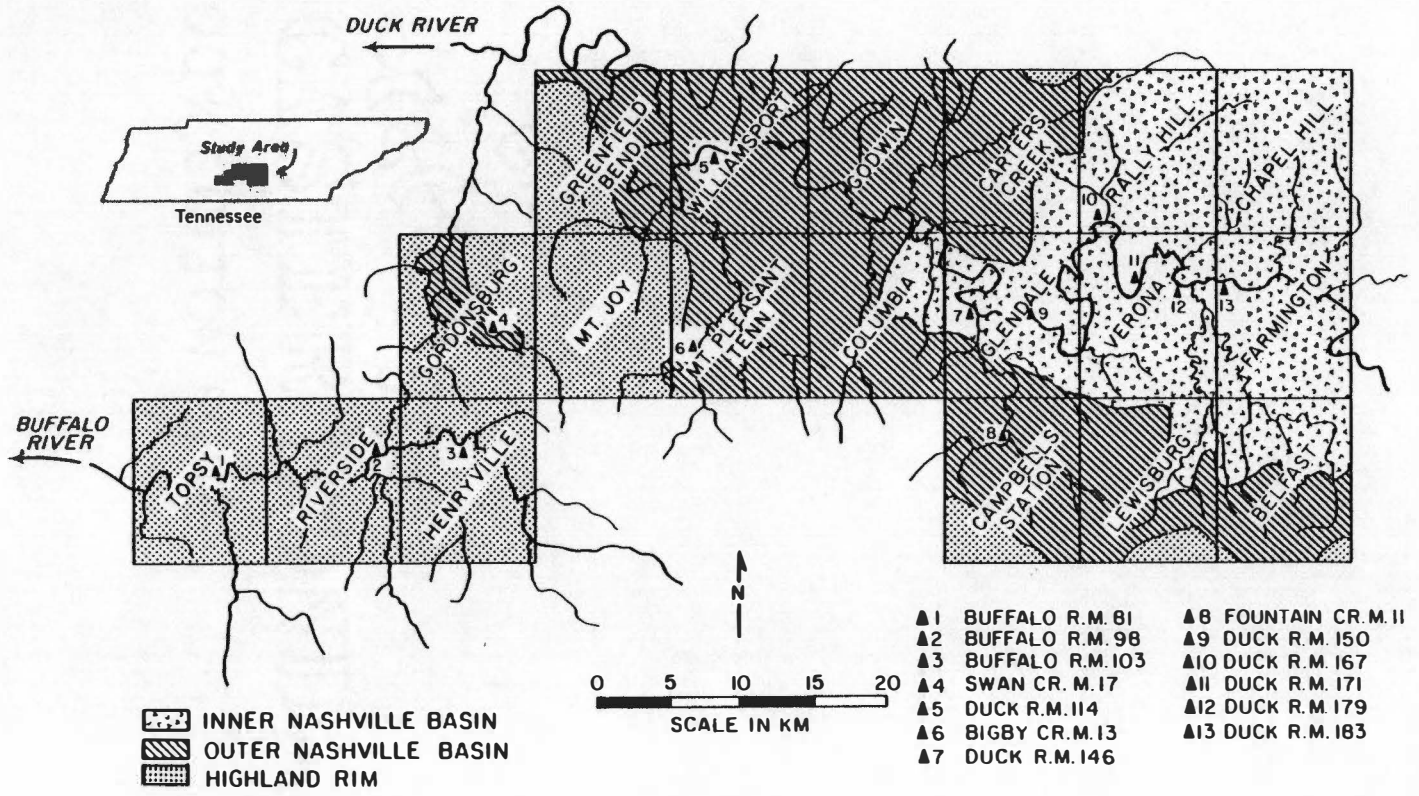

Figure 4.1. Gravel collection locations.

Collection procedures involved a combination of areal-grid and downstream transect methods. Only chert gravels greater than 5 cm in length were collected. This was an arbitrary decision based on technological considerations and sampling expediency. All chert gravels longer than 5 cm were collected from the surface of a 1 m diameter unit. The collection units were spaced at 10 m intervals in a downstream transect originating at the upstream tip of the bar. The number of units varied between collection sites due to factors of bar size and vegetation density. The sampling method employed was designed to: (1) standardize the collection technique; (2) enable comparisons of gravel density (abundance) per given area; and (3) control effects of downstream sorting at a given location. The collected gravels were each weighed to the nearest tenth of a gram; measured to the nearest millimeter along length, width, and thickness dimensions; and fractured to determine chert type (based on the controlled synoptic collection) and texture.

A nested design analysis of variance was conducted to determine if significant differences might exist between mean gravel weight of collection sites or units nested within sites. The overall F-statistic was 3.89, significant at the .0001 level with 23 degrees of freedom. Table 4.1 presents the results of the nested design. Significant differences exist among sites and among units within sites. This suggests that there is variability within sites and that downstream transect collection techniques help control for these differences.

A Scheffe multiple comparison test was used to examine the nature of site differences (Table 4.2). Five groups were identified and one

Table 4.1. Inner Nashville Basin-Duck River gravel collections: nested analysis of variance by weight.

Source of Variation	df	Type I Sum of Squares	Mean Squares	F-Values	p > F
Sites	5	64990.77	12998.15	6.43	0.0001
Units (Sites)	18	115587.87	6421.55	3.18	0.0001
Error	1227	2478650.12	2020.09		
Total	1250	2659228.76			

Table 4.2. Inner Nashville Basin-Duck River gravels: Scheffe multiple comparisons test of site differences by weight.

Site	n	Mean Weight (g)	Grouping[a]
Duck R.M. 171	293	72.6	A
Duck R.M. 150	470	70.2	A B
Duck R.M. 183	262	66.5	A B
Duck R.M. 167	112	60.8	A B C
Duck R.M. 146	81	48.4	B C
Duck R.M. 179	61	43.7	C

[a] Means with the same letter are not significantly different (alpha = 0.01).

order relationship was established. The Duck R.M. 171 collection has significantly larger gravels than the Duck R.M. 146 and 179 collections. Examination of the site means suggests little difference between the sites, but sites located above major tributaries (Duck R.M. 171, 150, and 183) all exhibit larger mean gravel weights than those below tributaries. This apparent tributary effect results from the adjustment of backwater curves and is discussed later in more detail. This analysis suggests: (1) the sampling procedure may have eliminated within site downstream sorting effects and (2) there is no systematic downstream gravel size decrease. Primary variability among Inner Basin-Duck River gravels appears to be related to tributary effects.

Considering the small size and lack of systematic downstream variability among central Duck River Basin gravels, it was apparent that sampling locations closer to the headwater reaches was necessary to determine patterns of gravel variability which would be large enough to affect regional lithic technology systems. Seven more collections were made at various locations in the Western Outer Basin (Table C.3, Appendix C) and Western Highland Rim-Buffalo River (Table C.4, Appendix C). These locations were chosen primarily by opportunistic considerations (e.g., ease of access). Since the sampling procedure appeared sound, it was retained. However, the number of collection units was arbitrarily limited to 3 per site. It was also suspected that the time-consuming set of weight, length, width, and thickness measurements could be reduced. A correlation matrix of these attributes was constructed (Table 4.3). Inspection of the correlation coefficients indicated that weight would be the most profitable measure to retain.

Table 4.3. Inner Nashville Basin-Duck River gravels: metric attribute correlation matrix.

Attribute	Weight	Length	Width	Thickness
Weight	1.000	0.665	0.690	0.767
Length	---	1.000	0.418	0.412
Width	---	---	1.000	0.529
Thickness	---	---	---	1.000

Consequently, Outer Basin and Highland Rim gravels were weighed (to the nearest tenth of a gram) and then fractured to determine chert type and texture.

Results

The largest source of stream sediments is sheet erosion on the unrilled slopes near basin divides (Leopold et al. 1966:193, 239). The coarsest bed material is located within the stream headwaters where the gradient is steepest (Brush 1961:147). Particle size decreases exponentially downstream; consequently, the greatest decrease in mean grain size occurs in the first several kilometers of the headwater reaches (Leopold et al. 1964:189-191; Knighton 1980:60-61). Selective transport is the major factor behind progressive downstream sorting (Krumbein and Tisdel 1940:300-301; Plumley 1948:570; Knighton 1980:60). Lag gravels form the fraction of a deposit that the stream is incompetent to transport. As one moves downstream, slope decreases and competence increases. Knighton (1980:60) has noted

> the downstream increase in discharge partly compensates for the reduction in slope, particularly beyond the headwater area where the rate of slope decrease tends to exceed the rate of discharge increase. The lag deposition of coarser grains is therefore most likely in the headwater reaches.

Lag gravels are worn by abrasion (see Kuenen 1956) until they are small enough to be transported. Once coarse particles become transported, they wear by abrasion more rapidly than small particles (Krumbein and Tisdel 1940:300).

The majority of gravels throughout the Duck River system are derived from large tabular blocks of Fort Payne chert. Significant Fort

Payne Formation outcrops are present in the upper and lower Duck River Basin and along the southern divide of the central Duck River Basin (Figure 3.2, page 26). The Duck River system headwater areas roughly coincide with the Fort Payne Formation. The Western Highland Rim-Buffalo River gravel collections represent a typical headwater situation. These gravels are homologous to the headwater gravels of the Upper Duck River Basin. The mean weight of Western Highland Rim gravels ($\bar{x}$=188.3 g) is over 50% greater than Western Outer Basin gravels ($\bar{x}$=123.2 g) and nearly 200% greater than Inner Basin-Duck River gravels ($\bar{x}$=66.6 g). The Western Outer Basin gravel collections represent an intermediate downstream sample. This group is expected to characterize Outer Nashville Basin gravels. These gravels are typical of locations below the headwaters in the upper Duck River Basin; at the base of Elk Ridge, along the southern divide of the central Duck River Basin; and throughout the lower Duck River Basin. The average abundance of Western Outer Basin gravels (120) is nearly 20% greater than Western Highland Rim gravels (102) and nearly 150% greater than Inner Basin-Duck River gravels (49). This suggests a sort of "packing" optimum in Western Outer Basin gravel deposits (cf. Plumley 1948:544-545). Abundance may be related to changes in stream competence between the three physiographic areas. Stream gradient provides a rough estimate of stream competence. Stream gradient decreases 25% from the Western Highland Rim-Buffalo River (1.22 m/km) to the Western Outer Basin (0.91 m/km) and 75% to the Inner Basin-Duck River (0.30 m/km). Gravels apparently travel rapidly to the Outer Basin where movement slows and abrasion reduces them to sizes the stream is competent to transport

farther downstream. Tables C.2, C.3, and C.4 (Appendix C) also list the coefficient of variation of mean gravel weights. These data suggest greater variability in mean weight farther from the source. This implies a decrease in sorting downstream which contradicts prior expectations of progressive downstream sorting (Leopold et al. 1964:28; Bradley et al. 1972:1274; Gustavson 1974:377). However, other examples of "nonsystematic" downstream sorting have been reported in the geologic literature (Krumbein 1940:658; Plumley 1948:575) and this may simply reflect a size class specific phenomenon (Sneed and Folk 1958:115). Knighton (1980:59) has stated that "the degree of sorting is conditioned by the distance over which sorting processes operate." Since the local stream length varies considerably between collection sites, the apparent sorting decrease is considered to be related to processes which are recognized to still be incompletely understood among geomorphologists (cf. Knighton 1980:55-57).

The Inner Basin-Duck River gravels represent the most mature stage of gravel transport and abrasion/weathering. Fort Payne sources are the most distant from Inner Basin-Duck River locations. As noted above, mean gravel weight and abundance are lowest among these gravels. In addition, a measure of the maturity of these gravel deposits can be suggested by mean spherity. Sneed and Folk (1958:118) have defined maximum projection spherity or form as:

$$\sqrt[3]{\frac{S^2}{LI}}$$

where S, L, and I represent the short, long, and intermediate axes, respectively. Sphericity of chert gravel decreases downstream due to

greater reduction of the short axis (Sneed and Folk 1958:132-133). The maximum projection sphericity for Inner Basin-Duck River gravels is 0.62. This value is squarely within the "bladed" form category. Sneed and Folk (1958:146-148) have noted that geological processes tend to favor the production of bladed forms as a modal group. The mature sphericity value of Inner Basin-Duck River gravels supports the notion that downstream sorting processes are essentially stable through this region.

The general pattern of longitudinal downstream gravel change can be roughly described as first exponential decrease, then sinusoidal fluctuation (Bradley et al. 1972:1270; Knighton 1980:57-58). This pattern of gravel change will be described using the 13 gravel collections. A one-way analysis of variance of mean gravel weight indicates that significant differences exist between the 13 collections (Table 4.4). A Scheffe multiple comparison test was used to examine the nature of these differences (Table 4.5). Eight groups were identified and are listed below:

(1) Western Highland Rim - Buffalo R.M. 98

(2) Western Highland Rim - Buffalo R.M. 103

(3) Western Highland Rim - Buffalo R.M. 81

(4) Western Outer Basin - Duck R.M. 114

(5) Western Outer Basin - Bigby Cr. M. 13

Western Outer Basin - Swan Cr. M. 17

Western Outer Basin - Fountain Cr. M. 11

Inner Basin - Duck R.M. 171 (above Flat Cr.)

Inner Basin - Duck R.M. 150 (above Fountain Cr.)

Table 4.4. Comparison of gravel collection sites by mean weights: analysis of variance.

Source of Variation	df	Sum of Squares	Mean Squares	F-Value	p > F
Between (Model)	12	10800106.71	900008.89	22.92	0.0001
Within (Error)	3622	142257474.49	39275.95		
Totals	3634	153057581.19			

Inner Basin - Duck R.M. 183 (above Big Rock Cr.)

(6) Inner Basin - Duck R.M. 167 (below Flat Cr.)

(7) Inner Basin - Duck R.M. 146 (below Fountain Cr.)

(8) Inner Basin - Duck R.M. 179 (below Big Rock Cr.)

Three order relationships were established among these groups; group 1 is significantly larger than 5 through 8; groups 1 and 2 are significantly larger than 6 through 8; and groups 1 through 3 are significantly larger than 8. Examination of the ordered means in Table 4.5 shows significant patterning. The Western Highland Rim-Buffalo River collections display the largest mean weights. The extremely high mean at Buffalo R.M. 98 ($\bar{x}$=254.6 g) may be due to the presence of large beds of Fort Payne chert which were observed to outcrop in the stream bed a few kilometers upstream. The Western Outer Basin gravels follow the Buffalo River collections in mean weight. The high mean ($\bar{x}$=153.2 g) at Duck R.M. 114 suggests that gravels throughout the lower Duck River may be of this size magnitude. The Inner Basin-Duck River gravel collections are ranked below the Western Outer Basin collections. However, the Scheffe multiple comparison (Table 4.5) indicates that Inner Basin-Duck River gravels above major tributaries are not significantly smaller than the three lowest Western Outer Basin collection means. The lowest mean gravel size is recorded for Inner Basin-Duck River gravels below major tributaries.

The rapid 62.6% decrease in mean gravel weight between Buffalo R.M. 98 ($\bar{x}$=254.6 g) and Buffalo R.M. 81 ($\bar{x}$=159.6 g) is probably a reflection of the initial exponential decrease of gravel size within the headwater reaches. The rate of mean weight decrease appears to have leveled off

Table 4.5. Comparison of gravel collection sites by weight: Scheffe multiple comparison test.

Physiographic Stratum	Site	n	Mean Weight (g)	Grouping[a]
Western Highland Rim	Buffalo R.M. 98	263	254.6	A
Western Highland Rim	Buffalo R.M. 103	146	168.8	A B
Western Highland Rim	Buffalo R.M. 81	508	159.6	A B C
Western Outer Basin	Duck R.M. 114	368	153.2	A B C D
Western Outer Basin	Bigby Cr.M. 13	382	147.0	B C D E
Western Outer Basin	Swan Cr.M. 17	374	94.8	B C D E
Western Outer Basin	Fountain Cr.M. 11	315	93.0	B C D E
Inner Basin - above	Duck R.M. 171	293	72.6	B C D E
Inner Basin - above	Duck R.M. 150	470	70.2	B C D E
Inner Basin - above	Duck R.M. 183	262	66.5	B C D E
Inner Basin - below	Duck R.M. 167	112	60.8	C D E
Inner Basin - below	Duck R.M. 146	81	48.4	D E
Inner Basin - below	Duck R.M. 179	61	43.7	E

[a] Means with the same letter are not significantly different (alpha = 0.01).

through the Inner Basin-Duck River stretch. Major fluctuations through this river segment seem to be related to tributary influence. Knighton (1980:57-58) has noted similar tributary effects. The sinusoidal function of larger gravels above and smaller gravels below major tributaries is indicative of mature gravel deposits. Lighthill and Whitham (1955a:309-310) have suggested that tributary discharges influence the flow of the main river channel upstream of their junction and produce modifications within the kinematic wave patterns. Below the tributary, propagation speed increases which could increase competence and move larger gravels away from the tributary. Above the tributary, gravel loads are dropped due to the adjustment of backwater curves which decrease stream competence upstream of the confluence. This alternating stream competence pattern is responsible for the sinusoidal function appearance of mature gravel deposits, such as the Inner Basin-Duck River gravels. In addition to mean weight fluctuation, Amick (1981:49) reported that Inner Basin-Duck River gravels are about 3 times more abundant above major tributary confluences. As well as differences in size, form, and abundance, the Duck River gravels exhibit significant lithological composition differences.

Changing lithology in stream gravels has been recognized in many geological studies. Whittel (1979:211) has stated that changing catchment geology is the most important factor influencing gravel composition. Differences in the size and location of source rock formations lead to variability of gravel composition (Knighton 1980:59). McCammon (1961:73) suggests that valley segments be defined for gravel composition studies. A drainage is carved out of and flows across

particular rock types which cause dissimilarities between the segments by geomorphic history and lithology of underlying bedrocks. Since the divisions of the Duck River Basin are based on geologic and physiographic parameters, it is suspected that these divisions will accurately reflect changing catchment geologies through gravel composition. In evaluating lithologic composition of gravels, it is important to consider the potential source contributors. McCammon (1961:76) has recognized three basic sources of gravel contamination: (1) terrestrial gravel deposits; (2) tributary influxes; and (3) bedrock outcrops. It is generally accepted that the most influential sources affecting gravel lithic content are differences in the drainage lithologies of major tributaries (Plumley 1948:551; Leopold et al. 1964:225; Knighton 1980:61). Although all three of the contamination sources listed by McCammon (1961:76) are present in the Duck River Basin, major tributaries are viewed as the primary factor affecting gravel lithologic change.

In measuring the downstream change of gravel lithology, it is important to recognize that "the apparent decrease of one rock type . . . may be due only to the addition of new material of another rock type as the stream crosses an exposure of that new material" (Plumley 1948:553). This has been expressed as the progressive dilution concept (Pettijohn 1957:565; McCammon 1961:76, 79). As such, the decrease of upstream source rock frequencies is seen as a result of contamination by new sources. The restriction of this study to a single rock type (chert) derived from different geologic formations controls for the effects of

differential sorting and abrasion between rock types (i.e., Plumley 1948:555; Sneed and Folk 1958:114; Bradley 1970:65).

Tables C.5, C.6, and C.7 (Appendix C) show the chert type compositions of the collected gravels. The Western Highland Rim-Buffalo River collections are over 99% Fort Payne in origin. A residual amount of Brassfield is present at Buffalo R.M. 81 which lies upon the Brassfield/Wayne Formations. The Western Outer Basin collections are nearly 98% Fort Payne. Fountain Cr. M. 11 has almost 6% Carters chert and is located on the Carters Formation. Although this collection is technically within the Inner Basin, its physiographic location at the base of Elk Ridge is more typical of Outer Basin situations. Therefore, Fountain Cr. M. 11 is grouped with the Outer Basin collections. The Inner Basin-Duck River collections show less than 95% Fort Payne chert. The tributary influx of Inner Basin Ordovician Ridley and Carters Formation cherts is the cause for dilution of Fort Payne percentages in the central Duck River drainage (Amick 1981:50). Penny and McCollough (1973:157) note that upper Duck River gravels are over 99% Fort Payne. The Bigby-Cannon Formation contributes minor amounts of chert below the Eastern Highland Rim-Duck River. Fort Payne chert gravels become increasingly diluted by local bedrock contaminants as one progresses from Outer Basin to Inner Basin contexts. Fahnestock (1963:24) and Brush (1961:155, 169-174) have suggested that local contaminants can alter mean gravel size and shape. The comparison of Inner Basin-Duck River gravel metric attributes by chert type (Table C.8, Appendix C), suggests that local Ridley and Carters cherts are not significantly different in size or shape than Fort Payne gravels derived from upstream

sources. They are slightly larger, but not as large as Outer Basin gravels.

Tables C.9, C.10, and C.11 (Appendix C) present diversity statistics for the gravel collection lithologic frequencies. Pielou (1975:7-17) discusses various diversity calculations. The Shannon-Wiener method was employed in these tables (see Pielou 1975). Diversity (H') is highest among Inner Basin-Duck River gravels. Western Outer Basin gravels have the same maximum potential diversity (H' max); however, the evenness (J') of Inner Basin-Duck River gravels is higher which leads to greater diversity. Both diversity (H') and evenness (J') figures are quite low overall. This is undoubtedly a result of the high frequencies of Fort Payne at all collection sites.

The final aspect of longitudinal gravel change considered by this report concerns abrasion and weathering. Each cobble was also classified by texture. The resulting texture frequencies are presented in Tables C.12, C.13, and C.14 (Appendix C). Texture is assumed to be roughly equated with "quality." Vitreous and fine-textured specimens are considered suitable for tool production. Medium-textured specimens are sometimes improved to fine-texture quality when thermally altered. The only obvious patterns in these tables involved the desilicified category. First, there is a downstream increase of desilicified chert gravel in the Inner Basin-Duck River. This seems to be a reflection of increased weathering of gravels moving farther from their source. Secondly, there is an increase in desilicified frequencies from Highland Rim to Outer Basin to Inner Basin. Some of the uninterpretable frequencies shown in these tables may be due to new source influxes and

differential weathering of chert types. Carters chert in particular appears to weather quite rapidly (Amick 1981:50). Ridley may weather in a similar fashion. This seems to be related to the more grainy texture of these materials compared to Fort Payne.

Gravel Study Summary

The use of gravel studies as an aid in developing models of lithic resource distributions is increasing in frequency (e.g., Gatus 1983; Bass 1981; Amick 1981; Ray 1982). Gravels form an easily accessible, abundant, and renewable source of lithic material. More importantly, gravels provide a means for quantitative discrimination of lithic resource distribution patterns. Consideration of gravel lithic sources is also important when it is recognized that they form a part of local prehistoric lithic industries.

Despite the increased interest in gravel lithic sources by archaeologists, they have overlooked a substantial body of relevant geological literature. Gravel studies must be grounded in geological principles and methods in order to be interpretable. However, archaeological gravel studies should be designed with archaeological problems in mind. The most important consideration for both geological and archaeological gravel studies is a regional perspective. McCammon (1961:73) has suggested that stratification of watershed systems on the basis of geomorphological history and underlying bedrock types is critical to understanding regional gravel distributions. This concept is complementary with archaeological approaches to regional stratification.

Three major strata of the Duck River system were compared by gravel attributes to examine patterns of resource distribution. The Western Highland Rim-Buffalo River group exhibits the greatest potential lithic source for prehistoric populations in the region. These gravels are characterized by large, angular, and abundant Fort Payne deposits. Western Outer Basin gravels are slightly more abundant than Western Highland Rim-Buffalo River gravels. However, they are generally intermediate between Highland Rim and Inner Basin gravels in size, angularity, and diversity. The Inner Basin-Duck River gravels are the least attractive in terms of lithic technology considerations. They are smallest in size, least angular, and least abundant of the three strata. However, they display the greatest degree of chert type diversity. Within the Inner Basin-Duck River, there appear to be slight differences between gravels above and below major tributaries. The gravels above major tributaries are larger and more abundant than those below. The gravel deposits in the Duck River Basin appear to be directly affected by distance to the Fort Payne Formation which serves as the primary gravel source. As one nears the Fort Payne outcrops, gravels become larger, more angular, and more abundant.

Certain methodological improvements are now apparent for the gravel study. Sampling larger areal-grid units located only at the upstream tip of a gravel bar rather than in a downstream transect would probably be adequate. Low vegetation cover at this location and only slight within-bar size variability promotes this strategy. Sieved size grading analysis might increase analytical expediency and metric analysis of a limited sample of gravels from each collection site is probably adequate

for comparative purposes. Increasing the expediency of gravel analysis could allow collection of a greater number of sites over a larger regional area. The most important consideration of any gravel study is the inclusion of samples which can be used to characterize the watershed system as a whole.

CHAPTER V

DESIGNING AND TESTING A MODEL OF RAW MATERIAL VARIABILITY: THE CLAY MINE (40MU347) SITE

The purpose of this section is to develop and test a model for raw material procurement and utilization strategies in the central Duck River Basin. Middle and Late Archaic components at the Clay Mine Site (40MU347) are compared in terms of differential procurement, technology, and settlement system organizational strategies. Raw material variability or the pattern of lithic material procurement and utilization is used as the basis of this test. The emphasis is on general assemblage characteristics rather than specific lithic reduction systems and relies on the evaluation of differential use of various lithic resources. Results of the test suggest organizational changes are apparent and that environmental factors of demography and climate are instrumental in effecting these changes.

Middle-Range Theory

In order to develop a model of central Duck River Basin chert exploitation, arguments concerning the formation of the archaeological record are necessary. Work by Binford (1973, 1977a, 1978a, 1978b, 1979, 1980, 1982) is particularly relevant concerning the organization of hunter-gatherer procurement, technological, and settlement systems. Binford's organizational principles are meant to be applicable for a wide range of situations and are consequently rather generalized. In addition to their generality, Binford's organizational principles are

typically clinal along a single dimension. Theoretical opposites serve as the extremes of a continuum of intergradations, but are not mutually exclusive. There can be flexible organizational mixings of strategies, such that forms of behavioral organization will be selected with regard to particular circumstances (Binford 1980:17; Wills 1980:96). Wiessner (1982:176) has suggested that a dichotomous system of organizational principles would be easier to assess with archaeological data than Binford's graded series system. Despite the analytical amenities of a dichotomous scheme, the use of graded flexible mixings of strategy seems more appropriate. Recognition of the flexibility and mixability of these strategies adds a more realistic dimension to organizational studies. Binford's organizational principles serve as a heuristic vehicle to study adaptation to resources. These principles provide testable archaeological implications concerning aspects of behavioral organization that may be investigated through analysis of raw material variability. These strategies are modeled along procurement, technological, and settlement-subsistence organizational dimensions.

Procurement Organization

Procurement of raw materials may be direct, indirect, or embedded. Direct procurement refers to the collection of raw materials as the express and exclusive purpose of the particular procurement episode (Binford 1977:260). "Indirect procurement is defined here as procurement through the mediation of some other individual or social group" (Luedtke 1976:27). This form is most frequently expressed by trade network development. Among hunter-gatherers, it is assumed that

embedded strategies prevail, that is, "raw materials used in the manufacture of implements are normally obtained incidentally to the execution of basic subsistence tasks" (Binford 1979:259). The archaeological significance of this strategy should not be overlooked since it can be argued that raw material variability may be an indicator of group mobility patterns and settlement-subsistence strategies (e.g., Francis 1980; Goodyear 1979; Gramly 1980; Reher and Frison 1980).

Technological Organization

Lithic technologies are internally differentiated in organizational terms "with regard to the production, use, and maintenance of tools" (Binford 1979:256). Archaeological assemblages should reflect regular contrasts for

> cultural systems differing in their degrees of technological organisation on a scale from completely expedient manufacture, use and abandonment of tools versus a curated and maintained technology (Binford 1977:34).

As such, technologies may be curatorial and focus on specific (specialized) resource exploitation, or expedient and practice less discriminant local resource exploitation. The organization of technology has direct implications for settlement-subsistence organization, particularly regarding the degree of logistical organization.

Settlement-Subsistence Organization

Hunter-gatherer must develop settlement-subsistence strategies to cope with spatial incongruence of resources (Binford 1980:10). These

strategies can be generally distinguished by degrees of logistical organization. Logistically organized strategies are characterized by: (1) large social groups, (2) low residential mobility, (3) movement of resources to consumers, (4) procurement of specific resources in specific context by specially organized task groups, and (5) field processing of resources by task groups before transport (Binford 1980:10). Non-logistically organized (foraging) strategies are characterized by: (1) small social groups, (2) high residential mobility, (3) movement of consumers to resources, (4) frequent procurement activities, and (5) intensive exploitation of local resources (Binford 1980:5-9).

Lithic Resource Base

Environmental constraints on lithic technologies are essentially inflexible; therefore, lithic technologies tend to be adapted to the nature of available geologic resources (Collins 1975:20). Major interrelated environmental parameters affecting the utilization of a material are: physical properties of the material, spatial distribution of material sources, and abundance and accessibility of sources. These factors can also affect assemblage content variability which may have critical implications for interpreting site function (O'Connell 1977; Straus 1980) and chronological position (Straus 1980).

Detailed observations on the physical properties, spatial distribution, and abundance/accessibility of chert resources in the central Duck River Basin have been explored in the previous two chapters. This geological research is summarized below.

Inner Basin Resources

Chert resources within the Inner Nashville Basin are widely available, but of poor quality. The Middle Ordovician Ridley and Carters Formations contain replacement cherts which are typically coarse-grained and exhibit numerous incipient fracture planes. Blocky fragments of this material are widely available as surface residuum and to a minor degree in gravel deposits. The major constituent of local gravel deposits in Mississippian Fort Payne chert, which tends to be finer grained than the Middle Ordovician cherts, but rarely exceeds 8 or 9 cm in maximum dimension. In addition, small amounts of upper Ordovician Bigby-Cannon chert are present in gravel deposits. This chert is generally of high quality, but also limited in size.

Western Outer Basin Resources

Western Outer Nashville Basin chert deposits are localized gravels less restricted in size than Inner Basin gravels. Upper Ordovician Formations contribute little chert in this area. The Silurian Brassfield Formation exhibits fine-grained chert of moderate nodule size, but outcrops of this thin discontinuous formation are rare. Stream, river, and terrace gravels contain abundant amounts of Fort Payne chert, which is typically fine-grained, moderately sized, and subangular in shape. These properties enhance the desirability of Outer Basin chert resources.

Highland Rim Resources

Chert sources of the Highland Rim are abundant and of high quality. Fort Payne Formation chert is available in primary and secondary

depositional contexts. Matrix sources of this material tend to fissure into large rhomboidal blocks. This characteristic, coupled with high quality and abundance, suggests that Highland Rim Fort Payne chert would be an attractive material, particularly for industries oriented toward large bifacial blank production. In addition, Mississippian St. Louis Formation chert, a vitreous nodular material, is available at higher elevations on the Highland Rim. Although this is a very high quality material, its presence is greatly overshadowed by the extremely abundant Fort Payne chert on the Highland Rim.

The Clay Mine (40MU347) Site

Archaeological investigations at 40MU347, located in the Inner Nashville Basin (Figure 2.1, page 16), were conducted during fall 1979 in conjunction with deep site testing in the proposed Columbia Reservoir. The work at the Clay Mine Site has been summarized by Amick (1983). Two buried components were present at the Clay Mine Site. Diagnostic projectile point/knives indicated assignment of the lower component to the Middle Archaic period (Sykes-Whites Springs Cluster), and the upper component to the Late Archaic period (Ledbetter Cluster). Radiocarbon analysis confirmed these assignments with respective dates of 6240±500 years B.P. (A-2367) and 3215±125 years B.P. (UGa-3350). The materials recovered from the two 5x5 meter excavation blocks in each component stratum (Amick 1983:3) are employed as the assemblages for this analysis. Only lithic materials greater than 1 cm in length are considered in this analysis. Emphasis is placed on comparing the Middle and Late Archaic assemblages in an attempt to isolate systemic

readjustments or adaptive changes (Sheets 1975:378) with a specific focus on technological organization as a monitor of settlement system parameters and group mobility.

Clay Mine Site Geologic Setting

The Clay Mine Site (40MU347), like most other Columbia Reservoir sites, is located in the Inner Nashville Basin. The Middle Ordovician Ridley Formation surrounds the site. This setting offers an excellent opportunity to investigate exploitative strategies developed by prehistoric inhabitants to cope with this particular spatial incongruence of resources. The location of both Middle and Late Archaic assemblages in an identical geologic setting greatly simplifies the initial raw material variability model-building efforts. Generally, a transect from Inner Basin to Highland Rim reveals a clinal trend from a chert resource "poor" zone to a chert resource "rich" zone. At 40MU347, local cherts are widely abundant, but are frequently grainy or of small size. Ridley chert is found in gravel and residuum contexts. Carters chert is also found in gravel and residuum contexts but at an approximately distance of 6.5 to 16 km from the site. Minor amounts of Bigby-Cannon chert are present in local gravel deposits, but these deposits are primarily composed of small Fort Payne cobbles. Logically, as one nears the Highland Rim Fort Payne Formation, larger pieces are available. Western Outer Basin gravel deposits contain an abundance of moderately sized Fort Payne cobbles at an approximate distance of 16 to 24 km. The Highland Rim contains the highest quality and most abundant

sources of Fort Payne chert, but it is located approximately 24 to 32 km from 40MU347.

Hypothesis Testing

Assessment of differential technological organization and implications of group mobility are particularly important in comparing the 40MU347 components. Lithic resource utilization should reflect mobility patterns. Two hypotheses based on assumptions between the relationship of settlement organization to procurement and technological organization are considered. Each hypothesis is then operationalized by a set of expected archaeological implications. Most implications are expressed in terms of relative frequency expectations and therefore tested for statistical independence by G-tests of (Sokal and Rohlf 1969). G-statistics are based on the $\underline{X}^2$-distribution and preferred to $\underline{X}^2$-statistics because they more closely approximate the $\underline{X}^2$-distribution (see Sokal and Rohlf 1969:550-560 for a thorough discussion). Confidence levels are set at 95% for each test implication. The hypotheses are attributable to Binford's work noted above. The test implications are primarily derived from considerations of the chert resource base and general lithic reduction sequence principles.

Hypothesis 1

H_1: If bands are non-logistically organized, then more intensive exploitation of local resources is expected.

Archaeological implications.

(1) Assemblages should exhibit relatively high frequencies of local materials.

(2) Assemblages should exhibit a diversity of materials.

(3) Local materials should reflect high selectivity processes.

Discussion. All of these implications rely primarily on the spatial incongruence of resources discussed above. The major consideration involved is the location of 40MU347 in what may be generally termed a resource poor area. Cherts are locally available, but are inferior to more distant sources. Consequently, the increased use of local cherts (e.g., Ridley, Carters) should reflect greater territorial circumscription and a lesser degree of logistical mobility. The second implication is based on the fact that a great diversity of materials is available in the Inner Basin. If more local materials are being exploited then assemblages should reflect this diversity. The final implication is based on the premise that intense exploitation of local materials will lead to increased familiarity with local resource distributions. This should lead to higher qualitative selectivity among local materials within an assemblage.

Hypothesis 2

H_2: If bands are non-logistically organized, then technologies are expected to be more expediently organized.

Archaeological implications.

(1) Assemblages should exhibit high relative frequencies of initial reduction stages.

(A) Assemblages should show high relative frequencies of cortex presence.

(B) Assemblages should show a high relative frequency of early stage reduction debris.

(2) Tool assemblages should reflect high coarse to fine-grained material ratios.

Discussion. These implications rely on the particular spatial incongruity of resources recognized from the 40MU347 location also. If technologies are not logistically "keying" on particular resources, then it is expected that they will be less organized and more expedient with regard to raw material selection and utilization. Increase in technological expedience will lead to more frequent procurement and manufacturing activities. This should result in the presence of greater amounts of initial reduction stage debris which can be monitored by the varying presence of cortex among assemblages. Finally, expedient technologies are expected to show lesser selectivity among tool assemblage material quality. This can be assessed by the ratio of coarse- to fine-grained materials within a tool assemblage.

It is recognized that the implications for H_1 are not independent from those of H_2. However, this is to be expected, since the organizational principles from which the hypotheses are derived are not independent. Nonetheless, it is suggested that implications for H_1

relate primarily to intensive exploitation of local resources while implications for H_2 relate primarily to degree of technological expediency. Since Ridley chert is restricted to Inner Basin contexts, it is contrasted with Fort Payne chert as a rough approximation of a local:non-local dichotomy.

Results

Hypothesis 1

Three measures were considered concerning the relative frequencies of Ridley and Fort Payne cherts: (1) total assemblages, (2) debitage, and (3) tools. Tables 5.1, 5.2, and 5.3 present the results of these tests respectively. In all cases, there were statistically significant differences between the two components. Ridley consistently showed higher relative frequencies in the Middle Archaic assemblage and Fort Payne showed higher relative frequencies in the Late Archaic assemblage. Although these three comparisons were not strictly independent due to the reproductive properties of chi-squares, the G-statistics indicated debitage as the best discriminator of this pattern.

Information theory has stimulated development of mathematical models for assessing the diversity or information content of a code. Pielou (1975:7-17) addresses the desirable properties of an adequate diversity-index and suggests the Shannon-Wiener index (H') as the most useful when specimens in an assemblage are classifiable in more than one way. However, diversity is increased by a more even distribution of types present and thus equitability (J') must be considered as an integral component of diversity. Tables 5.4 and 5.5 present the chert

Table 5.1. Ridley and Fort Payne chert variability between the 40MU347 total chipped-stone assemblages: G-test contingency analysis.[a]

Assemblage	Chert Type		Totals
	Ridley	Fort Payne	
Middle Archaic (Area 1)	170 (39.81)	257 (60.19)	427
Late Archaic (Area 2)	276 (26.56)	763 (73.44)	1039
Totals	446	1020	1466

[a] $\underline{G} = 24.313$, $\underline{df} = 1$, $\underline{p} < 0.05$.

H_0 is rejected (a significant difference occurs).

Table 5.2. Ridley and Fort Payne chert variability between the 40MU347 debitage assemblages: G-test contingency analysis.[a]

Assemblage	Chert Type		Totals
	Ridley	Fort Payne	
Middle Archaic (Area 1)	124 (36.47)	216 (63.53)	340
Late Archaic (Area 2)	142 (17.64)	662 (82.36)	804
Totals	266	878	1144

[a] $\underline{G} = 45.045$, $\underline{df} = 1$, $\underline{p} < 0.05$.

H_0 is rejected (a significant difference occurs).

Table 5.3. Ridley and Fort Payne chert variability between the 40MU347 tool assemblages: G-test contingency analysis.[a]

Assemblage	Chert Type		Totals
	Ridley	Fort Payne	
Middle Archaic (Area 1)	13 (32.50)	27 (67.50)	40
Late Archaic (Area 2)	13 (16.25)	67 (83.75)	80
Totals	26	94	120

[a] $\underline{G} = 3.919$, $\underline{df} = 1$, $\underline{p} < 0.05$.

H_0 is rejected (a significant difference occurs).

Table 5.4. Raw material frequencies for the 40MU347 total chipped-stone assemblages.

Assemblage	Chert Type					Totals
	Ridley	Carters	Bigby-Cannon	Fort Payne	St. Louis	
Middle Archaic (Area 1)	170 (.3820)	1 (.0022)	17 (.0382)	257 (.5775)	--- ---	445
Late Archaic (Area 2)	276 (.2572)	7 (.0065)	26 (.0242)	763 (.7111)	1 (.0009)	1073
Totals	446	8	43	1020	1	1518

Table 5.5. Raw material diversity statistics for the 40MU347 total chipped-stone assemblages.

Assemblage	Diversity Statistics[a]			
	Types Present (s)	Maximum Diversity (H max)	Evenness (J')	Diversity (H')
Middle Archaic (Area 1)	4	.6021	.5936	.3574
Late Archaic (Area 2)	5	.6990	.4478	.3130

[a] $H' = \Sigma\ p_i \log p_i,\ p = (i=1, \ldots s)$

$H'max = \log s$

$J' = H'/H\ max$

where, s = Number of types present.

H' = Index of type diversity (information content).

H max = Maximum possible diversity with given s.

J' = Evenness or equitability of specimens among types.

type frequencies and diversity-indices for both assemblages. The Late Archaic assemblage has a greater number of types present which should lead to a higher diversity-index, but the Middle Archaic assemblage shows higher diversity. Equitability figures indicate that this is due to a less even distribution of types within the Late Archaic assemblage. This suggests greater keying on a specific resource (i.e., Fort Payne) for the Late Archaic.

If the local environment is more intensively utilized, then it is expected that higher qualitative selectivity of local materials should result. Considering texture as a measure of quality, the frequencies of fine- and coarse-textured Ridley are compared for both assemblages. Table 5.6 indicates a statistically significant difference between the two components. The Middle Archaic assemblage exhibits selectivity for fine-textured Ridley, implying more intensive coverage of the local environment. The focus of procurement organization for both assemblages is indicated in Table 5.7. A comparison of cortex types shows a significant statistical difference between the components. Cell frequencies suggest a more intensive focus on gravel deposit chert sources during the Middle Archaic.

Hypothesis 2

The expediency of a technology may be assessed by the occurrence of initial reduction stage debris and standards of quality in raw material selection. Ebert (1979:68) has noted that the amount of energy expended in tool manufacture varies with group mobility. Higher ratios of initial to later reduction stage debris should indicate a greater degree

Table 5.6. Texture variability of Ridley chert between the 40MU347 debitage/tool assemblages: G-test contingency analysis.[a]

Assemblage	Texture		Totals
	Fine	Coarse	
Middle Archaic (Area 1)	86 (62.77)	51 (37.23)	137
Late Archaic (Area 2)	76 (49.36)	79 (50.64)	155
Totals	162	130	292

[a] $\underline{G} = 5.353$, $\underline{df} = 1$, $\underline{p} < 0.05$.

H_0 is rejected (a significant difference occurs).

Table 5.7. Cortex type variability between the 40MU347 debitage assemblages: G-test contingency analysis.[a]

Assemblage	Cortex Type		Totals
	Cobble	Matrix/Residual	
Middle Archaic (Area 1)	189 (78.42)	52 (21.58)	241
Late Archaic (Area 2)	69 (44.81)	85 (55.19)	154
Totals	258	137	395

[a] $\underline{G} = 46.663$, $\underline{df} = 1$, $\underline{p} < 0.05$.

H_o is rejected (a significant difference occurs).

of technological expediency and higher group mobility. The frequency of initial reduction stage debris is measured by cortex presence and absence for total assemblages and debitage. In both overall assemblage (Table 5.8) and debitage (Table 5.9) comparisons, the Middle Archaic exhibits statistically higher frequencies of cortex presence, indicating technological expediency.

In addition, the reduction sequence can be categorized as early or late. Primary and secondary decortication flakes indicate early removal. Tertiary (or interior) and biface thinning flakes indicate later removal. Comparison of unbroken debitage frequencies indicates a statistically significant difference between the assemblages (Table 5.10). The Middle Archaic component shows a high frequency of initial stage reduction indicating technological expediency. Later stage reduction appears more frequent in the Late Archaic component, indicating possible attrition due to "staging" or field processing at some other location(s).

If technologies are more expedient, it is expected that tool assemblages should reflect a lesser degree of selectivity in raw material acquisition. Tool-material textures are compared for both assemblages in Table 5.11. These data indicate a significant statistical difference between the components, but the frequency trend is the reverse of that expected. Middle Archaic tools exhibit a higher frequency of fine-textured material. A variety of considerations influence tool material texture. Selection of fine-textured material may reflect greater anticipated use-life of Middle Archaic tools.

Table 5.8. Variability of cortex presence between the 40MU347 total chipped-stone assemblages: G-test contingency analysis.[a]

Assemblage	Cortex		Totals
	Present	Absent	
Middle Archaic (Area 1)	302 (68.95)	136 (31.05)	438
Late Archaic (Area 2)	262 (25.41)	769 (74.59)	1031
Totals	564	905	1469

[a] $\underline{G} = 245.68$, $\underline{df} = 1$, $\underline{p} < 0.05$.

H_0 is rejected (a significant difference occurs).

Table 5.9. Variability of cortex presence between the 40MU347 debitage assemblages: G-test contingency analysis.[a]

Assemblage	Cortex		Totals
	Present	Absent	
Middle Archaic (Area 1)	241 (66.57)	121 (33.43)	362
Late Archaic (Area 2)	154 (18.59)	679 (81.41)	833
Totals	395	800	1195

[a] $\underline{G} = 256.424$, $\underline{df} = 1$, $\underline{p} < 0.05$.

H_o is rejected (a significant difference occurs).

Table 5.10. Reduction stage debris variability between the 40MU347 debitage assemblages: G-test contingency analysis.[a]

	Reduction Stage[b]		
Assemblage	Early[c]	Late[d]	Totals
Middle Archaic (Area 1)	71 (65.74)	37 (34.26)	108
Late Archaic (Area 2)	74 (24.10)	233 (75.90)	307
Totals	145	270	415

[a] $\underline{G} = 59.259$, $\underline{df} = 1$, $\underline{p} < 0.05$.

H_o is rejected (a significant difference occurs).

[b] Unbroken debitage only.

[c] Primary and secondary decortication flakes.

[d] Tertiary (interior) and biface thinning flakes.

Table 5.11 Texture variability between the 40MU347 tool assemblages: G-test contingency analysis.[a]

Assemblage	Texture		Totals
	Fine	Coarse	
Middle Archaic (Area 1)	40 (97.56)	1[b] (02.44)	41
Late Archaic (Area 2)	74 (89.16)	9 (10.84)	83
Totals	114	10	124

[a] $\underline{G} = 5.130$, $\underline{df} = 1$, $\underline{p} < 0.05$.

H_o is rejected (a significant difference occurs).

[b] Low cell frequency may have produced spurious significance, therefore results are considered ambiguous.

However, low cell frequencies may have produced spurious significance and these results are considered ambiguous.

First Approximation Evaluation

Viewing raw material selection as an adaptive strategy, several components contributing to processual change must be considered. Kirch (1980:115) identifies these components as demography, environment, selection, and variability. Environmental selection pressures increase behavioral variability over time (Kirch 1980:116). Diversity of behavioral variability can therefore indicate degrees of environmental "stress."

Increasing population pressure and environmental stress during the Middle Archaic in the central Duck River Basin may have been resolved by an intensification of resource utilization within established territories. Environmental stress during mid-Holocene times evidently required Middle Archaic peoples to use a broader spectrum of secondary or back-up resources. The diversity of paleobotanical remains from the Clay Mine appears to be greater for the Middle Archaic component which may be a reflection of this broad spectrum adaptation (Amick 1983:8).

Fort Payne chert has been recognized as the most abundantly utilized material in the central Duck River Basin (McCluskey 1976:706). Smith's (1981) data from 40MU272, an Early Archaic surface site, and the Clay Mine Late Archaic data indicate that Fort Payne was highly preferred during these periods. As such, Fort Payne served as a key resource for prehistoric groups in the central Duck River Basin. This is probably related to its ubiquitous availability. The Middle Archaic

assemblage at 40MU347 reflects a continued reliance on Fort Payne, but an increased utilization of local Ridley chert is also indicated. Ridley probably represents a supplemental resource and reflects mid-Holocene environmental stress among central Duck River Basin Middle Archaic groups. Results of the test implications suggest that Middle Archaic groups were less logistically organized and consequently more residentially mobile than Late Archaic groups. It is proposed that environmental stress led to constraints on their ability to key as intensively on a "specific resource in a specific context" (in this case Fort Payne chert) than earlier or later groups.

In order to refine this model, it is necessary to review some of the weaknesses and strengths of the present analysis. Since 40MU347 is a deeply buried site, there were limitations on excavation strategies and it is not certain that the recovered assemblages are representative of the site or region. This is particularly the case for the Middle Archaic component with a total sample size of 567 specimens. Later testing at the site suggested that this sample was taken from a low density portion of the component (Amick 1983:5). However, the components provide a good basis for comparison since they are: (1) located in the same setting, (2) well separated by 1.5 m of alluvial deposits, and (3) chronologically established.

The widespread availability of Fort Payne chert in the central Duck River Basin causes particular analytical problems. Its presence on Inner Basin sites cannot be accurately assessed as a non-local or more distant resource. Although the amount of cortex presence may reflect source distance (especially with matrix/residual cortex), variability in

field preparation reduction strategies may confound this measure. Since failure in biface manufacture occurs most often during early reduction stages, these operations are most efficiently accomplished at or near the material source (Callahan 1979:40, 163-164; Johnson 1979:25-28). Assemblages from the Outer Basin and Highland Rim are expected to exhibit significantly higher degrees of Fort Payne biface manufacture debris than Inner Basin assemblages, and may indicate locations of Fort Payne procurement for large biface manufacture in Inner Basin assemblages. However, emphasis on locally limited raw materials (i.e., Ridley and Carters) which were probably used supplementary to a key resource (i.e., Fort Payne) can be much more informative in examining technological change as illustrated by the analysis. The low frequencies of Carters chert in the 40MU347 assemblages indicate that it may serve a function similar to Ridley as a second-line resource to Fort Payne. Examination of assemblages from sites located on the Carters Formation may be used to test this proposition. Additionally the relationship of chert types to debitage and tool types requires examination.

In summary, a review of the test implications indicate that locally limited raw materials, debitage, and cortex appear to be the best discriminators of behavioral variability for this model. It should be stressed that this is only the first test for this model. The comparison of material recovered at other Middle and Late Archaic sites in the region is necessary for better model resolution. Overall, the analysis of raw material variability in terms of adaptive strategies tends to reflect the direct relationship of hunter-gatherer cultural

systems to the physical environment. Flexibility of organization and adjustment to changing environmental and demographic conditions seem to be apparent through patterns of raw material procurement and utilization.

CHAPTER VI

RECONSIDERING THE MODEL: A SEVEN ASSEMBLAGE SOLUTION

The primary problem with the model at this point is sample size. The consideration of only two assemblages ignores potential interassemblage variability. In order to more confidently assess the notion of organizational change through time, more assemblages are required. However, the addition of more assemblages leads to tactical problems. First is the pragmatic issue of locating and excavating assemblages which are appropriate to the research design. This problem is not only limited to buried site sampling issues, but includes the more urgent constraints of labor-time and budget. In addition, these assemblages are generated as part of a larger research design for cultural resource management. This larger framework dictated the building of a regional chronology, evaluative testing of buried site deposits, and the development of an understanding of local interassemblage variability. Another tactical problem results from the inability of the current hypotheses and hypothesis testing methods to conveniently accommodate more than two assemblages simultaneously. Consequently, although the initial hypotheses are retained, the evaluation of their accuracy must rely on more flexible and descriptive procedures.

This chapter represents an attempt at refining the model. The addition of more assemblages which fit within the problem framework is considered to be the most appropriate alteration. Additional changes at higher levels of the model are avoided at this stage in order to isolate

problems between the hypotheses and data. First, the descriptions of the new assemblages are given. This is followed by a review of the current hypotheses and test results. Modifications of the hypotheses and test implications are specified. Then the hypothesis testing methods used for this test are described. The results of these methods follow with a summary and discussion on apparent data patterning and inferences for further model revision.

Building the Assemblage Sample

The generation of assemblages comparable to the Clay Mine (40MU347) case was accomplished in an opportunistic manner. Four of the assemblages result from test excavations at buried floodplain sites along the central Duck River. These sites were located through intuitive backhoe trenching of the Holocene terrace deposits. The local geomorphological/geochronological work by Brakenridge during the summers of 1980-1981 and reported in his dissertation (1982) was a vital foundation for the development of a local buried site location/interpretation program. In addition, the stratigraphic section recording and field interpretation techniques developed by Turner et al. (1982) proved invaluable during the investigation of buried floodplain sites. The fifth assemblage results from test excavations at the Topsy Site (40WY204) on the Buffalo River floodplain, located about 45 km west-southwest of the central Duck River Basin (Amick 1982).

Describing the data set collection methods as opportunistic is not meant to imply randomness or haphazardness. Rather the collection strategy was purposive and built around particular research design

parameters. When an assemblage which fit within the research framework was recovered, advantage was taken of the circumstances; and the assemblage was incorporated within the data set. The research design parameters were basically defined by temporal and spatial constraints. Obviously, acceptable data were restricted to Middle and Late Archaic lithic assemblages located in the Duck River watershed and particularly the Inner Nashville Basin physiographic area. In addition, other constraints were operative within the research design, these included: an excavated and dated context, and an open-site floodplain location. Radiocarbon dating was required in order to document a secure local chronological sequence for the assemblages. Excavated material was clearly a prerequisite for reliable dating of the assemblages. Multiple occupations, poor chronological control, and differences in natural site formation processes characteristic of surface assemblages militated against mixing of excavated and surface collected materials within a single model. The restriction of the sample along particular parameters was an effort to reduce potential sources of variability and simplify the early stages of model building. This was seen as a conservative approach allowing exploration of controlled aspects of variability within the data set. The consideration of only open-site floodplain location assemblages was a further sampling constraint designed to reduce potential variability associated with topographically related factors of site locations (e.g., uplands, valley slopes) and types (e.g., caves, rockshelters).

Despite violating some of the sampling restrictions, the Topsy assemblage was included in the data set. The Topsy assemblage probably

represents multiple occupations and it is not radiocarbon dated. Furthermore, the Topsy site is not in the central Duck River Basin-Inner Nashville Basin. Topsy is located on the Western Highland Rim and it represents primarily Late Archaic occupations. It is because of these two facts that the Topsy assemblage is included in the data set. Early during the developmental stages of assessing chert resource distributions, it was recognized that Outer Nashville Basin and Highland Rim assemblages would be important to understanding Inner Nashville Basin assemblage variability (Amick 1981:50). In the preceding chapter, it was suggested that Late Archaic assemblages outside the central Duck River Basin were particularly important to understanding regional assemblage variability. Since the Topsy assemblage fulfills these desirable chronological and spatial properties, it is included in the data set. Additionally, the Topsy assemblage is included because it was sorted and classified in a manner comparable to the other assemblages.

A further aspect of the opportunism in sampling strategy is related to the problems inherent to buried alluvial site testing. Brown (1975:155-158) suggests that the primary problem of deep-site sampling is related to the "blindness" of testing strategies relative to occupational limits and patterns of artifact deposition. His recommended solutions to this problem include either complete excavation or increasing the number of small-scale probes and achieving compensatory control over intrasite variability by extensive coring or trenching. Despite Brown's proposed solutions, Cowgill (1975a:272) notes that the strategies of deep-site sampling "remain very refractory problems" due to the concealed nature of buried site deposits. The

location and size of buried site test probes reported in this study were purposively selected as the first stage of a multistage research design. Multistaging (Binford 1964; Redman 1973; Cowgill 1975a:274) is considered to be the most intelligent approach to buried site excavation. In addition, purposive rather than probability or systematic test probe methods were employed. The goals of this strategy were to recover chronologically sensitive artifacts (e.g., projectile points/knives) and to assess the depositional integrity of the buried component. The primary means of achieving these goals were extensive backhoe trenching and mapping followed by limited controlled hand excavations. Excavations were usually conducted within what appeared to be the most dense concentration of artifactual material. Nonetheless, each buried site presented a unique situation and testing strategy varied by site as a consequence. It seemed detrimental to the overall research goals to prohibit improvements on the individual testing strategies as experience accumulated. Therefore, the testing strategy was allowed to evolve and maintain a high degree of flexibility. The natural evolution of the testing strategy is apparent in the site descriptions below.

The research goals included the recovery of datable limited occupation lithic assemblages representing an organizational facet of cultural systems. Brown (1975:157) has stated that small-scale test probes are "incapable of predicting the contents of a buried site." It is asserted in this study that interpreting the contents of an assemblage sample rather than predicting the contents of a site assemblage is the more relevant goal. Furthermore, it is insisted that

organizational dimensions are so deeply embedded within lithic assemblages that intrasite sampling problems cannot seriously distort organizational interpretations. At this stage in model building, it can be stated quite simply that:

> Sampling is concerned with getting as clear a picture as possible, within the limits of stated budget, labor investments, and the research goals of the archaeological record as it exists (Binford 1975:253).

The central Duck River Basin sites used in this study are typical of buried floodplain manifestations in the region. They are characteristically about 30 cm thick and probably represent dispersed occupational surfaces. Preservation is generally poor with most components yielding lithic material and charred botanical remains. Few faunal remains have been recovered and these are usually extremely decomposed. Soil deposits are intensely compact homogeneous clays which are resistant to excavation and matrix dissolution. The homogeneity of the soil deposits obscures natural stratigraphy and, consequently, excavation proceeded in arbitrary 10 cm levels at these sites. Flotation samples of various sizes were obtained at all sites and these provided charred hickory nutshell for radiocarbon assays. Site disturbance and mixing of assemblages appear to be minimal. Primary sources of deposit disturbance seem to stem from shrink-swell action of the clay matrix, frost action, and bioturbation. These forces are responsible for the vertical dispersion of material in the cultural strata. Rapid accretion of the floodplain deposits indicates that repeated occupation/artifact deposition episodes were limited to a

rather short temporal framework which probably did not exceed a few seasons.

Together the seven assemblages cross-cut several dimensions. Topsy (40WY204) is located on the Western Highland Rim, all others are central Duck River-Inner Nashville Basin sites. The Bench Site (40MU433) is in Cannon Bend which is characterized by deeper soils, homogeneous mixed hardwood forest, and Carters Formation chert. The other central Duck River sites are located in the Cheek Bend area which is characterized by shallow soils, patchy heterogeneous cedar glade vegetation, and Ridley Formation chert. Topsy (40WY204), Clay Mine-Area 2 (40MU347), and Leftwich (40MU262) represent Late Archaic Ledbetter phase occupations between 4000 and 3000 years B.P. The four other assemblages are Middle Archaic occupations ranging between 7500 and 6000 years B.P. The Sykes-White Springs phase is represented by Clay Mine-Area 1 (40MU347) and Cedar Creek (40MU432) while the Eva-Morrow Mountain phase is represented by Cave Spring (40MU141) and Bench (40MU433). Individual descriptions of these five new assemblages are given below in chronological order of excavation.

Cave Spring (40MU141)

Backhoe testing and limited hand excavations were conducted at the Cave Spring Site (40MU141) in the summer of 1980. Success in locating buried components at the Clay Mine Site (40MU347) during the previous field season served as impetus for testing at the Cave Spring location. The Cave Spring Site is located approximately 1.6 km downstream from the Clay Mine Site (Figure 2.1, page 16). Both sites are situated within

Holocene floodplain deposits of Cheek Bend. Specific information regarding Cave Spring testing strategy, methodology, and results have been presented elsewhere by Hofman (1981, 1982). A summary of this information with emphasis on application of the Cave Spring lithic assemblage to raw material variability modeling follows.

The Cave Spring material employed by this study consists of 7585 lithic specimens greater than 1 cm in maximum dimension. These pieces were recovered from two 2 x 3 meter excavation areas which were carried through the 30-50 cm thick buried cultural stratum at 40MU141. This assemblage represents the largest of this study (42.73% of all seven assemblages combined) due to an extremely high density of excavated material (approximately 630 pieces/m^3). The majority of bifaces in the assemblage can be assigned to the Eva-Morrow Mountain cluster (Faulkner and McCollough 1973:53-54) of the Middle Archaic period. However, several Early Archaic period biface and flake tool forms were recognized in the collection. These specimens are heavily patinated and in some cases reworked, exposing unpatinated chert. This seems to suggest collection of these earlier pieces by Middle Archaic peoples who then incorporated the finished tools into their own tool inventories. A great deal of the work at Cave Spring has been directed toward interpretation of the depositional site formation processes which created this cultural stratum. Hofman (1981) has used several independent methods (e.g. refitting analysis, material sorting, gravel analysis, and morphological analysis of Eva-Morrow Mountain points) to suggest that the material recovered at Cave Spring represents a single primary depositional surface. Three radiocarbon dates have been

reported by Hofman (1982) for the Cave Spring assemblage: 6885 ± 90, 6540 ± 110, and 7250 ± 350 years B.P. These dates are in general agreement with other dates reported from Eva-Morrow Mountain components in the Southeast. Locational, temporal, and depositional attributes of the Cave Spring assemblage suggest that its inclusion in the model-building effort is appropriate to the problem framework.

Leftwich (40MU262)

The Leftwich Site (40MU262) was one of the first buried sites recognized in the course of Columbia Archaeological Project activities. It is located about 3.2 km upstream from the Clay Mine Site (40MU347) on the left bank of the Duck River (Figure 2.1, page 16). In 1978, the Tennessee Valley Authority began panning the Leftwich Site (40MU262) to produce fill for construction of the new Leftwich Bridge located immediately upstream from the site. Some lithic material and possible hearths were observed in the borrow pit. Six 2 x 2 m units were excavated to about 30 cm deep in the borrow area and revealed some cultural material. Four 2 x 2 m units were excavated to a depth of 100 cm on the T2 (Pleistocene terrace) crest and face. Surface material was dense on this undisturbed T2 remnant, but excavation indicated little material present below the plowzone. At this time, the T2 was not recognized as Pleistocene in age.

In the summer of 1980, Leftwich was revisited during the conduct of alluvial geomorphology studies of the area (Brakenridge 1982). The T2 was now recognized to be Pleistocene deposited and investigations focused on the Holocene deposited T1 sediments. Although most of the T1

had been removed during the bridge construction, a portion of the T1 levee remained undisturbed. A backhoe trench was excavated through this remnant; Brakenridge (1982:24, Figure 5J) refers to this trench as "section J." Buried components were apparent at approximate depths of 1.5 and 2.5 meters. Two radiocarbon dates were determined for the upper component, 4130±130 (A-2553) and 4190±260 (A-2366) years B.P. (Brakenridge 1982:34-36). The lower component was dated at 6160±330 years B.P. (A-2365).

Armed with the knowledge that stratified Middle and Late Archaic components appeared to be present at the Leftwich locality, manual excavations were implemented the following field season (summer 1981). A 2 x 3 m excavation block (Area A) was established parallel to the old backhoe trench (Figure 6.1). Area A was excavated in 1 m^2 units by arbitrary 10 cm levels. Two partial levels adjacent to Area A were also excavated during the course of a wheelbarrow ramp alteration. Area A was excavated to a depth of approximately two meters. All of this excavated material was graded through 0.64 cm^2 mesh. Frequency counts of lithic specimens recovered from the excavations suggest a strong peak at 1.4 m below the surface. As one nears the two meter depth, a second peak begins to appear. These frequency count peaks show good correspondence with the component depths recorded in the adjacent trench section J.

The Leftwich excavations show dispersion of cultural material between the upper and lower components. Furthermore, it appears that excavations have not succeeded in recovering the lower component materials. Consequently, it was decided to employ only a sample of the

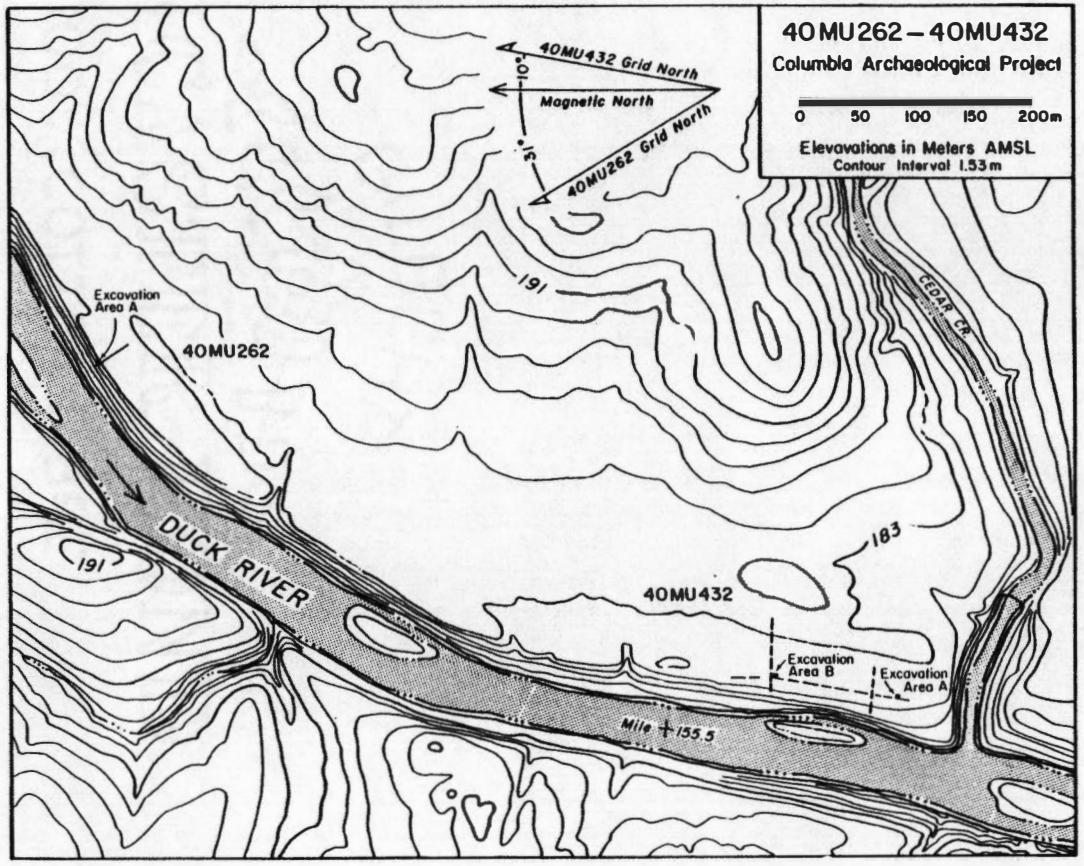

Figure 6.1. Location and excavation plans of Leftwich (40MU262) and Cedar Creek (40MU432) sites.

upper component assemblage in this analysis. This sample consists of 2481 lithic specimens representing 13.98% of the seven assemblage total. This sample ranks behind Topsy (40WY204) and Cave Spring (40MU141) in number of pieces. The Leftwich sample is derived from all lithic specimens in Levels 8 through 15 (approximately 1 to 1.8 m deep) retained by the 0.64 cm^2 mesh. Several diagnostic specimens were recovered from this sample (Figure 6.2). Six of these points seem to be Ledbetter Cluster types; however, one specimen resembles the "Benton Stemmed" type (Kneberg 1956:25-26; Faulkner and McCollough 1973:118). Benton points are suggested to be a transitional Middle to Late Archaic type. Diagnostic points and radiocarbon dates from the upper component at Leftwich indicate that this assemblage fills a critical chronological gap between the upper and lower Clay Mine components. In addition, the geographic proximity of Leftwich to four of the other assemblages (Cedar Creek, Clay Mine-Area 1, Clay Mine-Area 2, and Cave Spring) recommends its consideration in further regional raw material variability analyses.

Cedar Creek (40MU432)

In the summer and fall of 1981, extensive backhoe testing and limited hand excavations were conducted at the Cedar Creek Site (40MU432). This site is located approximately 1.6 km north (upstream) of Clay Mine (40MU347) and 1.6 km south (downstream) of Leftwich (40MU262). The Cedar Creek Site (40MU432) is on the left bank of the Duck River immediately above the confluence of Cedar Creek (Figure 2.1, page 16 and Figure 6.1). A primary focus of the Cedar Creek testing was the accurate delineation of site boundaries and intrasite variability of

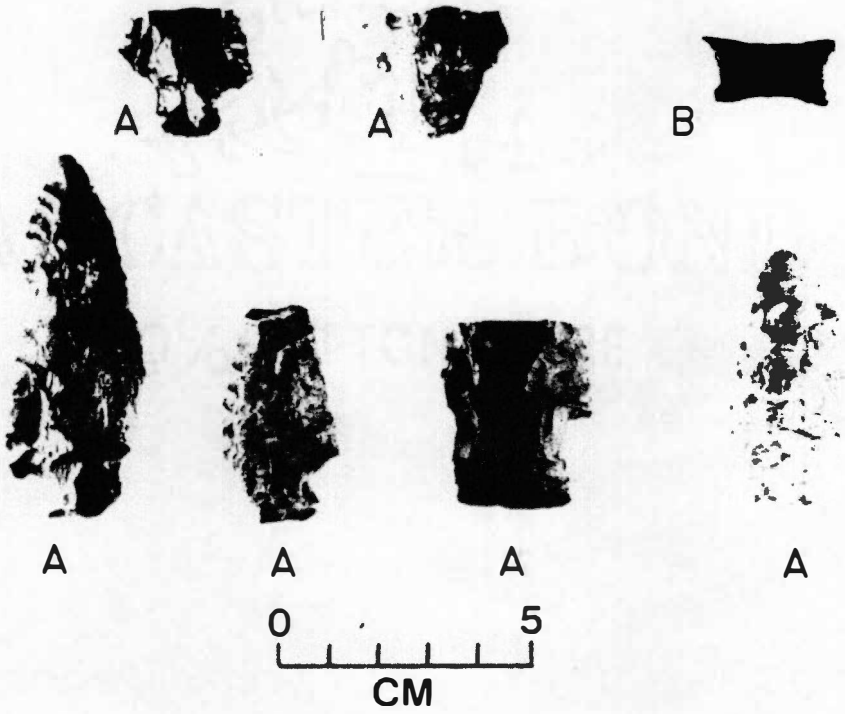

Figure 6.2. Leftwich (40MU262) diagnostic bifaces. A. Ledbetter Cluster, B. Benton Stemmed.

horizontal and vertical cultural material density. Since the use of manual test pits at the Clay Mine Site (Amick 1983) and augering at the Cave Spring Site (Hofman 1981) appeared to be rather poor methods of estimating the spatial parameters of buried floodplain sites, a program of extensive backhoe testing was implemented at the Cedar Creek location.

This program consisted of excavating two trenches perpendicular to the river through the Holocene terrace (T1) deposits. These trenches were spaced about 100 meters apart. Both trenches revealed buried cultural materials and indicated the local sequence of geomorphological stratigraphy at each profile. At this point, two questions became apparent: (1) what was the correspondence between the two slightly different geomorphological profiles; and (2) what was the relationship between the two cultural strata, that is, did they represent a single continuous stratum or were they actually two depositionally distinct "sites?" It was decided that the excavation of a trench parallel to river which would link the two original trenches offered the greatest potential for solving these problems. This trench also extended about 25 meters beyond the two original trenches.

The linking trench indicated that a single cultural stratum located about one meter deep extended 150 m north-south by 30 m east-west parallel to the river. This stratum is present within the T1b deposits. Two trends are apparent in the stratigraphy from north to south (parallel to the river and toward Cedar Creek): (1) the T1b deposits become thinner, and (2) the cultural stratum seems more diffuse. In the southern portion of the site, the diffuse cultural material appeared to

represent two possible cultural strata, one within the upper T1b deposits (approximately one meter deep) and another below this at the T1b-T1a contact (approximately 1.5 m deep). Since the cultural stratigraphic relations were still somewhat ambiguous at this point, it was decided that manual excavation blocks in the south (Area A) and north (Area B) ends of the site might help clarify the situation (Figure 6.1, page 138).

Approximately half a meter of overburden was removed from each area and excavation proceeded by one meter square units in 10 cm levels. Area A consisted of a 2 x 2 m block which was excavated to a depth of about 2.1 meters (excavated volume equalled approximately 6.4 m^3). Area B consisted of a 2 x 3 m block adjacent to a backhoe trench and was excavated to a depth of about 1.6 meters. A two meter long balk approximately 30-60 cm wide existed between Area B and Trench 7-Section 6 to the west. Previous experience with a similar balk at the Leftwich Site (40MU262) indicated that excavation area drainage and accessibility could be greatly improved by removing the balk. However, rather than discarding the balk as was the case at Leftwich, the balk perimeter was measured and excavated by 10 cm levels with the rest of Area B. This strategy conferred several advantages: better drainage was promoted, accessibility and ease of excavation were improved, recovery of cultural material was maximized, and stratigraphic control was improved due to the ability to work directly from the trench profile. The volume of excavated fill from Area B was approximately seven cubic meters.

Excavations in both Area A and Area B were halted when 20 cm of culturally sterile earth had been encountered. In Area B, excavations

ceased at the T1b-T1a contact. Excavations in Area A proceeded to a much greater depth and continued approximately 50 cm past the T1b-T1a contact into T1a sediments. Frequency counts of the recovered lithic material from Area B showed a unimodal distribution, suggesting a single cultural stratum. However, the frequency of lithic materials recovered in Area A showed a trimodal distribution. The uppermost frequency peak seems to correspond with the one meter deep cultural stratum ubiquitously distributed at the site. About 50 cm below this peak, a weak second mode appears just above the T1b-T1a contact. This mode may represent fortuitous concentrations of artifacts derived from downward movement of materials from the upper stratum. The presence of this concentration at the T1b-T1a contact may indicate greater resistance to downward movement by T1a sediments. In fact, the T1a sediments are notably more cohesive than the T1b sediments. The third mode is extremely weak and lies approximately 45 cm below the second. This places it well within the T1a sediments. Brakenridge (1982:22, 40) states that T1a sediments represent early Holocene deposits, that is, they were deposited prior to Middle Archaic times.

The interpretation of the cultural stratigraphy at Cedar Creek is critical for determining appropriate samples for the raw material variability model. Temporally sensitive diagnostic specimens aided this interpretation. Six diagnostic projectile points/knives were recovered by the Cedar Creek investigations. These diagnostics are illustrated in Figures 6.3 and 6.4. Area B yielded an Eva-Morrow Mountain Cluster specimen and a Kirk specimen. In addition, a triangular biface was recovered in Area B, these bifaces appear to be regional Middle Archaic

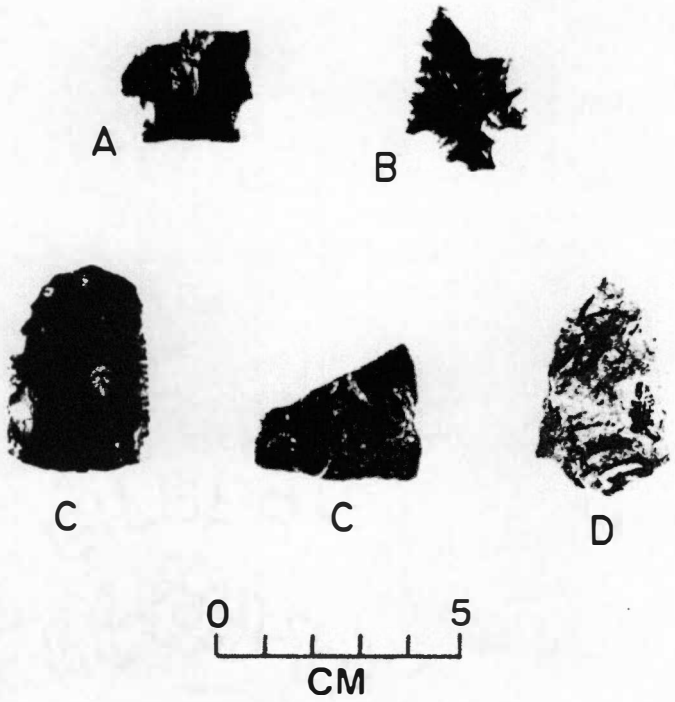

Figure 6.3. Cedar Creek (40MU432) diagnostic bifaces. A. White Springs-Sykes (Area A), B. Eva-Morrow Mountain (Area B), C. triangular bifaces (left-Area A/right-Area B), D. Eva-Morrow Mountain (Area A).

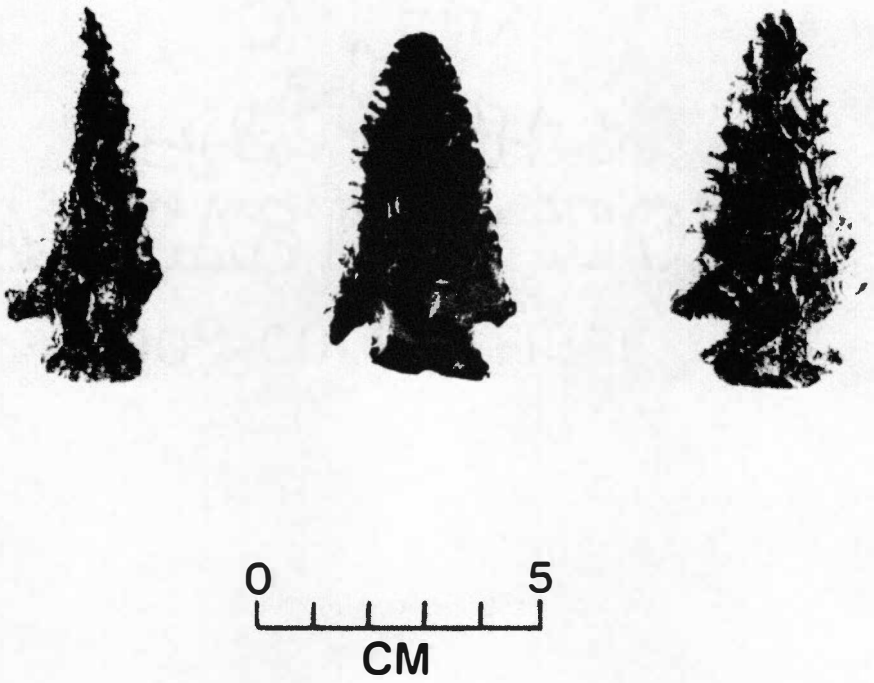

Figure 6.4. Cedar Creek (40MU432) Early Archaic points (Kirk Cluster). All are patinated, specimen on left is reworked.

horizon markers (Amick 1983:5). Another Kirk specimen was found within this cultural stratum in a nearby trench profile. The unit and level from which the Eva-Morrow Mountain point was recovered was radiocarbon dated at 6375 ± 215 (GX-8822) years B.P.. A third Kirk specimen was found in the upper component stratum in another trench profile. One of the Kirk points was resharpened subsequent to patination, all three Kirk points were patinated, no other lithic specimens within the Cedar Creek assemblage exhibited patination. This evidence is substantiated by similar evidence at the Cave Spring Site (Hofman 1981) that indicates systematic procurement and reuse of Early Archaic pieces by Middle Archaic peoples. Area A yielded a Sykes-White Springs, an Eva-Morrow Mountain, and a triangular biface. All of these specimens were recovered in the upper cultural stratum. The lower two lithic material frequency peaks did not yield any diagnostics. In addition, both of these modes exhibited unusually high relative frequencies of Bigby-Cannon chert (about 50%) within their assemblages. This may indicate very limited episodes of Bigby-Cannon lithic reduction during occupations prior to the dated Middle Archaic stratum. Since the interpretation of the lower two cultural strata in Area A is rather tenuous at this point, they are excluded from consideration in the model. The Cedar Creek Site (40MU432) sample employed in this analysis consists of only those materials derived from the Middle Archaic upper component stratum. This includes all of the Area B material and Levels 1 through 6 of the Area A material. All pieces were sorted by 0.64 cm^2 mesh which yields a total of 1267 lithic specimens from approximately 9.4 m^3 of excavated fill. The Cedar Creek sample is fifth in size

behind Bench (40MU433) and above Clay Mine-Area 2 (40MU347). The density of material is relatively low (about 135 pieces/m^3) for this assemblage.

Bench (40MU433)

Extensive backhoe trenching and limited hand test excavations were conducted at the Bench Site (40MU433) during the summer and fall of 1981. Although this site is located in the central Duck River Basin like five of the other seven assemblages, it differs from those five in being approximately 30 km downstream (Figure 2.1, page 16). There are a number of environmental differences associated with this distance. Basal geology in the Bench area is composed of the Carters Formation rather than the Ridley Formation which exists at the five sites upstream. These two formations contain chert which is similar in quality and quantity but distinct in appearance. Perhaps more importantly, soil depth is greater in the Cannon Bend area (where the Bench Site is located) than the Cheek Bend area (where the other five assemblages are found). This difference in soil depth leads to vegetation pattern differences between the two areas. The Cannon Bend area can be characterized by homogeneous mixed deciduous forest, while the Cheek Bend area exhibits heterogeneous forest cover marked by patches of cedar glade communities. Despite the geographic proximity of these two areas (approximately 8 km), distinct differences in resource configuration are evident. It is expected that the comparison of lithic assemblages between Cheek and Cannon Bends may provide insights regarding environmental adaptations related to these resource

configurations as reflected by differences in settlement-subsistence and resource exploitation patterns.

The Bench Site (40MU433) is located in a rather unique depositional setting on the left bank of the Duck River just above Cannon Bend (Figure 6.5). The site is composed of a small floodplain approximately 250 m long by 50 m wide. The Bench is bordered on the south by the river and on the north by a steep limestone bluff. This bluff is actually a neck of land about 200 m wide and 35 m high that is bounded by the Duck River on each side. East of the neck lies Cannon Bend, an oxbow meander loop surrounded by a 5.5 km stretch of the Duck River. The presence of the bluff on the south side of the meander neck suggests that the river once incised from this direction, but the Holocene floodplain deposits at the base of this bluff indicate that deposition is now the predominant geomorphological process at this location. The Cannon Bend meander neck is more likely being eroded from the northern side at this time.

The numerous backhoe trench profiles at the Bench suggested a subtle and complex geomorphological history at this depositional setting. At least three buried components were recognized in the trenches. A Woodland ceramic-bearing component was noted at the upstream end of the Bench, slightly downstream was a probable Late Archaic period component. Stratigraphy between these two components suggested a slight upstream dip of the sediments. Near the center of the Bench, an apparent Middle Archaic component was recorded. Stratigraphy in this location indicated moderately steep arching of the sediments along a rounded crest parallel to the river. Sediments sloped

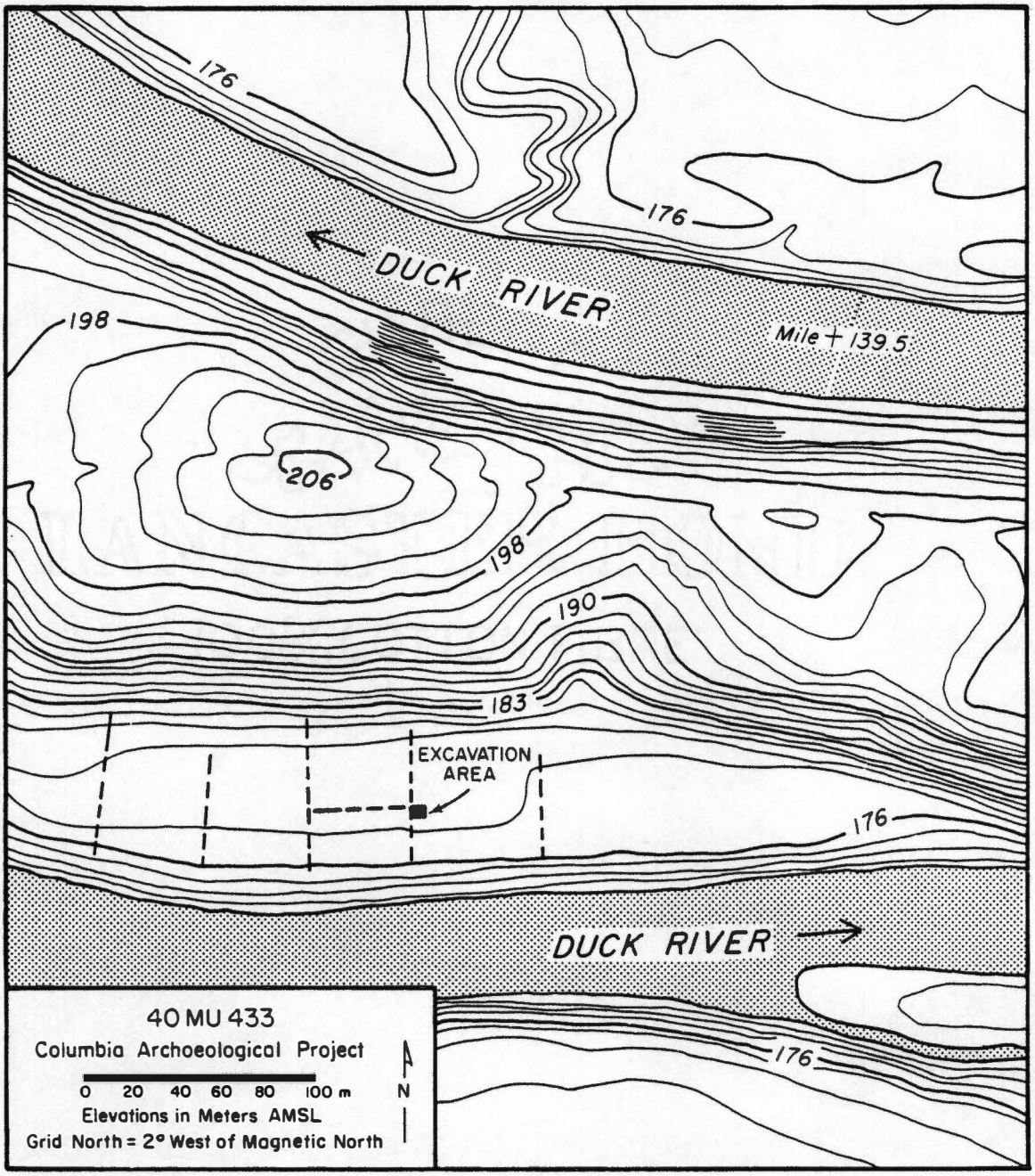

Figure 6.5. Location and excavation plan of Bench Site (40MU433).

away from this crest toward both the bluff and river. The sediments along the bluff/floodplain interface suggested a combination of colluvial and alluvial origin. It is suggested that the Bench originated as a gravel bar which evolved into an island and eventually a lateral terrace accretion. This notion is supported by the crested sloping stratigraphy and successive addition of later components and soils at the upstream end of the Bench. This relatively recent and rapid evolution of the spatially limited Bench area suggests a potentially unstable depositional surface. Nonetheless, the Bench offers a uniquely advantageous location protected from northerly winds by the bluff and potentially controlling access to Cannon Bend.

Excavations at the Bench Site focused on the Middle Archaic component located in the T1a paleosol sediments. Previous experience at the Cave Spring Site (40MU141) indicated that cultural material found in T1a paleosol would likely be Middle Archaic and about seven thousand years old. A 2 x 3 m excavation block immediately east of Trench 4972-Section 4 was cleared by backhoe to just above the two meter deep T1a paleosol and associated cultural stratum. This block was excavated in one meter square units by arbitrary 10 cm levels. In addition, a balk (approximately 30-70 cm wide and 3 m long) between the trench and excavation area was excavated by 10 cm levels accordingly. This strategy had been successfully employed at the Cedar Creek Site (40MU432) previously. The excavation in each unit proceeded until 10 cm of culturally sterile earth had been excavated. This resulted in the manually excavated units ranging from 50 to 60 to 70 cm in depth. The units toward the river were deepest as a result of the sloping

stratigraphy. The excavation block was apparently situated upon the river-facing slope of a crested land surface. Approximately 4.5 m^3 of fill was removed from the excavation area. Screening this material through 0.64 cm^2 mesh yielded 1645 lithic specimens. This results in a moderately high density of 366 pieces/cubic meter. The Bench lithic assemblage represents 9.27% of all assemblages totaled and is ranked fourth behind Leftwich (40MU262) and ahead of Cedar Creek (40MU432) in sample size.

Few temporally diagnostic specimens were recovered during the Bench excavations (Figure 6.6). Two triangular bifaces were found which appear to be regional Middle Archaic horizon markers at the Clay Mine Site (Amick 1983:5) and Cedar Creek Site (40MU432). A fragmentary Eva-Morrow Mountain point was also recovered in the Bench manual excavations. An indeterminate point type was also recovered. This specimen was found during the backhoe excavation of Trench 4972-Section 4 at a depth of approximately 2.2 meters. Similarities with the Kirk Cluster are suggested for this specimen, but it is too fragmentary for certain assignment. However, if this specimen were an Early Archaic Kirk type, then its presence within a Middle Archaic assemblage could be interpreted as further evidence of the procurement and reuse of Early Archaic points by Middle Archaic peoples already noted at the Cave Spring and Cedar Creek Sites.

It was hoped that a radiocarbon date could help establish the age of the Bench assemblage. The date was assayed from a more than adequate 14.3 g sample of hickory (Carya sp.) nut shell at 8885 ± 360 years B.P. (GX-8821). Conaty and Nance (1983:2) have reported a similar date of

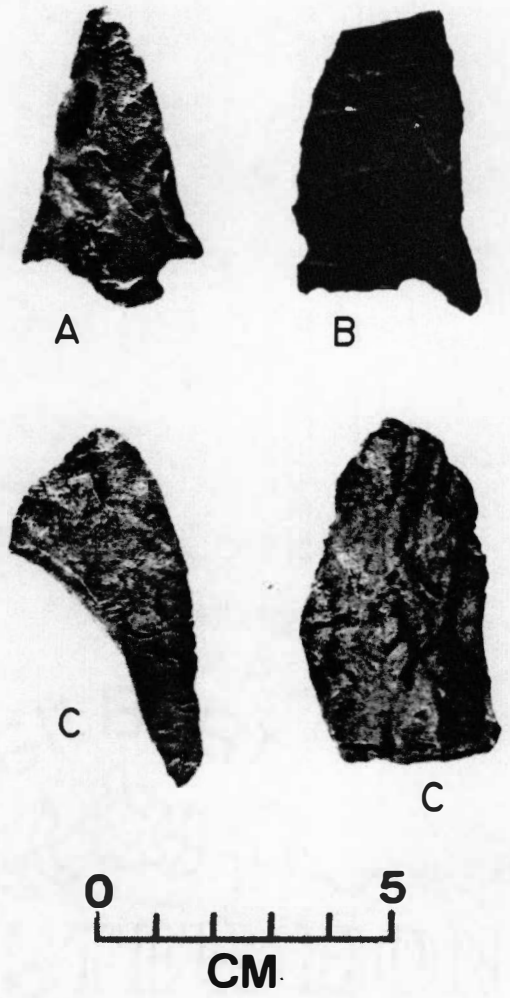

Figure 6.6. Bench (40MU433) diagnostic bifaces. A. Indeterminate (possibly Kirk Cluster), B. Eva-Morrow Mountain, C. triangular bifaces (Carters chert).

8220 ± 100 from a stratum associated with Eva and Kirk corner-notched points at the Morrisroe Site in Western Kentucky. But local Duck River stratigraphic geochronology and temporal diagnostic artifact evidence suggests the Bench date may be about 1500 years too early. A possible explanation of this date might be the presence of both Early and Middle Archaic cultural material within the T1a paleosol. This sediment might represent a very old stable surface spanning Early and Middle Archaic times (about 3000 years) or it could be the result of an intervening deflation of Middle Archaic material upon the Early Archaic surface. Brakenridge's (1982, 1984) geomorphological model would appear to refute this. In addition, the lithic assemblage from the Bench excavation suggests that this is unlikely. The two bifaces recovered at the Bench are made from Carters chert and much of the recovered debitage is also Carters. Early in the field and laboratory work, it became evident that these flakes represented a limited episode of trimming and thinning Carters' bifaces. Informal "refitting" sessions have proven that many of the flakes and biface fragments can be reconstructed. Furthermore, nearly three times more material was recovered from Unit 1-Level 3 than any other unit. This material included both bifaces, the Eva-Morrow Mountain point, and the majority of the Carters bifacial thinning debitage. The lithic evidence suggests that a single component and probably a very limited activity are represented by the Bench assemblage.

A second possible explanation for the early date could be contamination of the radiocarbon sample. Haynes (1980:583-585) discusses several possible causes of radiocarbon contamination.

Charcoal has an affinity for absorbing organic contaminants. These contaminants can derive from leaching of buried soils or organic deposits. Generally these humate contaminants are younger than the associated charcoal since they usually overlie them. However, they could be older due to local groundwater fluctuations, or in the case of Bench, derived from ancient soils on the bluff north of the site. Either of these causes could explain contamination, or insensitive field and/or laboratory processing could be the cause of contamination. The use of fossil fuels (gasoline, oil) by the waterpump with which the samples were cleaned in the field could have caused contamination. The accidental contamination by fossil fuels or chemic derivatives thereof may have occurred directly or indirectly at many of the radiocarbon sample processing stages. Precise determination of the accuracy of the Bench date is difficult. However, most evidence suggests the date is too early and that contamination was a likely cause of this error. In addition, the evidence of stratigraphy, temporal diagnostics, and debitage homogeneity credit the interpretation of the Bench material as a limited depositional episode representing an Eva-Morrow Mountain assemblage.

Topsy (40WY204)

During the spring of 1982, archaeological investigations consisting of controlled surface collection, backhoe testing, and manual excavations were conducted at the Topsy Site (40WY204). Unlike the Tennessee Valley Authority-Columbia Reservoir sponsored work which generated the other assemblages, this work was sponsored by the

Tennessee Department of Transportation in conjunction with a bridge relocation project. More importantly, the Topsy assemblage represents material from the Southwestern Highland Rim-Buffalo River region (Figure 2.1, page 16) rather than the Inner Nashville Basin-Duck River region. Details concerning archaeological investigations at Topsy are reported by Amick (1982). This information and the value of this data set to modeling raw material variability in the central Duck River Basin are discussed below.

The interpretation of archaeological assemblages within the central Duck River basin is difficult without reference to larger interregional considerations, particularly in regard to resource exploitation and settlement systems. Both chert resource distribution data and evidence provided by the Late Archaic Clay Mine assemblage suggested that Highland Rim and Outer Nashville Basin resources were an important part of central Duck River Basin Late Archaic lithic technology systems. The data generated by research at the Topsy Site (40WY204) provided an excellent opportunity to test notions regarding the influence of adjacent Highland Rim and Outer Nashville Basin chert resources on Inner Nashville Basin adaptation. It is suggested that the Topsy assemblage represents a generalized case which could apply equally well to lower and upper Duck River Basin and possibly Elk River Basin Late Archaic manifestations. That is, the location of the Topsy Site in the Buffalo River Basin is not meant to imply specific connections between central Duck River Basin and Buffalo River Basin site assemblages. Rather the Topsy assemblage in this analysis is provided as a contrastive data set to help interpret central Duck River Basin assemblage variability.

Late Archaic period diagnostics predominate within the Topsy assemblage (Amick 1982:28-29). Ledbetter Cluster points comprise over 60% (n=42) of the diagnostics. Wade (n=7) and Motley (n=3) points raise the Late Archaic total to over 75%. Therefore, the Topsy assemblage is regarded as primarily attributable to Ledbetter-Wade phase occupations. Radiocarbon dates were not obtainable at the Topsy Site, but dates available from other Ledbetter (Faulkner and McCollough 1973:151-152; Amick 1983) and Wade phase sites (Faulkner and McCollough 1973:149; Faulkner and McCollough 1974:320; Keel 1978:156-160) would suggest a date of approximately 3900 to 2900 years B.P.

A total of 3247 lithic specimens from the Topsy assemblage are used in this analysis. They represent 18.29% of the seven assemblage data set. This is second only to the Cave Spring (40MU141) assemblage in number of pieces. The Topsy data is restricted to excavated Stratum I material. This stratigraphic unit is a mixed "plowzone" unit. The Stratum I sample restriction was imposed in order to make the Topsy data as comparable as possible to the six central Duck River Basin assemblages. The Topsy surface collection was excluded due to demonstrated assemblage content differences related to "size effect" phenomena (Baker 1978; Amick 1982:23). The Topsy Stratum II excavated material was excluded since it appeared to represent a limited occupational episode of indeterminate chronological origin (Amick 1982:27-28). The 3247 Topsy Stratum I lithic specimens were recovered by waterscreening approximately four cubic meters of earth through 0.64 cm^2 mesh. This results in a relatively high density of about 812 pieces per cubic meter.

The Model Revised

Revision of the model focuses on the relationship between hypotheses and data. Results of the first test suggested that the two Clay Mine assemblages might not be representative. Developing a better understanding of interassemblage variability appears to be the most compulsive problem during this stage of model-building. The new assemblages to be compared are described above. The consideration of more than two assemblages simultaneously leads to analytical stresses in the model. Simple four cell contingency table methods are inappropriate. The hypotheses and test implications are not designed to accommodate variability within the sample. For these reasons, it is suggested that the current hypotheses and results be reviewed and that hypothesis and test implication modifications be outlined.

The hypotheses have been stated as "if-then" propositions. It is suggested that Late Archaic groups are more logistically organized than Middle Archaic groups. Less extensive exploitation of local lithic resources and less expediently organized lithic technology are cited as evidence of settlement organization differences. Test implications suggest that chert type frequency and diversity, cortex frequency, and debitage variability are the best discriminators of these patterns. These variables are also intuitively satisfying technological vectors. To summarize, Late Archaic groups are characterized by high logistical mobility and curatorially organized technology. Extensive resource exploitation patterns marked by keying on specific resources and staged manufacture are evident. More specifically, central Duck River Basin

Late Archaic lithic assemblages exhibit high frequencies of late stage manufacture debris and non-local Fort Payne chert. Middle Archaic groups are characterized as residentially mobile and technologically expedient, relying on intensive resource exploitation patterns. The use of a greater diversity of raw materials and particularly poor quality local cherts suggest this. In addition, the high frequency of early reduction stage debris at central Duck River Basin Middle Archaic sites gives further evidence of this pattern.

Perhaps it is best to rephrase the hypothesis as: Late Archaic groups are more logistically organized than Middle Archaic groups in the central Duck River Basin. This hypothesis more accurately reflects the research problem and it is also capable of handling interassemblage variability. However, before inferring meaning from the archaeological record, it is necessary to consider more middle-range theory on cultural site formation processes. This theory forms bridging arguments between observations of interassemblage variability and settlement system organization. Following this middle- range theory discussion, some test implications are generated.

The Nunamiut Revisited

The earlier Clay Mine analysis did not require considerations of interassemblage variability. Fortunately, observations regarding the relationship between hunter-gatherer settlement system organization and interassemblage variability have been made by Binford (especially 1978a, 1980, 1982, 1983a) during his Nunamiut Eskimo ethnoarchaeology work. This body of middle-range theory is appropriate to the problem of

Archaic period interassemblage raw material variability in the central Duck River Basin.

A few terms regarding interassemblage variability need to be defined and discussed. The notion of an archaeological assemblage is perhaps the most germane issue. Archaeological assemblages are thought of "as a temporal sample of some organized series of events characteristic of a (cultural) system" (Binford 1978a:483). As such, they are visualized "as an accumulation of by-products derived from the particular series of events that occurred during an occupation" (Binford 1978a:483). Consequently, there may be variable degrees of resolution between the specific events (which condition the archaeological record) and the archaeological remains. Binford (1978a:483, 1980:17-18) refers to this degree of resolution as the "grain" of an assemblage. Archaeological remains which exhibit poor resolution with specific events are considered coarse-grained. As resolution improves, the assemblages are considered more fine-grained.

The degree of interassemblage variability is conditioned by both mobility and seasonality in activities. The grain of an assemblage is regulated by mobility (Binford 1980:17). More specifically,

> The factor that regulates the grain of archaeological samples is the pattern of mobility characteristic of the system under investigation. How frequently a social unit moves and in turn the duration of occupations at different locations condition the grain of the assemblages that result from the occupations. High mobility results in fine-grained assemblages, whereas low mobility results in coarse-grained assemblages. The grain of the assemblages does not directly regulate the variability in assemblage content (Binford 1978a:483, emphasis in original).

Aside from the important relationship between mobility and assemblage grain recognized here, attention is called to the last sentence of the quote. It is the serial differentiation of events which regulates assemblage content variability. Moreover, the major conditioner of event differentiation in subsistence activities is seasonal variance in basic climatic variables (Binford 1978a:483-484). Three general statements can be made regarding the relationship of these variables to assemblage grain.

> (1) It should be clear that insofar as events are serially differentiated, and the composition of assemblages responsive to event differences, the more fine grained the temporal samples obtained the greater the probable content variability among assemblages (Binford 1978a:483, see also Binford 1980:17, emphasis altered).
>
> (2) It should be clear that as there is an increase in the degree to which events are serially differentiated, there will be an increase in content variability among assemblages given moderate- to fine-grained assemblages (Binford 1978a:483, emphasis altered).
>
> (3) Increased seasonal variability, given assemblage responsiveness to event differentiations, leads to increased residential site interassemblage variability as noted in the second statement. These conditions also favor increased logistical dependence and reduced residential mobility which increases assemblage grain coarseness. Increased coarseness in turn should have the effect of reducing interasemblage variability among residential sites of a single or closely related system occupied during comparable seasons. It would, of course, also have the effect of increasing complexity and 'scale' of assemblage content referable to any given uninterrupted occupation, assuming, that is, a responsiveness of assemblage content to event differentiation (Binford 1980:18, emphasis altered).

Some basic implications of assemblage grain should be apparent. Fine-grained assemblages reflect short occupation spans, limited activities, and high mobility. Coarse-grained assemblages suggest

longer occupation spans, a greater diversity of activities, and low mobility. In addition to assemblage grain, site function must be considered regarding interassemblage variability. Site function is roughly classified as maintenance or extraction (Binford and Binford 1966, 1969; Binford 1973). This dichotomy approximates a residential and special-purpose site distinction respectively (Binford 1978a). Extraction or special-purpose sites are regarded as logistically used sites and expected to yield fine-grained assemblages. Residential sites are expected to be more coarse-grained. Numerous other expectations relating to functional site types and assemblage grain are recognized. Among residential sites, expectations are: (1) flexibility in location and high variability in assemblage content, (2) complex interassemblage variability patterns, (3) multiple activities and events with complex accumulative effects, and (4) heterogeneous assemblages (Binford 1978a:486-491, 1980:15). Among special-purpose sites, expectations are: (1) discreteness in location and redundancy in use and assemblage content, (2) intersite variability dependent upon factors conditioning differential production of the sites, (3) limited activities and events with little accumulative effects, and (4) maintenance of functional integrity leading to better defined site "types" and within-type homogeneity (Binford 1978a:486-492, 1982:16-21). This last point is related to similar effects produced by reducing residential mobility and increasing the degree of logistical organization.

> The overall effect of reduced residential mobility among logistically organized hunters and gatherers, from the standpoint of patterning, would be an archaeological record characterized by better defined "types" of sites giving the appearance of greater specialization in functions, when in

> fact all that may have gone on is that the same activities were increasingly located in the same places (Binford 1982: 21).

The complexity of the interrelationships among assemblage grain, assemblage content, site function, settlement system organization, seasonality, and mobility patterns is evident. This complexity leads to some difficulty in understanding interassemblage variability. However, it is recognized that three basic activity dimensions condition the magnitude and character of intersite variability: (1) the degree of activity differentiation seasonally indicative of an adaptation, (2) the degree of residential mobility, and (3) the degree of logistical organization (Binford 1978a:487). Patterning in assemblage content derived from the first two dimensions is graded and seriational and related to seasonality. The third dimension results in categorical assemblage types with little gradation. This variability derives from situational conditions and particular strategies.

Despite the numerous inferences that have been cited concerning the interpretation of intersite variability, it is acknowledged that temporal change in assemblage content may not always measure culture change. Chronological interassemblage content change may not reflect changes in system organization, but rather system positioning within the region and annual range changes (Binford 1983a:46-47). Therefore, interassemblage variability may not measure culture change, but only repositioning of the extant system in space. This caveat aside, test implications derived from this discussion and their implementation are outlined below.

Test Implications

Late Archaic lithic assemblages from the central Duck River Basin are expected to reflect greater logistical organization than Middle Archaic assemblages. Viewing this expectation from the perspective of interassemblage variability, greater heterogeneity is expected between Late Archaic assemblages. If Late Archaic groups are more logistically organized, then it is anticipated that they produce better defined categorical types of sites. Some of these site types are expected to yield fine-grained assemblages characteristic of special-purpose locations which were used in a logistical manner. Assemblages from logistically used sites are expected to represent short trajectory segments with low diversity. Measures of lithic assemblage trajectory length and diversity have been successfully employed by others (Raab et al. 1979; Johnson 1981a, 1981b, 1982; Jefferies 1982a; Tippitt and Marquardt 1982).

Middle Archaic assemblages in the central Duck River Basin are suggested to exhibit greater interassemblage homogeneity. Site types are expected to be poorly defined and characterized by coarse-grained assemblages. Long trajectory segments and high assemblage diversity are are anticipated to be typical. Although this may suggest residential/maintenance site functions, it may also indicate a low degree of logistical organization and an expedient technological strategy. Variability among assemblages is expected to be graded rather than categorical.

Three basic dimensions are considered regarding the assessment of interassemblage variability. These are technological/morphological

artifact type, cortex type, and chert type variability. Artifact types are derived from Amick (1982). Variability within entire assemblages as well as debitage populations is investigated. Cortex type variability is considered for all debitage, biface thinning flakes, and Fort Payne debitage. Chert type variability is examined among all debitage, biface thinning flakes, and bifaces. Emphasis is placed upon debitage populations and biface manufacturing processes and products. A series of descriptive and association statistics are computed for each dimension of the assemblages considered.

Redesigning the Hypothesis Testing Methods

The expansion of the model to accommodate seven assemblages requires revision of the hypothesis testing methods. At the first stage of model testing, only the two Clay Mine (40MU347) assemblages were used. This greatly simplified comparisons and 2 x 2 contingency tables were easily adapted to the task. Classification of the lithic assemblages was based on a nominal system of particular discrete attribute states for a number of variables which were recorded for each artifact. Variables included chert type, cortex type, thermal alteration evidence, and technological-morphological characters. This technique has been described elsewhere (Amick 1982, cf. Hofman and Turner 1979).

Emphasis on nominal scaling and the measurement of truly discrete phenomena yields the most elementary information contained by a data set. These are basic facts that can be sorted into categories. Despite the fundamental nature of nominal scale data, analytical problems arise

as the dimensionality or number of variables of the cross-classification increases. In addition to multidimensionality, the variability in numbers and types of discrete attribute states can lead to contingency table problems. These statistical analysis difficulties notwithstanding, it is emphasized that nominal scale measurements reflect the fundamental aspects of lithic assemblages. However, increasing the number of assemblages at later stages of modeling may require quantitative scale measurements in order to facilitate multiple interassemblage comparisons.

The hypothesis testing strategy employed at this stage of modeling is similar to that used during the Clay Mine (40MU347) test. The strategy is based upon testing idiographic hypotheses about phenomenological differences in subpopulations. Cowgill (1975a:260-263) provides an excellent discussion on testing idiographic hypotheses. Like the Clay Mine test, the seven assemblage test is based upon a strategy of multiple statistical tests that ask closely related questions of the same sample. As Cowgill (1975a:270) has noted, this is not analogous to figuring associations between different variables, and although the statistical tests are different, they yield highly correlated results. Particular problems may arise by this strategy:

> Put more carefully, the question goes like this: 'If we compute 3 different statistics intended to ask substantially the same question of a specific sample, and 2 of them give results that are not highly significant while the 3rd is highly significant, what can we conclude (Cowgill 1975a:270)?'

This is one of the basic problems with tests of significance rather than estimation of population parameters. Idiographic inferences about a

subpopulation may be more parsimoniously consistent with an alternative theory. As Cowgill (1975a:270-271) phrases this,

> results that were consistent with the hypothesis of no differences between subpopulations might also be consistent with the alternative hypothesis of substantial differences. That is, the computations that do not yield high significances may not be in conflict with those that do give significance; they may simply be inconclusive.

However, not all test statistics are equally appropriate to the hypothesis. Different statistics ask different questions of a specific sample. Conclusions are based on the appropriateness of each test rather than a probability proposition of the frequency of significant results. Nonetheless, asking a few variants of the same basic questions leads to convincing results regarding the testing of idiographic hypotheses.

The purely logical approach of the "fallacy of affirming the consequent" is maintained. Blalock (1972:112-114) notes that by this logic one eliminates theories rather than establishes them and that good theory resists elimination. Although alternative theories and hypotheses could be constructed to account for the phenomena observed in this study, it is suggested that the proposed theories and hypotheses should be considered the best explanations until disproven. An attempt to model all alternative theories is simply beyond the capabilities of this study.

Due to the nature of nominal scale measurement, the test implications must rely on discrete attribute frequency information. Emphasis is placed on the discrete categories of chert types, cortex types, debitage, biface thinning flakes, bifaces, and the cross-

classifications of these categories. As such, the assemblages are compared along several discrete category dimensions. Assemblage comparisons are made both within and between these dimensions. Several approaches are considered for each test implication. These approaches involve the use of relative frequencies, similarity coefficients, diversity statistics, and independence tests. Both tabular and graphic presentations are enlisted in these efforts. A description of the approaches and their techniques follows.

Relative Frequencies

In the course of comparing the seven assemblages by discrete nominal scale attributes, initial work focused on the inspection of cross-classification tables. These tables are the sources of raw data from which subsequent statistical manipulation proceeded. All tables present raw counts of the data as well as relative frequencies. Relative frequencies or proportions are given to standardize sample size and facilitate comparisons. Since comparison of the assemblages is the objective, standardization controls for assemblage size and proportions are computed across the tables.

Recently, Cannon (1983:788-790) has indicated serious flaws regarding the use of proportions to quantify archaeological assemblages. Comprehending the relationship between the subject of inference and both aspects of the proportion is particularly important. Understanding the denominator and its effects on the proportion is especially critical (Blalock 1972:33; Cannon 1983:790). Despite the numerous caveats issued by Cannon concerning potential abuse of relative frequencies, they are

considered essential to interpreting large cross-classification tables of raw counts. Cannon's (1983:789) primary objections concern the unstable relationship between proportions of subpopulations illustrating dichotomous (presence/absence) attributes and the corresponding presence of particular activities assumed to be indicated by the presence of these attributes. Cannon's evaluation of proportions as a quantitative measure is marred by methodological problems associated with the dichotomous attribute data and deducing general conclusions from a highly specific inference built upon untenable assumptions regarding the relationship between artifacts and activities. If implications are made between artifact or artifact attribute proportions and specific activities, the nature of the implications need to be explicit. In addition, it is recognized that sampling method and size can result in serious bias (Cannon 1983:791).

It is stressed here that relative frequencies are extremely helpful for investigating patterning within cross-classification tables. The value of proportions is primarily as an aid to illustration rather than an interpretive tool. In this sense, it simplifies the inspection of large matrices. As a further aid to illustration, cumulative and triangular coordinates graphs based on proportions are given in certain cases.

Cumulative graphs. The use of cumulative graphs to compare archaeological assemblages was pioneered by Bordes (1950, 1952) over thirty years ago. Although Bordes' work focused upon isolating prehistoric ethnic groups on the basis of lithic assemblage graphs,

other applications, such as, chronological seriation (Jelinek 1962) have been devised. Despite the popularity of lithic assemblage comparison by cumulative graphs, particularly among the "Bordeaux group" (Bordes 1968: 27-31), the use of cumulative graphs has not been without its critics (e.g., Kerrich and Clarke 1967; Thomas 1971).

The primary objections to cumulative graph use concern percentage errors and ordering errors. Kerrich and Clarke (1967:59-60) note that since samples with different sizes are compared on the same graph, they are standardized by percentage conversion and scaled as equivalent in size. This problem may be mitigated by including a table of raw counts to accompany the graph (Doran and Hodson 1975:121). As noted above, raw count/assemblage proportion tables are constructed as an initial analytical step and cumulative graphs are included as a simple presentation device. The second problem of cumulative graphs is due to ordering along the abscissa. Cumulative graphs are intended for use with quantitatively scaled data. The use of discrete nominal data requires ordering these data along the abscissa. Kerrich and Clarke (1967:60-66) suggest that the arrangement of these data is often arbitrary. Further ordering problems have been noted by Thomas (1971:206-207):

> A high loading on any variable . . . can cause undue dissimilarity throughout the remainder of the curve. Furthermore, a reordering of variables on the abscissa produces variform curves . . . . In short, cumulative curves treat nominal data as if they were ordinal. They are not.

Regarding the case of lithic assemblages, Collins (1974:111) proposes that debitage categories "are not strictly ordinal, but arranged in a progressive order determined by the model and by the

physical nature of stone chipping as a reductive technology" and appropriate for cumulative graph use. As Doran and Hodson (1975:116) have observed, "the need to impose order on the categories where none may be justified is irritating but unavoidable." The ordering of qualitative attributes may be arbitrary, but not necessarily illogical. Two sets of variables are ordered in the analyses presented here. The first considers all artifact types and is arranged in a quasi-reduction sequence manner. The second form involves ordering chert types. These are simply arranged by decreasing source formation age. It is recalled that a general correspondence exists between decreasing formation age and increasing radial distance from the central Duck River Basin. The variables employed in these graphs are not precisely ordinal, but arrangement is made in a logical manner. The many advantages of cumulative graph use prevail over percentage and ordering criticisms.

One of the better summaries of the use, misuse, advantages, and disadvantages of cumulative graphs has been presented by Doran and Hodson (1975:116-124). The overwhelming advantage is that "more than one set of bar charts may be co-ordinated on one diagram and compared" (Doran and Hodson 1975:116). The general problem to be solved by cumulative graphs is that complex bar charts from several contexts must be illustrated on one diagram while conveying as much information as possible. Doran and Hodson (1975:120) find the only intractable disadvantage in cumulative graph use to be the "disproportionate visual effect of differences between counts at the beginning and the end of the cumulative sequence." Numerous advantages in cumulative graph use include:

(1) allowing inter- and intra-assemblage comparisons simultaneously;

(2) greater clarity than alternative frequency polygon methods by reduction in the degree of overlap;

(3) recording direct percentages of several categories;

(4) providing general summary profiles for category counts; and

(5) allowing presentation of many assemblages in a single graph (Doran and Hodson 1975:117-121).

The use of cumulative graphs as a method of initial data presentation and heuristic summary device rather than an interpretive tool is stressed here and considered to be justified with caveats and criticisms acknowledged.

Triangular coordinates graphs. Two of the variables under study have three attribute states each. These are debitage and cortex classifications. Since an equilateral triangle is formed by three equal lines, these may be taken to represent percentage scales for each discrete attribute state. A unique coordinate is represented by the intersection of the three attribute percentages. This point is located within the triangular space for each assemblage and illustrates the relative relationships of the assemblages for a particular variable.

Similarity Coefficients

The large relative frequency tables make comparison of any two assemblages difficult. It is apparent that expressing the total similarity of a pair of assemblages with a single number is desirable. Fortunately, a method of obtaining such a "similarity coefficient" from

nominal attributes has been devised by Robinson (1951). Doran and Hodson (1975:139) refer to this as the "Robinson coefficient of agreement" and note that it is a special case of the city block metric. Summed absolute differences rather than the Euclidean approach of squared differences between scores are used. This reduces the Euclidean measure effect of large differences being emphasized at the expense of small differences. The method of calculating similarity coefficients has been most clearly described by Spaulding (1960b:81-82). For each pair of assemblages, the difference between the nominal attribute percentages is determined. These differences are summed and subtracted from 200. The resulting score ranges from 0 (total dissimilarity) to 200 (identity). Doran and Hodson (1975:139) have summarized the properties of the similarity coefficient, noting that:

> it effectively totals the percentage differences between defined categories (types) for pairs of archaeological assemblages. In this form these differences would conform with the rules for metric distance even if they are clearly not Pythagorean. The maximal difference between any two units is 200 percent. By subtracting any calculated distance from 200 an equivalent measure of similarity or agreement is achieved . . .

Robinson's (1951) ultimate goals focused on the matrix-ordering of similarity coefficients in chronological seriation. However, as Spaulding (1960b:81) has noted, the systematic arrangement of similarity coefficient matrices should only be attempted if differences between one assemblage and another are the product of a single dominant and constant factor. Although matrix-ordering is the ultimate goal of most similarity coefficient calculations, it is not appropriate to this study. Chronological ordering of the assemblages is not the objective

and assemblage differences are certainly the result of multivariate causes. Nonetheless, the ability to express the relationship between any two assemblages along a particular discrete attribute dimension is very useful to this analysis.

Diversity Statistics

The use of diversity statistics was introduced in the previous chapter on the Clay Mine (40MU347) assemblages. Diversity statistics provide a relative estimate of the degree of variability within an assemblage and the probable cause of this variability. As noted before, Pielou (1975) presents an excellent discussion on various diversity measures and their calculation. The Shannon-Wiener index is employed in this study. This measure considers two variables, diversity and equitability. Diversity is based upon the number of types present. Equitability or evenness is based upon the distribution of types that are present. Therefore, evenness is a complementary function of diversity. Plots of diversity and evenness are given for all tabular forms of these statistics. These graphs illustrate the relative distance between assemblages along these dimensions. The relationship of evenness as a function of diversity is also apparent in these graphs.

Johnson (1981a:77) has recently remarked on the value and increasing popularity of diversity calculations in archaeological analysis. Although Cannon (1983:786) considered diversity as simply the number of artifact types present in an assemblage, he found this measure to be a more reliable predictor of activity than proportions or absolute frequencies. Diversity has the advantage of standardizing sample

samples (like proportions), but the relationship with an activity is not subject to effects of uncontrolled relationships with other variables. As Cannon (1983:791) states,

> the diversity of artifact types present in an assemblage is most directly and consistently a function of the presence or absence of specialized activities in the unit of analysis . . . The rationale behind this measure's relationship with the presence or absence of an associated behavior mode is direct, and assemblage diversity is not so encumbered by the effects of extraneous factors or unjustified assumptions as are the other measures.

Tests of Independence

At this point, the measures employed are all descriptive. They are capable of suggesting differences and similarities among the assemblages, however, it is desirable to be able to make statements based upon statistical probability about the relationships of the assemblages. Considering the nominal scale of data measurement and high level of association among some attributes (e.g., cortex type and flake type), a series of independence tests is suggested to be most appropriate. Unfortunately, with seven assemblages expressing a variety of attribute distributions, interpretability of which differences may be statistically significant is difficult. Recalling from the previous chapter, the G-test is preferred to the chi-square test. In addition, both of these test statistics possess an additive property. That is,

> the results of several G-tests can be assumed to yield meaningful results. Similarly, overall G-tests can be partitioned into separate G-tests representing individual degrees of freedom in a manner analogous to that practiced in anova (Sokal and Rohlf 1969:550).

Goodman (1969) discusses the theory and methods of cross-classification table partitioning. The use of this procedure is relatively recent to

archaeology; Simek and Leslie (1983) have reported a chi-square partitioning method concerning lithic raw material utilization patterns.

The procedure of partitioning G-statistics employed in this analysis is derived from Sokal and Rohlf (1969:598-601). These are referred to as R x C tests of independence; R and C represent the number of rows and columns in the contingency table. The number of rows is always seven, the number of assemblages. The number of columns varies according to the number of attribute states represented. Sokal and Rohlf (1969:703-704, 732-741) have provided a Fortran IV computer program which computes an overall G-statistic. In addition, the program partitions the G-statistic by rows through an posteriori simultaneous test procedure. This procedure produces a listing of the maximally nonsignificant subsets and their G-statistics. The subset elements represent groups of assemblages which are not significantly different at a specified level of confidence. Input parameters for the program consist of the overall R x C critical G-statistic, alpha level, R and C, and the raw count data in matrix form. This program is becoming somewhat archaic, but with a few modifications it is easily adapted to today's WATFIV compilers and well worth resurrecting for those faced with large contingency table analysis.

Although the R x C G-test provides a means of determining maximally nonsignificant subsets, understanding the relative relationships of several subsets and members is difficult. For this reason, a graphic aid was devised. A circle with seven equidistant partitions is used to illustrate the overall set. Each partition mark represents an assemblage; the assemblages are arranged by chronological order in a

clockwise fashion beginning at the twelve o'clock position. If an assemblage is included in a subset, a line is drawn between each member of the subset. Many lines on the circle graph indicate a great deal of similarity among the assemblages for a particular variable. Few lines indicate little similarity. Assemblages which exhibit few connecting lines are different from the other assemblages. The more connecting lines between assemblages, the greater degree of similarity is expressed. The use of circle graphs is helpful when there are many subsets or many members resulting from the partitioning.

The G-test methods described for the seven assemblage comparison differ from the two assemblage Clay Mine test in a few additional ways. First, due to the nature of the simultaneous test procedure which partitions the R x C G-tests, analysis must be considered a posteriori rather than the inductive hypothesis testing a priori methods. The analysis is weakened by this post hoc approach, but it is felt that clearer patterns of variability emerge since testing does not rely on specific contrasts. Second, the confidence level was raised to 99% (alpha lowered to .01) for all tests. This change is a conservative effort to test the hypotheses in a more stringent manner. Initially, attempts were made to reduce the risk of type II error, failing to reject an hypothesis when it is actually false. If a difference was present between the Clay Mine assemblages, an attempt was made to detect it. In the seven assemblage test, attempts are made to reduce the risk of type I error, rejecting a true hypothesis. If a difference is actually present, attempts are made to insure that it is real. Finally, the collapsing of tables is found to be useful in the seven assemblage

test because of low expected frequencies and sampling zeros. In all cases where tables are collapsed (along the column dimension), efforts are made to retain meaningful categories. Yarnold's rule (1970:865) regarding expected frequency size is used: "If the number of classes s is three or more, and if r denotes the number of expectations less than five, then the minimum expectation may be as small as 5r/s." However, it is required that at least 80% of the expectations be larger than 5r/s. If more than 20% of the expectations are less than this minimum requirement, the table is collapsed.

Interassemblage Variability: Seven Assemblages

This section represents the analysis results. Description of individual graphs and tables is given. Synthesis of the individual test results is provided in the following section. This synthesis integrates various measures of interassemblage variability provided here and assesses how well the data fit the hypotheses. Overall patterning is stressed.

Technological/Morphological Artifact Type Variability

Total assemblages. Table D.1 (Appendix D) lists the counts and proportions of the various artifact classes represented within each assemblage. The data from this table are summarized in a cumulative graph (Figure 6.7). This graph illustrates several relationships among the assemblages. Variability in fire-cracked rock frequency is perhaps greater than any other artifact class, ranging from 3.75% (n = 17, Clay Mine-Area 1) to 20.91% (n = 679, Topsy). Temporal patterning is not

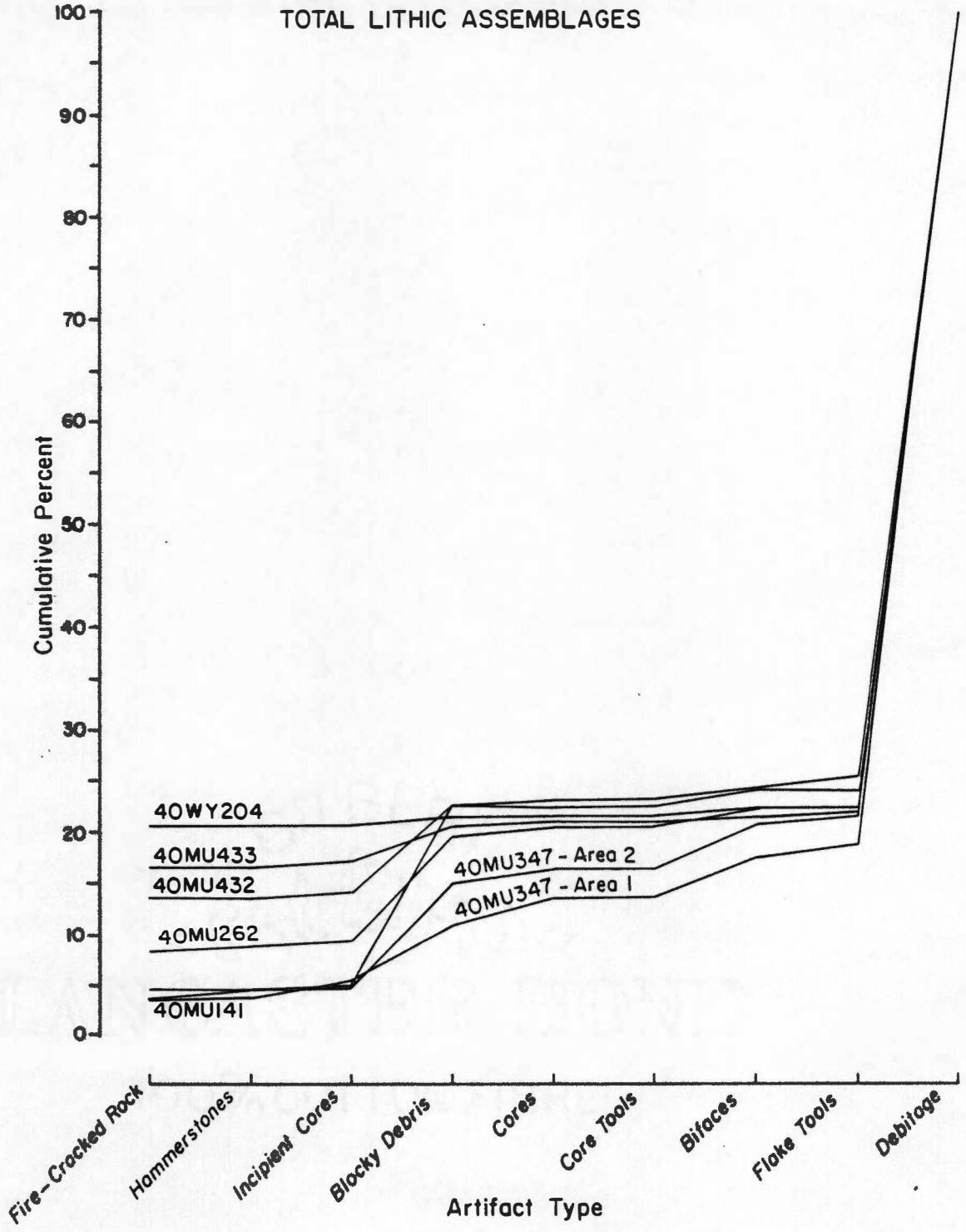

Figure 6.7. Cumulative graph of assemblage artifact type frequencies.

apparent. This is not too surprising and the technological significance of non-chipped fire-cracked rock fragments remains obscure at any rate. A second feature which is apparent from Table D.1 (Appendix D) and Figure 6.7 is the high proportion of blocky debris (17.55%, n = 1331) at Cave Spring. This contrasts with the low proportions at the Topsy (0.46%, n = 15) and Bench (3.59%, n = 59) Sites. Blocky debris is an early product in the lithic reduction sequence and is particularly associated with Ridley chert exploitation. Topsy and the Bench are the only sites in this study that are not located on the Ridley Formation. This seems to suggest that blocky debris is a technological/morphological by-product which is characteristic of Ridley chert reduction strategies. Another point illustrated by Figure 6.7 is the slightly higher proportion of bifaces (including fragments) within the two Clay Mine assemblages. However, it should be noted that the Late Archaic bifaces at the Clay Mine are typically intermediate finished forms, while the Middle Archaic bifaces exhibit early stage forms and very late stage forms. Despite these slight differences, the frequencies and graph indicate very little incongruence among the assemblages. Variability between debitage proportions is particularly low. General frequency profiles show very little differences among the assemblages by artifact types.

A matrix of similarity coefficients is presented in Table 6.1. Inspection of the matrix reveals the uniformity of the assemblages by artifact types. Scores range from 163 to 191, a relatively small distance. Topsy and Bench show the greatest similarity (191) along with

Table 6.1. Similarity matrix of artifact type assemblage variability.

	Topsy (40WY204)	Clay Mine-Area 2 (40MU347)	Leftwich (40MU262)	Clay Mine-Area 1 (40MU347)	Cedar Creek (40MU432)	Cave Spring (40MU141)	Bench (40MU433)
Topsy (40WY204)	200						
Clay Mine - Area 2 (40MU347)	166	200					
Leftwich (40MU262)	174	190	200				
Clay Mine - Area 1 (40MU347)	166	190	180	200			
Cedar Creek (40MU432)	177	179	185	174	200		
Cave Spring (40MU141)	163	184	187	175	177	200	
Bench (40MU433)	191	175	181	175	185	171	200

Clay Mine-Area 2 and Leftwich and Clay Mine-Area 1 (190). Topsy and Cave Spring exhibit the greatest dissimilarity (163).

Diversity statistics are presented in Table D.2 (Appendix D). These figures are based on the chipped-stone categories only (fire-cracked rock omitted). Since evenness is a function of diversity, these values are presented in a scatter diagram (Figure 6.8). The linear trend apparent in the graph documents the dependent relationship of evenness with diversity. Figure 6.8 illustrates three assemblage clusters. In order of increasing diversity and evenness, these are: (1) Topsy; (2) Bench, Cave Spring, Leftwich; and (3) Clay Mine-Area 2, Clay Mine-Area 1, Cedar Creek. Overall, the graph shows general dissimilarity of the Topsy assemblage with the more diverse and evenly distributed central Duck River Basin assemblages.

The results of an R x C G-test are presented in Table D.3 (Appendix D). These maximally nonsignificant groups are listed in ascending order of association strength. The two Clay Mine assemblages clearly exhibit the strongest association. Figure 6.9 illustrates the relationships of nonsignificant subsets. Topsy and Cave Spring appear quite dissimilar to the other assemblages since no subset member lines contact them. A great deal of similarity is noted between Cedar Creek, Leftwich, and the two Clay Mine assemblages. Topsy and the Bench are probably distinct by a lack of diversity among artifact types. Cave Spring is more likely distinct due to a high frequency of blocky debris.

Debitage assemblages. Two debitage classifications are employed in the debitage type comparisons. The first method is a ten-way

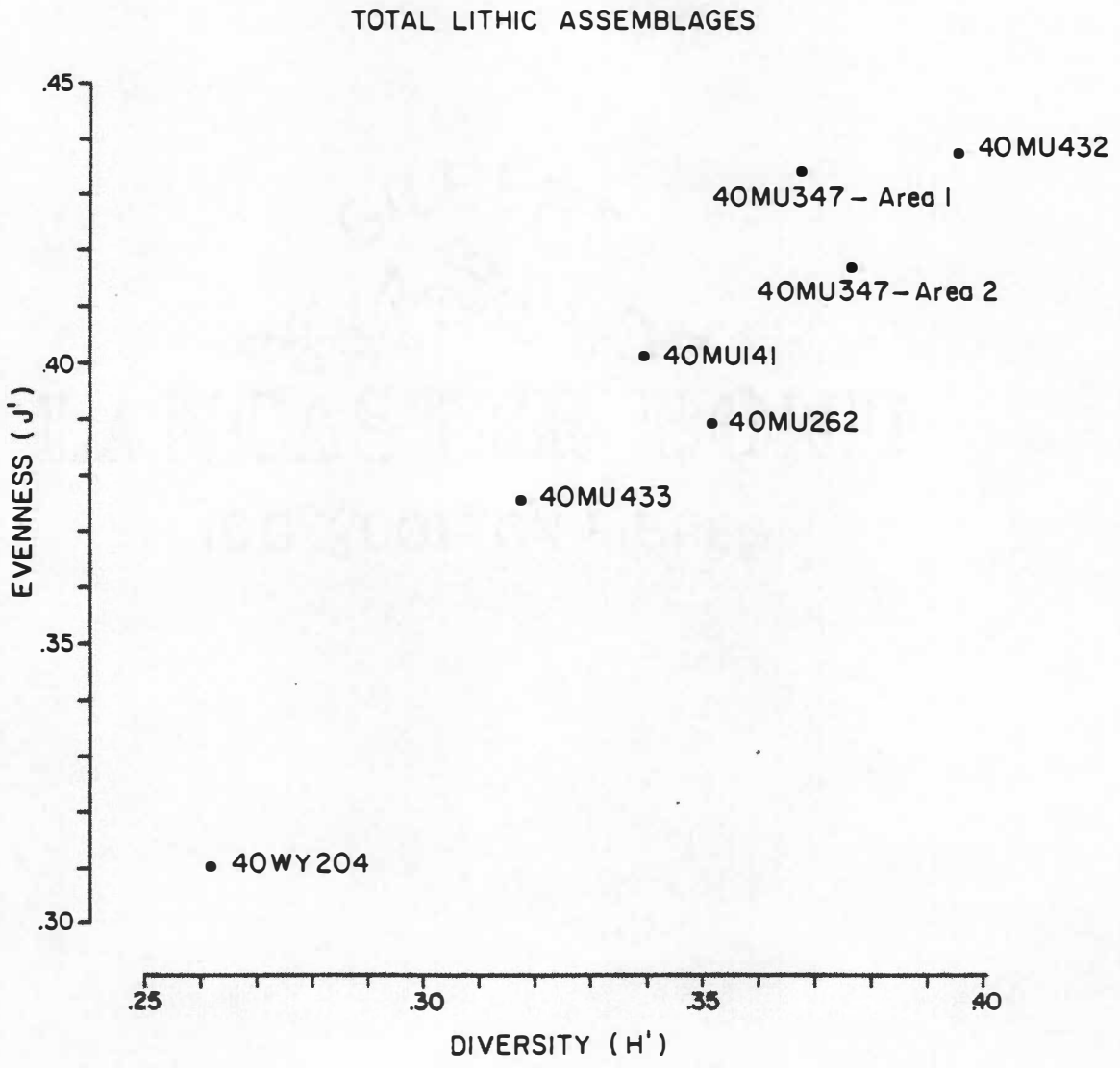

Figure 6.8. Plot of evenness and diversity for assemblage artifact type variability.

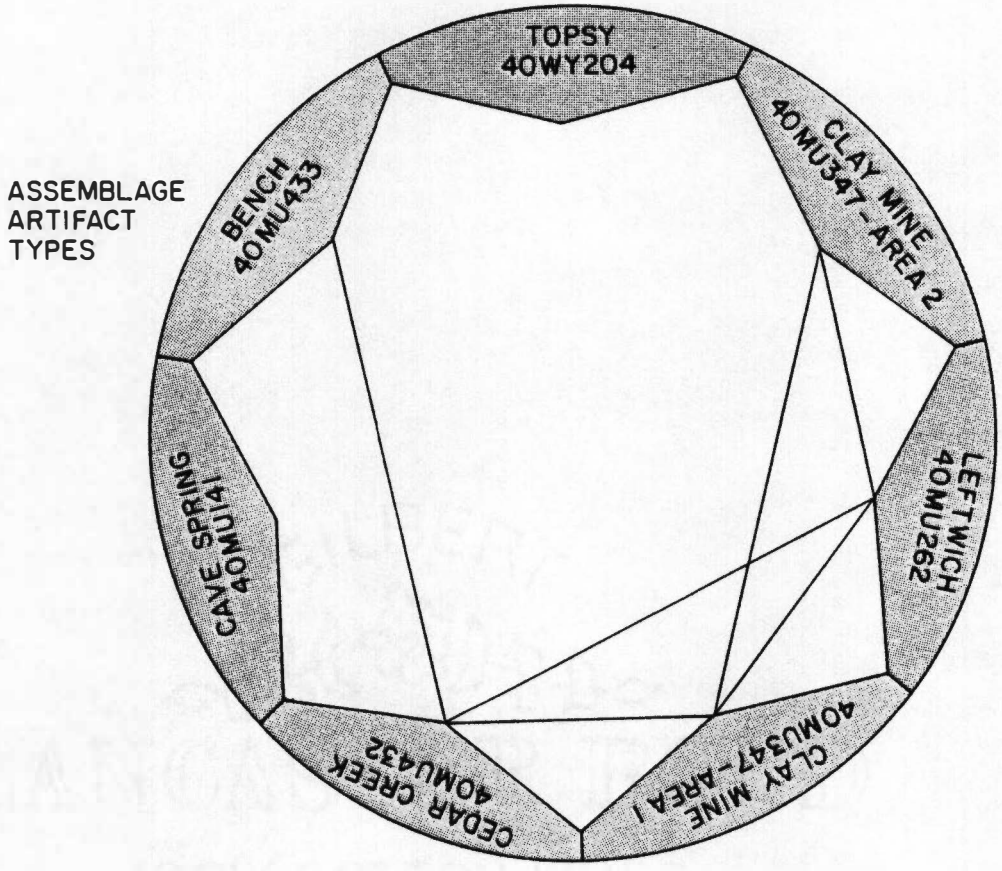

Figure 6.9. Circle graph of assemblage artifact type similarity.

classification based on categories described by Hofman and Turner (1979). The second method is a three-way classification which results from collapsing the ten category scheme. Combining categories in a three-way classification is intended to minimize insignificant "noise" within the ten-way classification. This is discussed further following the ten-way analysis results.

Table D.4 (Appendix D) presents the basic frequency data generated from the ten-way classification. A matrix of similarity coefficients derived from the frequency data is presented in Table 6.2. Scores in the matrix range from 105 to 183. Cedar Creek and the Bench show the greatest similarity (183) while Topsy and Clay Mine-Area 1 show the least similarity (105). Differences between Topsy and Clay Mine-Area 1 are indicated to be the high frequency of decortication (especially secondary) debris within the Clay Mine-Area 1 assemblage compared to the high frequency of bifacial thinning (especially small) debris within the Topsy assemblage. The similarity between the Bench and Cedar Creek assemblages appears to be due to the high frequency of non-platform non-cortex bearing (broken) flakes in both assemblages.

Diversity statistics are presented in Table D.5 (Appendix D). A plot of these values is shown in Figure 6.10. This figure shows that the Clay Mine-Area 1 assemblage is relatively distinct because of low diversity and evenness in the ten-way debitage classification comparisons. The other assemblages show greater variability along the evenness dimension than by diversity.

Table 6.3 presents the maximally nonsignificant subsets resulting from a R x C G-test of the ten-way classification. The ten-way

Table 6.2. Similarity matrix of the ten-way debitage classification.

	Topsy (40WY204)	Clay Mine-Area 2 (40MU347)	Leftwich (40MU262)	Clay Mine-Area 1 (40MU347)	Cedar Creek (40MU432)	Cave Spring (40MU141)	Bench (40MU433)
Topsy (40WY204)	200						
Clay Mine - Area 2 (40MU347)	144	200					
Leftwich (40MU262)	153	151	200				
Clay Mine - Area 1 (40MU347)	105	128	137	200			
Cedar Creek (40MU432)	151	140	153	125	200		
Cave Spring (40MU141)	118	124	164	150	145	200	
Bench (40MU433)	167	151	159	118	183	140	200

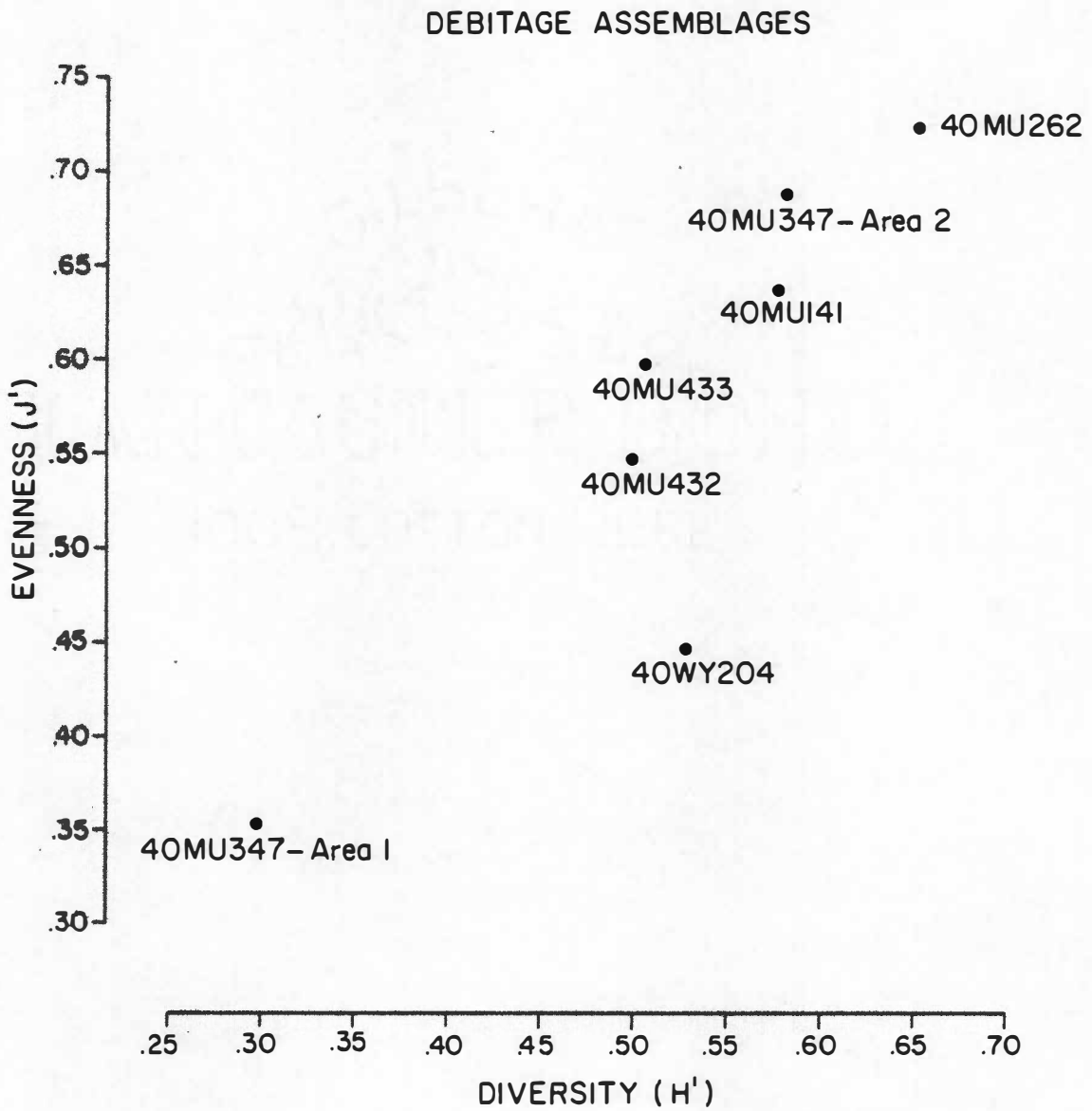

Figure 6.10. Plot of evenness and diversity for ten-way debitage classification variability.

Table 6.3. Maximally nonsignificant subsets of R x C G-test for seven-way debitage variability.[a]

Subset Members	G-Statistic
Cedar Creek (40MU432) Bench (40MU433)	30.48

[a] G-statistic for entire set = 2796.45
Critical G-statistic = 58.6
df = 36, alpha = .01

classification produced over 27% low cells, so the categories were collapsed to seven classes. Following methods presented by Yarnold (1970) and common sense regarding debitage types, these groups are: (1) primary decortication, (2) secondary decortication, (3) tertiary, (4) large biface thinning, (5) small biface thinning, (6) broken, and (7) other. The last category represents a collection of low frequency and enigmatic flake types. A subset containing Cedar Creek and Bench results. The similar high frequency of broken flakes in these assemblages appears to be the basis of their strong association.

Although the ten-way classification perceived some differences and similarities among the debitage assemblages, the large number of categories with low frequencies may have obscured significant patterning. In addition, the technological placement of numerous debitage categories into a reduction trajectory becomes unnecessarily complicated. For these reasons, a three-way classification scheme is attempted. In order of trajectory placement, these categories are: (1) primary decortication-initial reduction, (2) secondary decortication-core reduction/trimming, and (3) bifacial reduction/thinning. The first category includes all flakes with cortex present on the dorsal surface and without platform lipping (primary and secondary decortication in the ten-way scheme). This obviously represents early stage reduction within the trajectory. The bifacial reduction/thinning category obviously includes the biface thinning flake (lipped platform) groups of the ten-way grouping and represents the later stages of the reduction trajectory. The second category includes six flake types from the ten-way classification. This category is

considered to represent intermediate reduction stages, but is less exact in trajectory placement than the categories which bracket it. In order to strengthen the end points of the trajectory continuum, the middle category contains the flake types which are more difficult to place within the trajectory.

Table D.6 (Appendix D) presents the collapsed frequency data for the three-way debitage classification. These data are illustrated by a triangular coordinates graph in Figure 6.11. Clustering toward the lower left-hand corner indicates a relatively high frequency of intermediate stage reduction in all assemblages. The Clay Mine-Area 1 assemblage shows a high frequency of early reduction stage debris. Topsy and Clay Mine-Area 2 are characterized by relatively higher frequencies of bifacial thinning flakes than the other assemblages which typically exhibit high secondary decortication-core preparation/trimming flake frequencies. This suggests later stage reduction at Topsy and Clay Mine-Area 2. The intermediately positioned Cave Spring, Cedar Creek, Bench, and Leftwich assemblages may suggest longer trajectory segments than the early stage Clay Mine-Area 1 and late stage Topsy and Clay Mine-Area 2 assemblages.

A matrix of similarity coefficients based on the three-way frequency data is presented in Table 6.4. Scores range from 190 to 128. Topsy and Clay Mine-Area 2 are the most similar (190). An R x C G-test of the three-way classification produced a single maximally nonsignificant subset. This subset is presented in Table D.7 (Appendix D) and contains the Topsy and Clay Mine-Area 2 assemblages. This result is consistent with similarity coefficient calculations and apparently

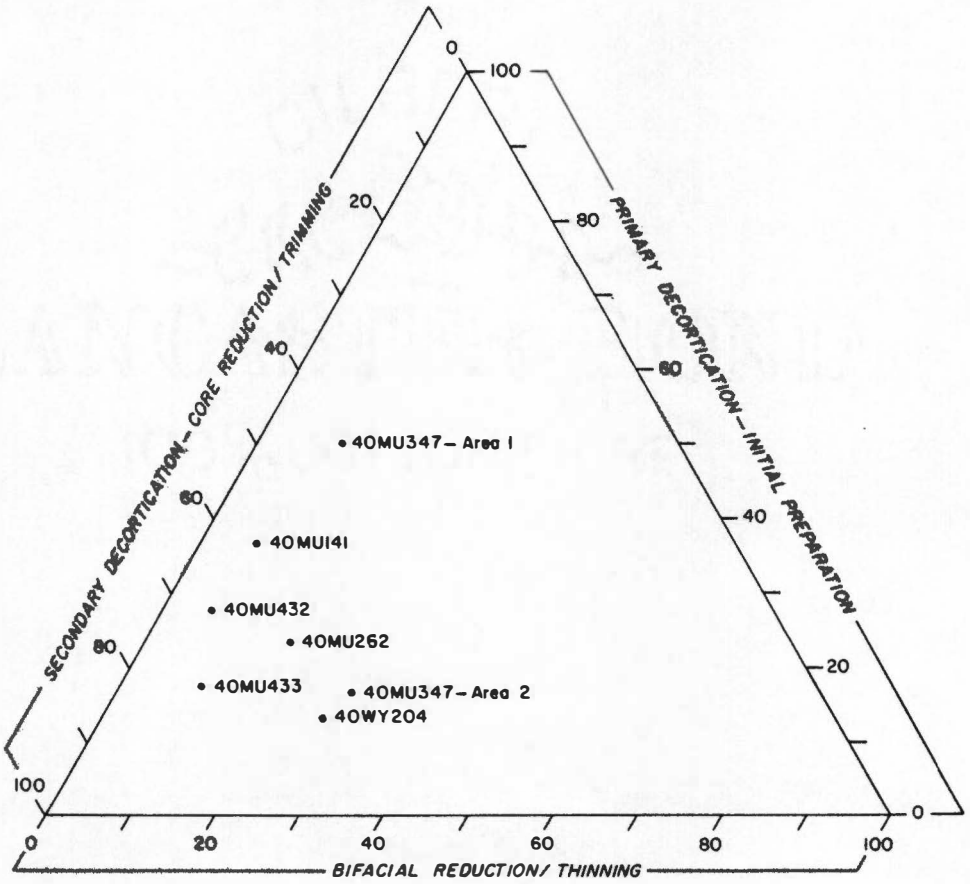

Figure 6.11. Triangular coordinates graph of three-way debitage classification frequencies.

Table 6.4. Similarity matrix for three-way debitage classification.

	Topsy (40WY204)	Clay Mine-Area 2 (40MU347)	Leftwich (40MU262)	Clay Mine-Area 1 (40MU347)	Cedar Creek (40MU432)	Cave Spring (40MU141)	Bench (40MU433)
Topsy (40WY204)	200						
Clay Mine - Area 2 (40MU347)	190	200					
Leftwich (40MU262)	181	179	200				
Clay Mine - Area 2 (40MU347)	128	134	147	200			
Cedar Creek (40MU432)	160	156	177	147	200		
Cave Spring (40MU141)	155	158	174	166	181	200	
Bench (40MU433)	167	163	173	135	181	163	200

related to high frequencies of bifacial thinning flakes in these assemblages.

Cortex Type Variability

Total debitage. Cortex type frequencies for the seven debitage assemblages are presented in Table D.8 (Appendix D). Since there are three possible cortex classes, these data are illustrated by a triangular coordinates graph (Figure 6.12). Clustering in the lower right-hand corner indicates a general low frequency of cortex presence. The Clay Mine-Area 1 assemblage appears isolated from the other assemblages due to a relatively high frequency of pieces exhibiting waterworn cortex. Matrix/residual cortex presence is relatively low, particularly in the Topsy assemblage. This may be related to its Highland Rim location and reliance upon Fort Payne stream cobbles.

Table 6.5 presents a matrix of similarity coefficients based on the debitage cortex type frequencies. Scores range from 104 to 193. Two assemblage pairs are tied for greatest similarity (193), Clay Mine-Area 2 and Bench, and Cedar Creek and Cave Spring. The most dissimilar pair is Clay Mine-Area 1 and Clay Mine-Area 2 (104). In addition, Clay Mine-Area 1 is very dissimilar with Leftwich (107), Topsy (110), and Bench (110). The similarity of Clay Mine-Area 2 and Bench (193) appears to be related to a low frequency of waterworn cortex. Cedar Creek and Cave Spring derive close similarity (193) from a moderately even distribution across all cortex types. Cortex presence is quite frequent in these assemblages. The great dissimilarity between the two Clay Mine assemblages (104) appears to be due to the very high relative frequency

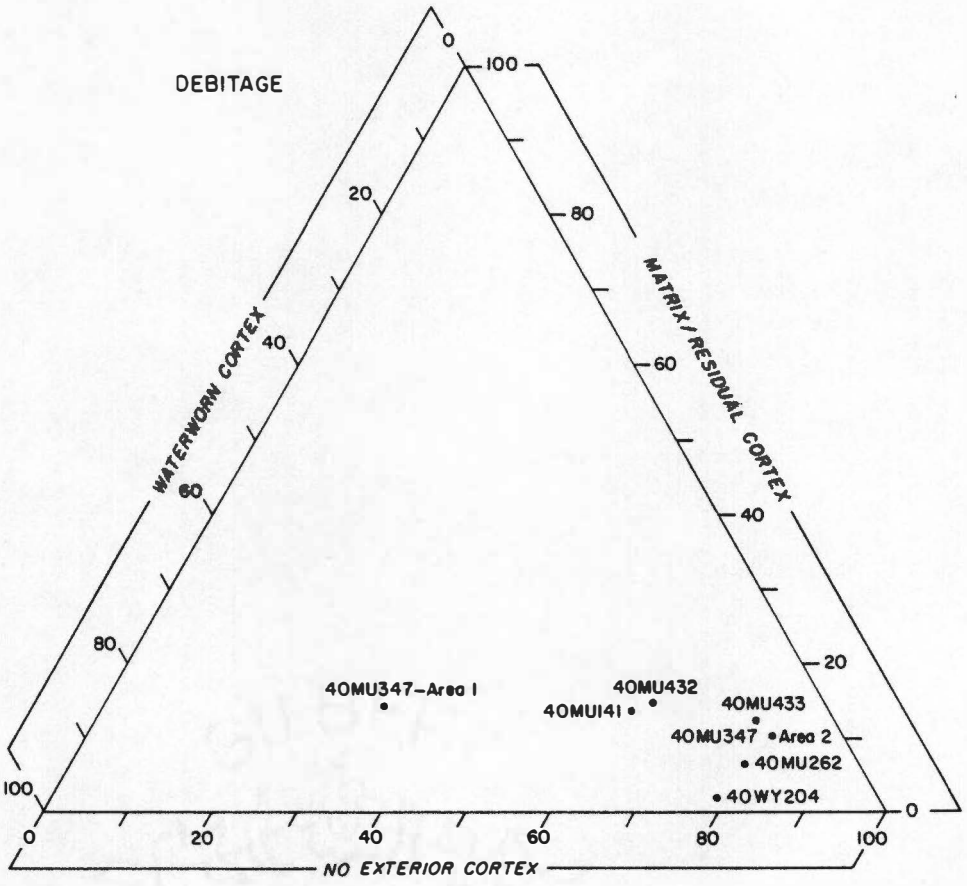

Figure 6.12. Triangular coordinates graph of debitage cortex type frequencies.

Table 6.5. Similarity matrix of debitage assemblage cortex type variability.

	Topsy (40WY204)	Clay Mine-Area 2 (40MU347)	Leftwich (40MU262)	Clay Mine-Area 1 (40MU347)	Cedar Creek (40MU432)	Cave Spring (40MU141)	Bench (40MU433)
Topsy (40WY204)	200						
Clay Mine - Area 2 (40MU347)	177	200					
Leftwich (40MU262)	188	190	200				
Clay Mine - Area 1 (40MU347)	110	104	107	200			
Cedar Creek (40MU432)	173	167	170	136	200		
Cave Spring (40MU141)	169	163	166	141	193	200	
Bench (40MU433)	179	193	188	110	173	169	200

of flakes exhibiting waterworn cortex in the Area 1 assemblage. High frequencies of cortex absence in the Leftwich, Topsy, and Bench assemblages result in analogous dissimilarities with Clay Mine-Area 1 frequencies.

An R x C G-test produced three maximally nonsignificant subsets (Table D.9, Appendix D). The relationship of these subsets is expressed in Figure 6.13. The Cedar Creek/Cave Spring and Clay Mine-Area 2/Bench pairs have been discussed in the similarity coefficient analysis. In addition, the Clay Mine-Area 2 and Leftwich assemblages show statistically significant similarities as expressed in Table D.9 (Appendix D). These similarities (similarity coefficient equals 190) appear to derive from high cortex absence frequencies and general evenness across all cortex type categories.

Biface thinning flakes. The consideration of biface thinning flakes is emphasized at this stage of model-building. It is recognized that these flakes may play a very important diagnostic role in interassemblage comparison. This recognition stems primarily from the emphasis on biface manufacture among Archaic period groups in the Midsouth. These flakes are suggested to be sensitive indicators of technological change. Table D.10 (Appendix D) presents cortex type frequencies for the seven biface thinning flake assemblages. Representing a late stage in the reduction trajectory, it is not surprising that most biface thinning flake assemblages show more than 90% cortex absence. The Clay Mine-Area 1 assemblage exhibits a serious

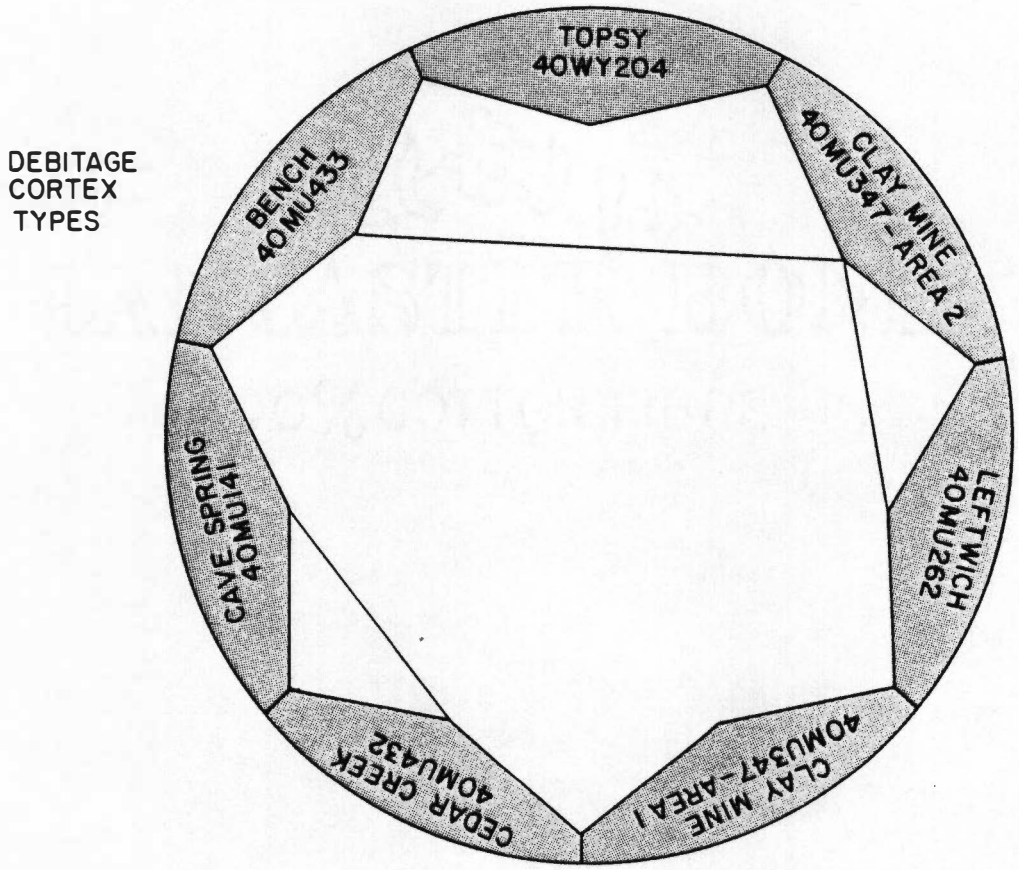

Figure 6.13. Circle graph of debitage cortex type similarity.

departure from this trend. Over 50% (n = 21) of this biface thinning flake assemblage exhibits waterworn cortex.

A similarity coefficient matrix helps to illustrate the situation (Table 6.6). The scores range from 87 to 196. However, the Clay Mine-Area 1 scores range from 87 to 105 while the remaining assemblage scores range from 179 to 196. This distribution of scores clearly indicates a striking dissimilarity of the Clay Mine-Area 1 assemblage to all others.

An R x C G-test was performed which produced seven large subsets (Table D.11, Appendix D). The resulting circle graph (Figure 6.14) illustrates the high interrelatedness of most of the assemblages. Conspicuously uninvolved in any nonsignificant subset is the Clay Mine-Area 1 assemblage. The Topsy assemblage exhibits some moderate dissimilarity from the other assemblages. This is probably due to the slightly high frequency (9.39%, n = 62) of waterworn cortex. Overall, these results tend to suggest that biface thinning flake cortex type is not an effective assemblage discriminator.

Fort Payne chert debitage. Following the analysis of the Clay Mine assemblages, it was suspected that cortex variability on Fort Payne chert debris might provide important insights on procurement organization. Since Fort Payne chert serves as the key lithic resource in Middle Tennessee, understanding Fort Payne procurement patterns is critical. Evidence of temporal change in procurement organization and lithic resource spectrums at the Clay Mine Site encourages a closer examination of these patterns. Isolating cortex variability for the key resource is an essential strategy. Table D.12 (Appendix D) lists

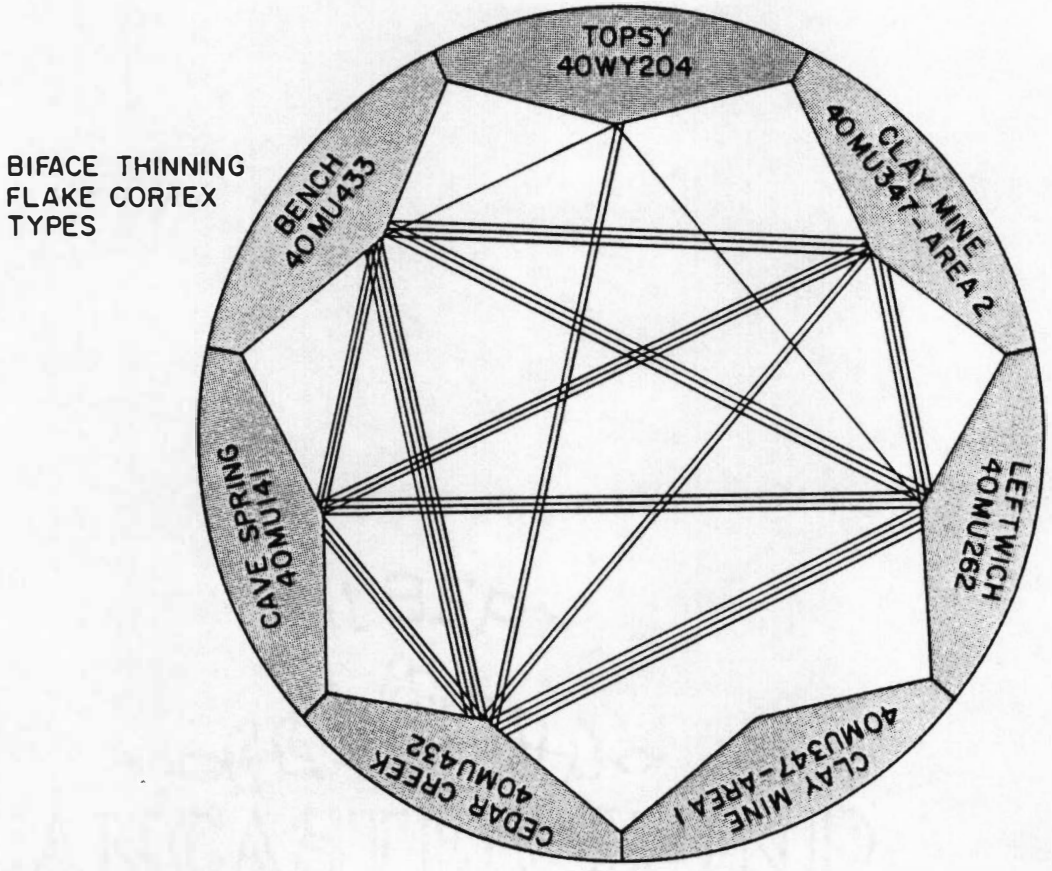

Figure 6.14. Circle graph of biface thinning flake cortex type similarity.

Table 6.6. Similarity matrix for biface thinning flake cortex type variability.

	Topsy (40WY204)	Clay Mine-Area 2 (40MU347)	Leftwich (40MU262)	Clay Mine-Area 1 (40MU347)	Cedar Creek (40MU432)	Cave Spring (40MU141)	Bench (40MU433)
Topsy (40WY204)	200						
Clay Mine - Area 2 (40MU347)	179	200					
Leftwich (40MU262)	185	194	200				
Clay Mine - Area 1 (40MU347)	105	87	92	200			
Cedar Creek (40MU432)	192	183	188	97	200		
Cave Spring (40MU141)	184	193	196	89	190	200	
Bench (40MU433)	186	190	194	91	193	196	200

frequency data for cortex variability of Fort Payne chert debitage among the seven assemblages. Proportional data is illustrated in triangular coordinates graph form in Figure 6.15. Clustering in the lower right-hand corner indicates generally low frequencies of cortex presence. The three Late Archaic assemblages (Topsy, Leftwich, Clay Mine-Area 2) exhibit the lowest cortex presence frequencies and are found in the extreme lower right-hand corner of the graph. The Middle Archaic assemblages are found to the left of this group. The primary source of variability appears to be the incidence of waterworn cortex; matrix/residual cortex frequencies are very low and show little interassemblage variability. The Clay Mine-Area 1 debitage assemblage is distinguished from the other assemblages by a Fort Payne chert-waterworn cortex frequency of over 60%.

A matrix of similarity coefficients is presented in Table 6.7. Scores range from 91 to 191. The greatest degree of similarity (191) is observed for two assemblage pairs: Cedar Creek and Bench, and Topsy and Leftwich. The Clay Mine assemblages exhibit the greatest dissimilarity (91). The Clay Mine-Area 1 assemblage also shows little similarity with the other Late Archaic assemblages, Topsy, (113) and Leftwich (104). The high frequency of waterworn cortex presence within the Clay Mine-Area 1 debitage assemblage is the most likely cause of this dissimilarity. In addition, the three Late Archaic assemblages exhibit the lowest incidence of Fort Payne debitage cortex presence.

Table D.13 (Appendix D) presents the maximally nonsignificant subsets resulting from an R x C G-test of the data. Five subsets

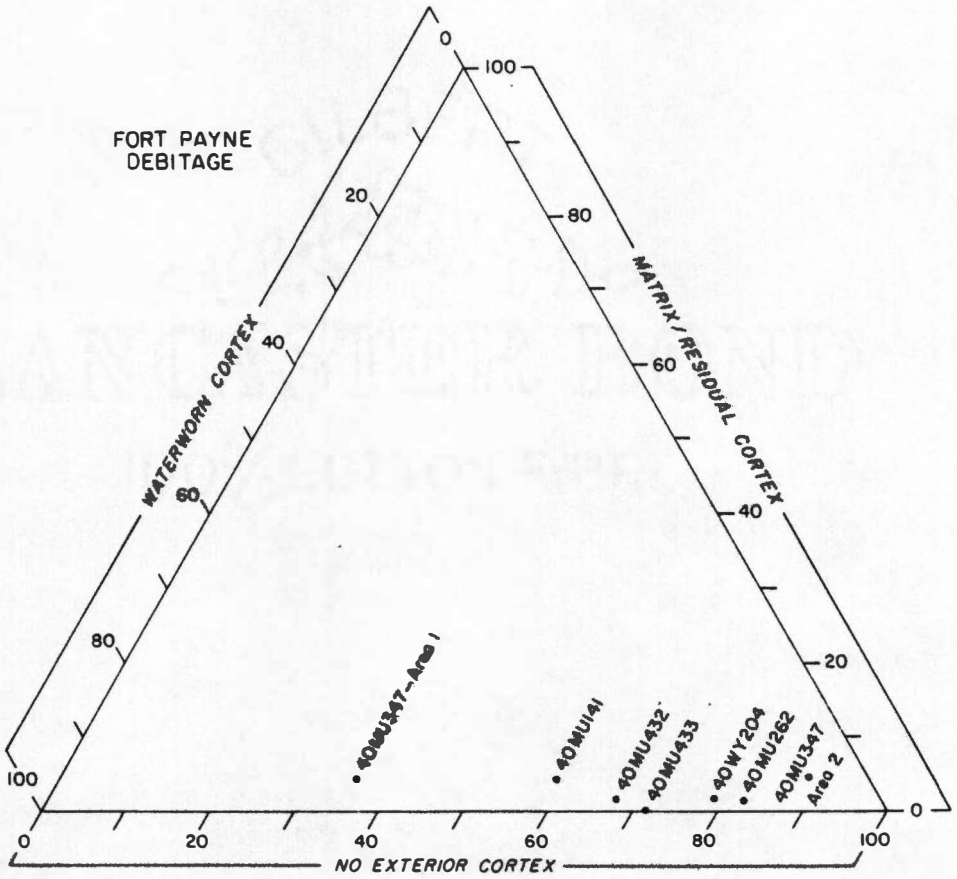

Figure 6.15. Triangular coordinates graph of Fort Payne debitage cortex type frequencies.

Table 6.7. Similarity matrix of Fort Payne debitage cortex type variability.

	Topsy (40WY204)	Clay Mine-Area 2 (40MU347)	Leftwich (40MU262)	Clay Mine-Area 1 (40MU347)	Cedar Creek (40MU432)	Cave Spring (40MU141)	Bench (40MU433)
Topsy (40WY204)	200						
Clay Mine - Area 2 (40MU347)	173	200					
Leftwich (40MU262)	191	181	200				
Clay Mine - Area 1 (40MU347)	113	91	104	200			
Cedar Creek (40MU432)	176	149	168	136	200		
Cave Spring (40MU141)	160	139	151	152	183	200	
Bench (40MU433)	182	155	174	127	191	175	200

containing two assemblages each are statistically nonsignificant at the 99% confidence level. These nonsignificant subsets are illustrated by a circle graph in Figure 6.16. The Clay Mine-Area 1 assemblage is notably uninvolved in any of the subsets. This undoubtedly reflects the unusually high proportion of waterworn cortex in that assemblage. The absence of the Clay Mine-Area 2 assemblage from any subset is curious. Examination of the frequency table (Table D.12, Appendix D) suggests this is due to an extremely high frequency of cortex absence combined with nearly equal proportions of waterworn and matrix/residual cortex. The two Clay Mine assemblages represent the extremes of a continuum along this dimension. This helps explain differences observed in these assemblages previously. Exploitation of predominantly Fort Payne local river gravels at the Clay Mine Site was much more important during Middle Archaic than Late Archaic occupations. When debitage assemblages are considered regardless of chert type, matrix/residual cortex frequencies are higher among the central Duck River Basin sites. This reflects procurement of the local Carters and Ridley cherts from upland contexts.

Chert Type Variability

Total debitage. Since debitage represent the direct by-products of activities reflected in an assemblage, analysis of chert type variability focuses on this class of artifacts. Previous considerations of total assemblages are seen to have created potential distortion of patterning. The introduction of non-debitage artifact classes into archaeological context is complex and should properly be considered

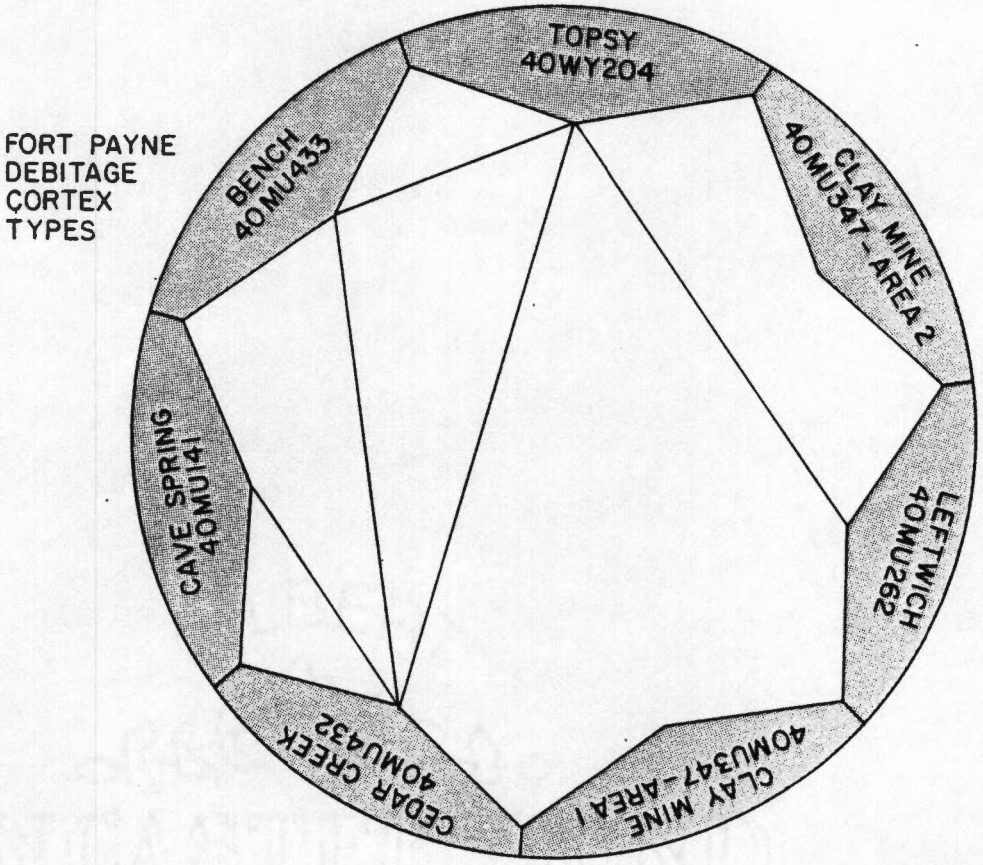

Figure 6.16. Circle graph of Fort Payne debitage cortex type similarity.

separately from more direct debitage assemblage formation processes. This is particularly important for investigations of cortex and chert type variability.

Table D.14 (Appendix D) presents basic frequency data on the chert types within the seven debitage assemblages. These data are illustrated in cumulative graph form in Figure 6.17. The ratio of Ridley chert (or Carters chert in the case of the Bench assemblage) to Fort Payne chert appears to be the major discriminating factor. Topsy is obviously the highest in Fort Payne chert frequency at the bottom of the graph. Moving up the graph, Fort Payne chert frequency decreases. The two Clay Mine assemblages follow Topsy; this is unexpected since earlier analysis suggested that these two assemblages were statistically significantly different along this dimension. Leftwich and Cedar Creek follow and are graphed as a single line because of their great similarity in profile. Cave Spring and Bench are lowest in Fort Payne frequency and differ only in the inverse relationship of the respective local Ridley and Carters chert frequencies. Overall, the profiles appear as anticipated, but the high frequency of Ridley chert in the Late Archaic Leftwich assemblage is unexpected.

A similarity coefficient matrix is produced in Table 6.8. Scores range from 57 to 198. The close similarity of frequency profiles for Leftwich and Cedar Creek in the cumulative graph is reflected by the largest similarity coefficient (198) for this pair. Topsy and Cave Spring are most dissimilar (57). This is a relatively high degree of variability. Examination of the Bench coefficients reveals a large source of this variability. The six Bench coefficients range from 59 to

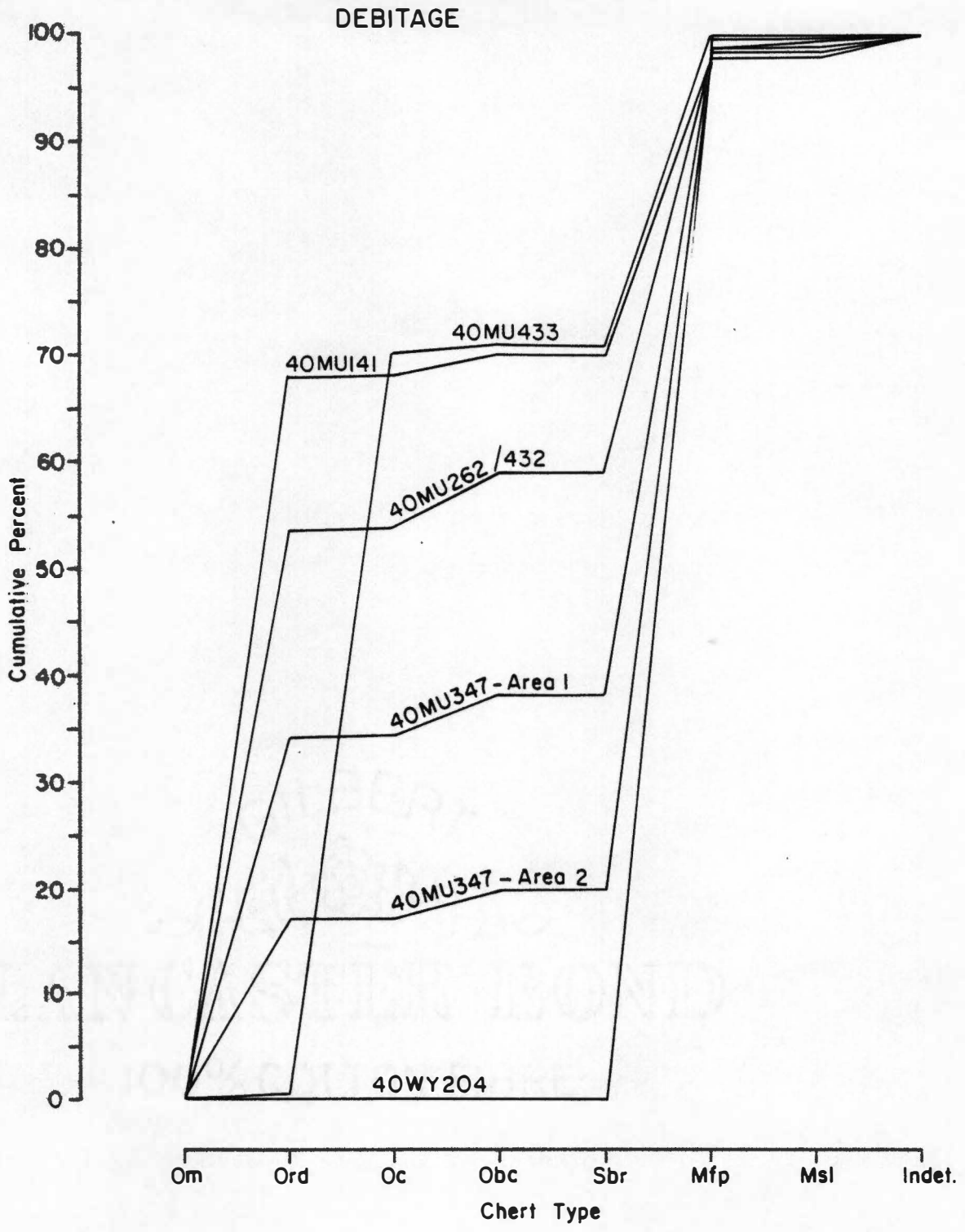

Figure 6.17. Cumulative graph of debitage chert type frequencies.

Table 6.8. Similarity matrix of debitage chert type variability.

	Topsy (40WY204)	Clay Mine-Area 2 (40MU347)	Leftwich (40MU262)	Clay Mine-Area 1 (40MU347)	Cedar Creek (40MU432)	Cave Spring (40MU141)	Bench (40MU433)
Topsy (40WY204)	200						
Clay Mine - Area 2 (40MU347)	159	200					
Leftwich (40MU262)	82	122	200				
Clay Mine - Area 1 (40MU347)	119	160	160	200			
Cedar Creek (40MU432)	80	121	198	158	200		
Cave Spring (40MU141)	57	96	169	130	170	200	
Bench (40MU433)	59	62	62	62	63	59	200
Bench[a] (40MU433)	59	96	168	130	169	195	200

[a] Ridley and Carters chert frequencies reversed.

63. This is a result of low Fort Payne frequency combined with high Carters (rather than Ridley) chert frequency. In order to demonstrate this simple Carters:Ridley inverse relationship, frequencies for these two chert types were reversed for the Bench assemblage and similarity coefficients were recalculated (Table 6.8). The additional row at the bottom of the matrix represents this reversal. The similarity coefficients are not much different from the Cave Spring assemblage with this change. In addition, Cave Spring and Bench exhibit a high similarity coefficient (195). The great decrease in variability reflects the influence of Carters:Ridley chert reversals. More importantly, this underscores the abruptness of chert type frequency changes concomitant with basal geologic formation catchment changes in the central Duck River Basin. This Carters:Ridley relationship was anticipated during early stages of the lithic resource survey (Amick 1981:50). The pattern of intense Carters or Ridley chert exploitation and restricted distribution of these cherts to their source formation areas appears most prominent during the Middle Archaic period. This exploitation/distribution pattern suggests a relatively high degree of technological expediency for these groups.

Diversity statistics are presented for chert type variability among the seven assemblages in Table D.15 (Appendix D). Pieces classified as indeterminate chert type are omitted. Figure 6.18 plots evenness as a function of diversity for the assemblages. Topsy is omitted because only one chert type (Fort Payne) is represented. Evenness figures which may be better information statistics than diversity show significant trends. The four Middle Archaic assemblages exhibit the highest

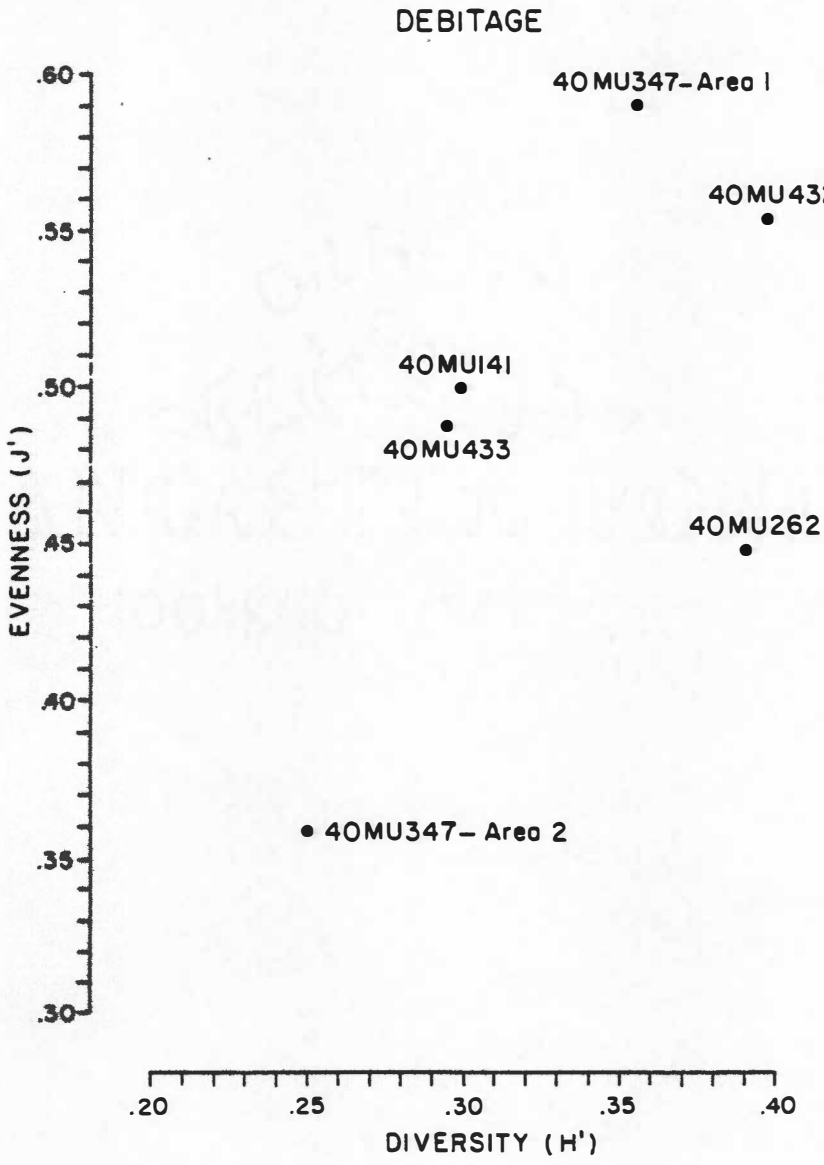

Figure 6.18. Plot of evenness and diversity for debitage chert type variability.

equitability statistics. This implies less intense keying on one particular resource. The notion that Middle Archaic technology is more casually or expediently organized appears to be supported. But the Late Archaic Leftwich assemblage spoils this simplistic solution. Rather than keying on Fort Payne chert as expected, Leftwich exhibits slightly higher frequencies of Ridley chert than Fort Payne and the largest suite of raw material types. This results in a high diversity score and a moderate equitability score.

Table D.16 (Appendix D) presents the maximally nonsignificant subset resulting from an R x C G-test of the data. Because of low cell problems, chert type categories were collapsed into three groups: (1) Ridley; (2) Carters, Bigby-Cannon, Brassfield, Indeterminate; and (3) Fort Payne, St. Louis. These categories are intended to reflect the primary sources of variability within the data set. They are based on geologic and geographic proximity factors. A single nonsignificant subset results which contains only two members, Leftwich and Cedar Creek. Recalling previous cumulative graph and similarity coefficient results, this is a consistent outcome.

Biface thinning flakes. As noted earlier, it is suggested that biface thinning flakes represent a sensitive indicator of technological change. In order to examine this notion further, chert type variability among the seven biface thinning flake assemblages is investigated. Frequency data for this category are presented in Table D.17 (Appendix D). A cumulative graph of this data is illustrated in Figure 6.19. The general patterns resemble the overall debitage profiles. Topsy and Clay

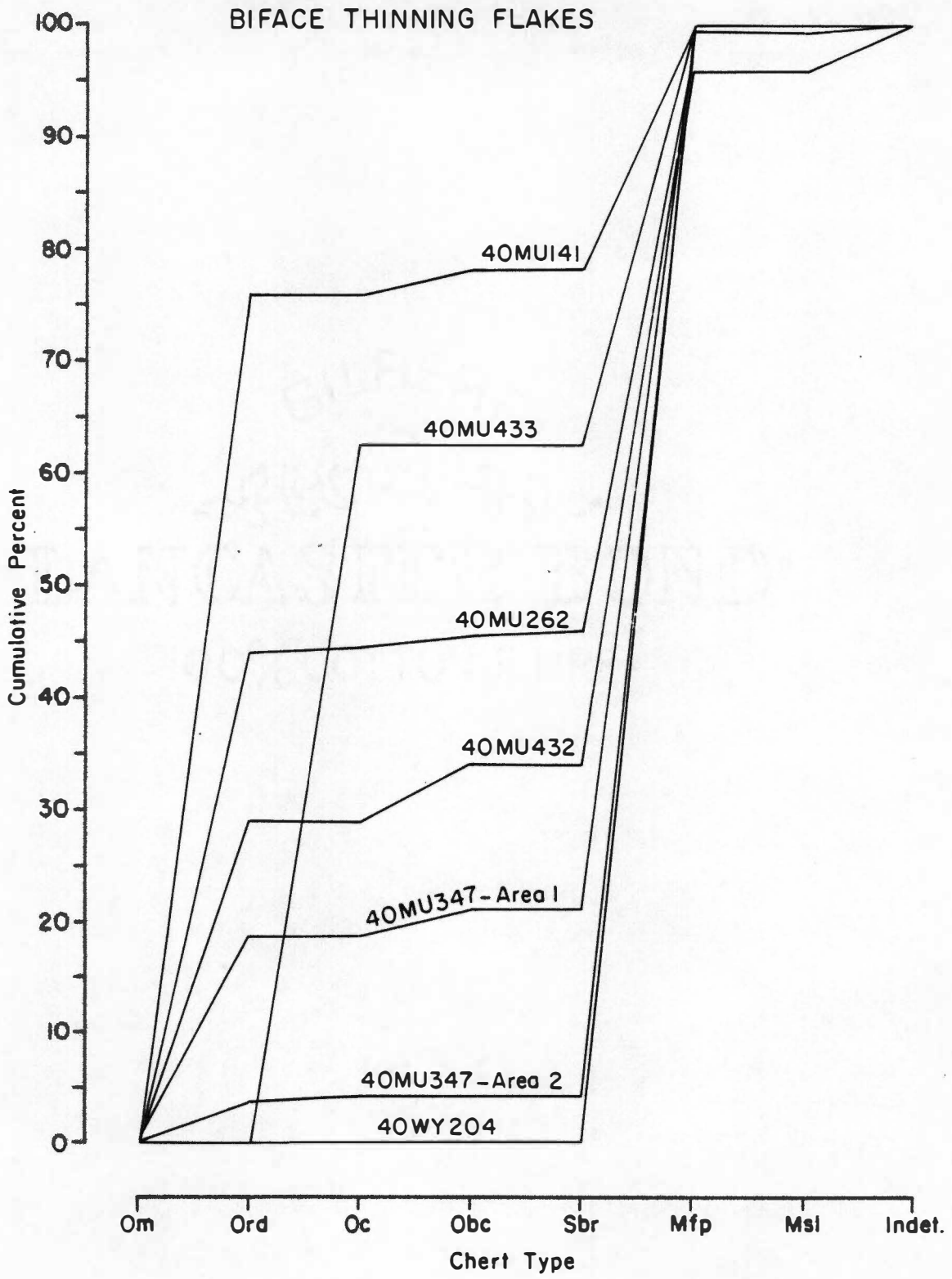

Figure 6.19. Cumulative graph of biface thinning flake chert type frequencies.

Mine-Area 2 appear somewhat closer because of higher Fort Payne incidence in the Clay Mine-Area 2 biface thinning flake assemblage. Leftwich is more distinct in profile from Cedar Creek. Furthermore, Leftwich exhibits higher proportions of Ridley biface thinning flakes than Cedar Creek. Cave Spring shows an extremely high proportion of Ridley biface thinning flakes (75.90%, n = 296).

A matrix of similarity coefficients for biface thinning flake chert type variability is presented in Table 6.9. The range of coefficients is 45 to 192. Topsy and Clay Mine-Area 2 exhibit the greatest similarity (192). Cave Spring and Topsy exhibit the least similarity (45). Bench and Cave Spring equal this dissimilarity (45). This is due to their nearly equal, but high inverse proportions of Carters and Ridley chert respectively. Cave Spring is also quite dissimilar to Clay Mine-Area 2 (52). Bench appears generally dissimilar to all other assemblages (75). These scores are altered when the Bench Carters:Ridley frequencies are inverted. Like the previous chert type variability matrix, an extra row has been added at the bottom which inverts Carters and Ridley chert frequencies for the Bench assemblage. After reversal, Bench shows much greater similarity to Cave Spring (170). Bench coefficients exhibit greater similarity to all other assemblages as well. This emphasizes the likeness of the Bench assemblage to Ridley dominated assemblages.

Table D.18 (Appendix D) lists the diversity statistics for biface thinning flake chert type variability. A scatter diagram of equitability and diversity figures is graphed in Figure 6.20. The Topsy assemblage is comprised of a single chert type (Fort Payne) and

Table 6.9. Similarity matrix of biface thinning flake chert type variability.

	Topsy (40WY204)	Clay Mine-Area 2 (40MU347)	Leftwich (40MU262)	Clay Mine-Area 1 (40MU347)	Cedar Creek (40MU432)	Cave Spring (40MU432)	Bench (40MU433)
Topsy (40WY204)	200						
Clay Mine - Area 2 (40MU347)	192	200					
Leftwich (40MU262)	107	115	200				
Clay Mine - Area 1 (40MU347)	157	165	148	200			
Cedar Creek (40MU432)	124	131	168	167	200		
Cave Spring (40MU141)	45	52	135	86	106	200	
Bench (40MU433)	75	75	75	75	75	45	200
Bench[a] (40MU433)	75	82	164	113	133	170	200

[a] Ridley and Carters chert frequencies reversed.

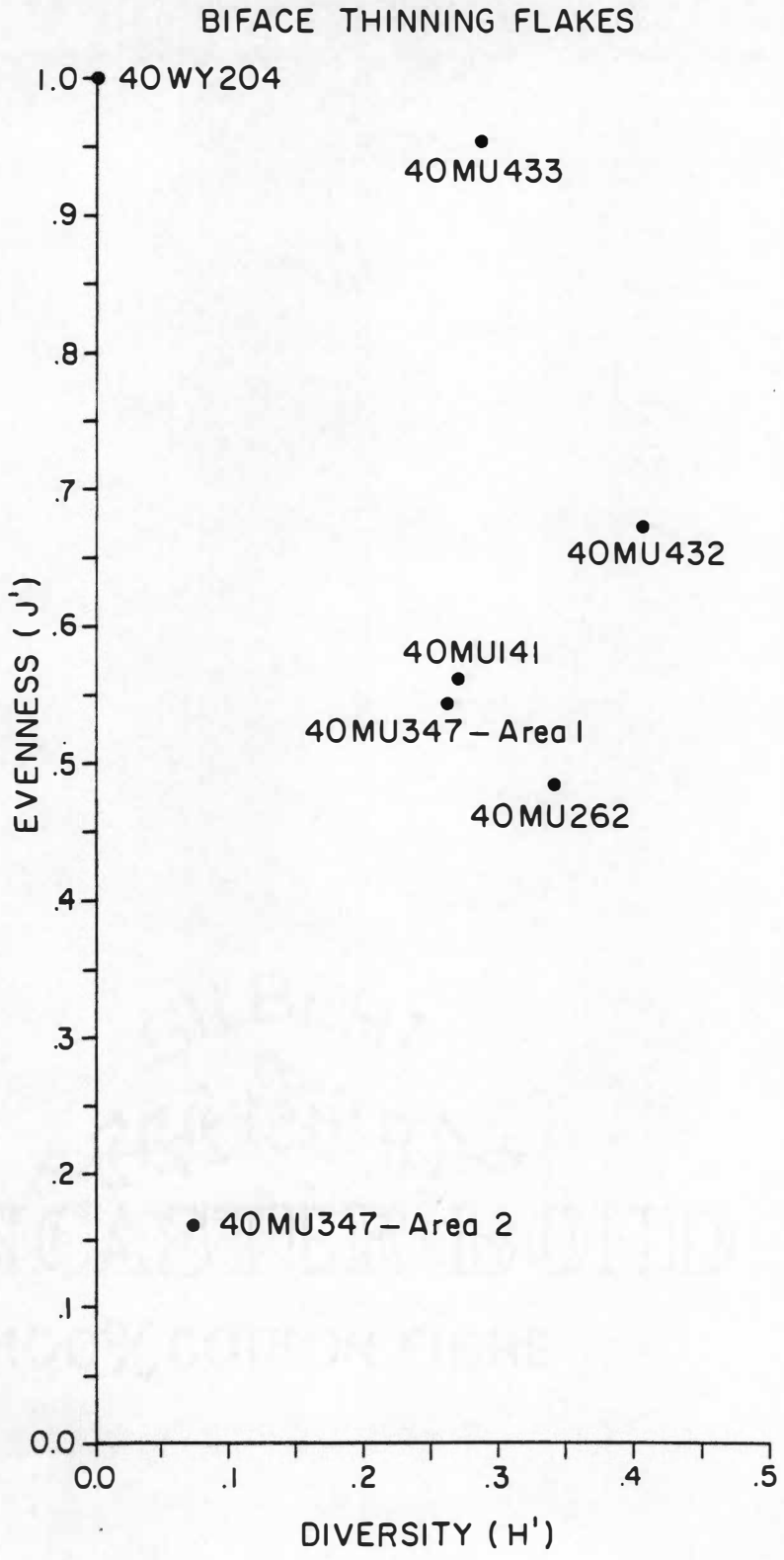

Figure 6.20. Plot of evenness and diversity for biface thinning flake chert type variability.

consequently possesses no diversity. Clay Mine-Area 2 shows low diversity and evenness figures due to high Fort Payne frequencies. Bench, on the other hand, exhibits high evenness and moderate diversity with only two chert types, Carters and Fort Payne, nearly equal in proportion. The other four assemblages (Cedar Creek, Cave Spring, Clay Mine-Area 1, Leftwich) are clumped together with moderate diversity and equitability figures. However, examination of Table D.18 (Appendix D) reveals that the four Middle Archaic assemblages produce the greatest equitability figures.

In attempt to perform an R x C G-test, chert type categories had to be collapsed to reduce the frequency of low cells. In order to meet Yarnold's (1970) criteria of minimal low cells, the data was classified as Fort Payne or non-Fort Payne (other). Since the primary question of interest concerned specific keying on Fort Payne chert for biface manufacture, this appeared to be a reasonable classification. Table D.19 (Appendix D) represents the maximally nonsignificant subsets that resulted from this test. These subsets are diagrammed in the circle graph in Figure 6.21. Topsy is uninvolved as a subset member and this is certainly due to a solitary reliance on Fort Payne chert. Cedar Creek and Leftwich exhibit similarities to each other as well as Bench and Clay Mine-Area 1. Interestingly, the two Clay Mine assemblages are included in a nonsignificant subset. This stems from a high relative frequency (78.38%, n = 29) of Fort Payne biface thinning flakes in the Clay Mine-Area 1 assemblage. Nonetheless, this figure is hardly as impressive as the 96.14% (n = 224) of Fort Payne biface thinning flakes from Clay Mine-Area 2.

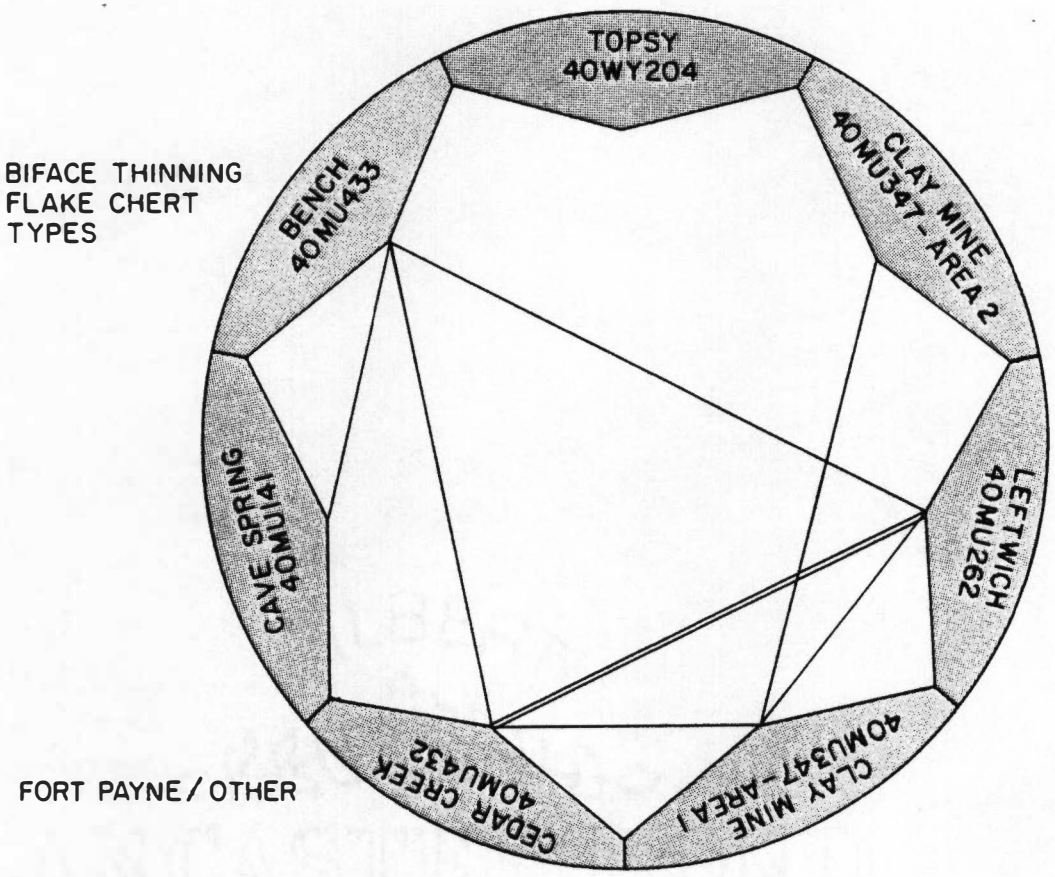

Figure 6.21. Circle graph of biface thinning flake chert type similarity (Fort Payne versus non-Fort Payne).

Biface assemblages. The consideration of bifaces and biface trajectory analysis as an aid to interpreting settlement systems is rapidly increasing (e.g., Johnson 1979, 1981a, 1981b, 1982; Johnson and Raspet 1980; Futato 1980; Amick 1982; Jefferies 1982a). This is not a new idea, but rather a rediscovered one from the works of Holmes (1890, 1893, 1894, 1897, 1919). Despite laying the groundwork for biface trajectory analysis, much of Holmes' work has been neglected for the past 80 years. Fortunately, Johnson (1981a:2-6) has recently credited Holmes for his many contributions to the understanding of biface production trajectories and their relationship to regional settlement systems. Johnson's (1979, 1981a, 1981b, 1982) work with the Yellow Creek Fort Payne upland quarries in northeast Mississippi has led to the development of two important breakthroughs in biface trajectory analysis. First, his analytical methods are able to accommodate fragmentary specimens (and, in fact, emphasize production failures). Second, he has devised an interval scale measurement (the "thinning index") which allows placement of bifaces and biface fragments along a production trajectory continuum. This measurement is simply weight divided by planview area. In addition, Johnson has used this method to develop a model of Archaic period settlement systems in the Fort Payne uplands. Unfortunately, the thinning index works best with specimens greater than 1.27 cm^2, biface samples that are large enough for confident statistical manipulation, and a single raw material type which is consistent in size and shape. These criteria cannot be met by the seven assemblage biface samples in this study. However, a successful implementation of the thinning index was conducted during the Topsy Site

biface analysis (Amick 1982). This study employed Fort Payne bifaces and biface fragments from all recovery contexts which totaled 328 specimens. A consideration of the results of that analysis is included in the discussion following this section.

Table D.20 (Appendix D) presents the chert type frequencies for the seven biface assemblages in this study. Figure 6.22 illustrates these proportions in cumulative graph form. The profiles show general agreement with the debitage chert type cumulative graphs illustrated previously. The bifaces from Topsy and Clay Mine-Area 2 are exclusively Fort Payne and are graphed as a single line. Most biface assemblages roughly approximate the corresponding profiles of their biface thinning flake assemblages. However, Clay Mine-Area 2 shows a slight decrease of local Ridley chert in comparing biface thinning flakes to bifaces. Differences in chert type proportions between biface thinning flakes and bifaces are very pronounced in the Cave Spring assemblage. The relative frequency of Ridley chert in the Cave Spring biface thinning flake assemblage is 75.90% (n = 296), whereas the Cave Spring biface assemblage exhibits only 30.77% (n = 24) Ridley chert.

Comparison of biface thinning flakes and bifaces yields a rough approximation of biface manufacturing activities versus biface discard. Patterns of biface discard are much more complex than manufacturing activities. Bifaces and biface fragments can enter the archaeological record through numerous pathways. Although intentional abandonment because of functional use-life termination is an ideal situation, unintentional breakage or loss are pragmatic considerations. Breakage during manufacture is probably the major source of biface fragments.

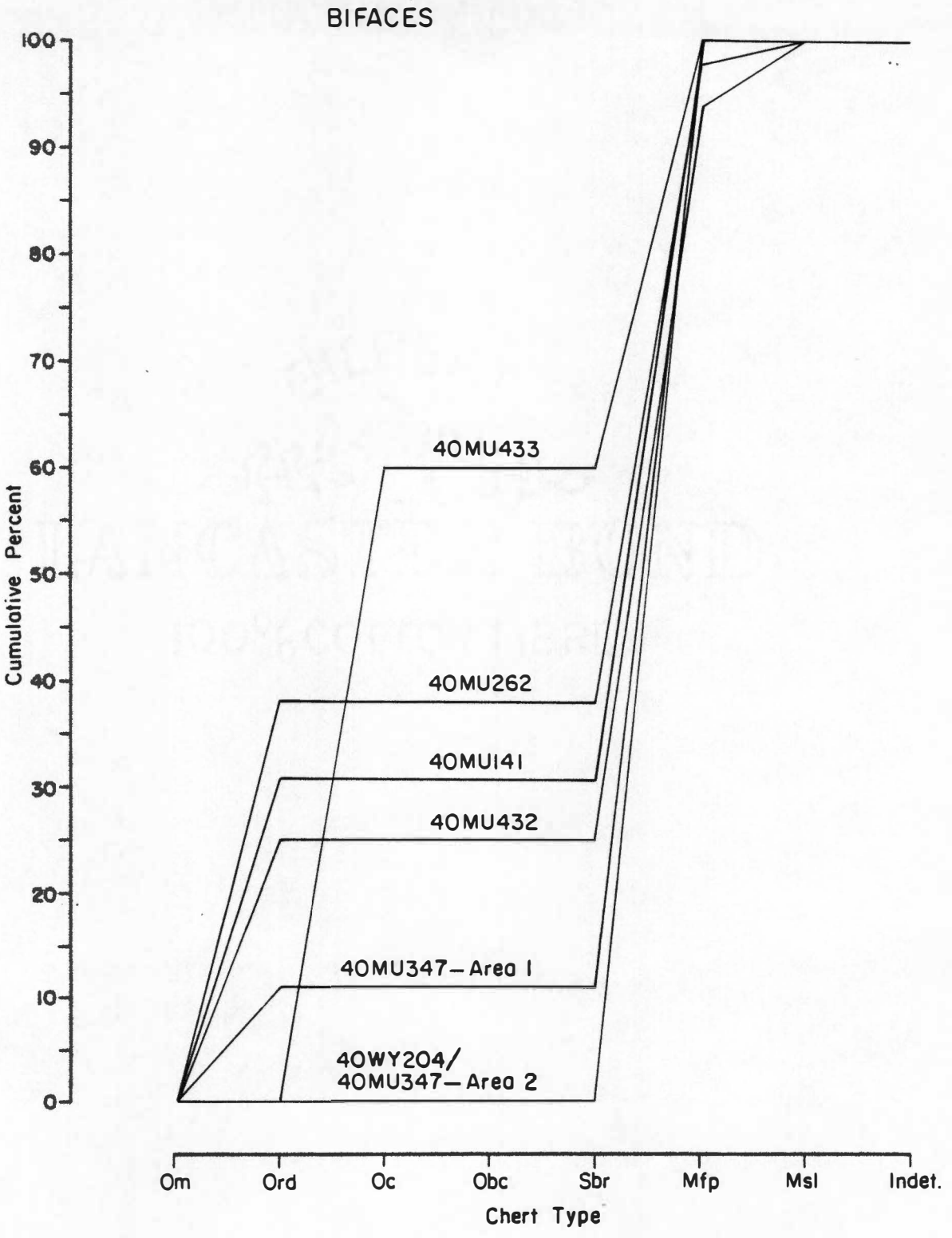

Figure 6.22. Cumulative graph of biface chert type frequencies.

Division of the biface assemblages into reduction stage classes (e.g., blank, preform, finished project point) might improve understanding of the probable activities leading to the deposition of a particular biface assemblage. But the generally low frequency and fragmentary nature of the bifaces in this study preclude such comparisons. Spurious patterning could be easily produced because of sample size problems.

The caveats of the preceding discussion in mind, it is suggested that the higher relative frequency of Ridley biface thinning flakes compared to bifaces at the Cave Spring Site indicates "gearing up" (Binford 1979:268) activities. That is, while expended Fort Payne bifaces were discarded at the site, biface manufacture using local Ridley chert was performed. The resulting Ridley bifaces were transported to subsequent habitation sites. The presence of discarded Fort Payne bifaces without an equivalent frequency of attendant manufacturing debris indicates previous habitation(s) in proximity of Fort Payne deposits. Overall, the "gearing up" pattern of biface manufacture and discard suggests high residential mobility for the prehistoric inhabitants of the Cave Spring locality. Although the proportion of Fort Payne chert is higher for bifaces than biface thinning flakes among all the assemblages, Cave Spring demonstrates the most convincing pattern.

Table 6.10 is a matrix of similarity coefficients for chert type variability among the biface assemblages. Scores range from 80 to 200. Topsy and Clay Mine-Area 2 are identical (200) with exclusive Fort Payne chert representation. Cave Spring is quite similar to Cedar Creek (188). The Bench assemblage is the most dissimilar to all assemblages

Table 6.10. Similarity matrix for biface chert type variability.

	Topsy (40WY204)	Clay Mine-Area 2 (40MU347)	Leftwich (40MU262)	Clay Mine-Area 1 (40MU347)	Cedar Creek (40MU432)	Cave Spring (40MU141)	Bench (40MU433)
Topsy (40WY204)	200						
Clay Mine - Area 2 (40MU347)	200	200					
Leftwich (40MU262)	120	120	200				
Clay Mine - Area 1 (40MU347)	178	178	142	200			
Cedar Creek (40MU432)	169	169	174	160	200		
Cave Spring (40MU141)	139	136	182	161	188	200	
Bench (40MU433)	80	80	80	80	80	80	200
Bench[a] (40MU433)	80	80	156	102	130	142	200

[a] Ridley and Carters chert frequencies reversed.

(80). This reflects a high frequency (60%, n = 6) of Carters chert which is absent from all other assemblages. Reversal of Carters and Ridley frequencies for the Bench assemblage provides more meaningful patterning. The bottom row of the matrix provides scores resulting after the reversal. The low coefficient of 80 remains for the similarity of Bench to Topsy or Clay Mine-Area 2 because of constant Fort Payne frequencies. However, the similarity of Bench to Leftwich (156) and Cave Spring (142) is greatly improved. Although a significantly low frequency of Fort Payne chert (40%) is present in the Bench biface assemblage, cautious interpretation is urged because of low sample size (n = 4).

An R x C G-test of the biface chert type data produced three maximally nonsignificant subsets (Table D.21, Appendix D). Like the preceding association test for biface thinning flakes, the chert type categories are collapsed to Fort Payne and non-Fort Payne (other) in order to reduce the proportion of low cells in the cross-classification. The subsets that result contain three to five members each. Consequently, the circle graph of related subset members (Figure 6.23) is rather intricate. Considering previous discussions regarding the complexity of biface assemblage formation processes, the poor discrimination of assemblages shown in Figure 6.23 is not unexpected. Clay Mine-Area 2 appears most different from other assemblages. Topsy might have equalled Clay Mine-Area 2, but smaller sample size (n = 27) resulted in inclusion in one additional subset. Overall, there appears to be a strong degree of association among Clay Mine-Area 1, Cedar Creek, and Cave Spring. This reflects a common high proportion of

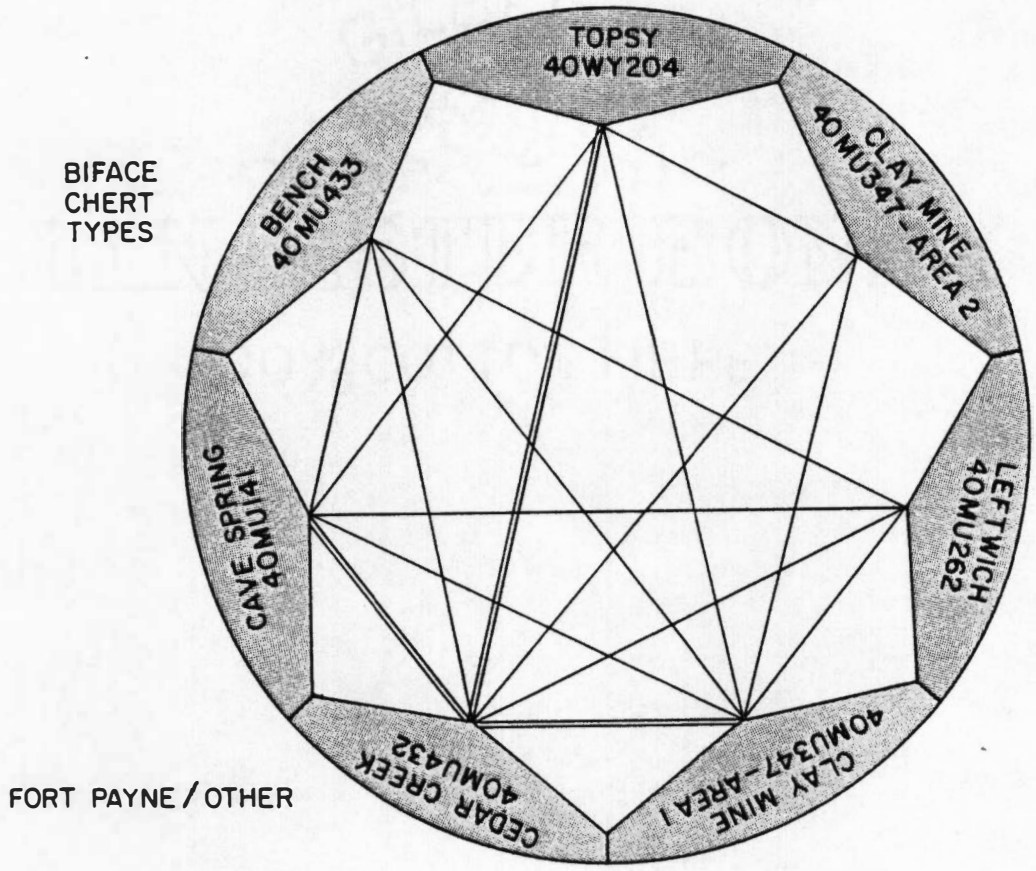

Figure 6.23. Circle graph of biface chert type similarity (Fort Payne versus non-Fort Payne).

non-Fort Payne (Ridley) bifaces. Leftwich and Bench with slightly higher proportions of non-Fort Payne (Ridley and Carters respectively) bifaces are involved in this association to a lesser degree.

Hypothesis Reevaluation

Synthesis of the analysis results is required in order to evaluate how the hypothesis has fared. The assemblages are regarded as two groups, Late and Middle Archaic. General characteristics of the groups are discussed, including assemblage specific comments. Emphasis is placed on unique assemblage characteristics as well as similarities and differences with the other assemblages. After this discussion, interpretation of the observed variability is considered.

Late Archaic

The Late Archaic group is comprised of three assemblages, Topsy, Clay Mine-Area 2, and Leftwich. Topsy and Clay Mine-Area 2 exhibit numerous similarities, but Leftwich is somewhat dissimilar. All three assemblages display low cortex presence frequencies. In particular, these assemblages possess the lowest proportions of cortex-bearing Fort Payne debitage. Topsy, which is surrounded by Fort Payne deposits, was expected to yield higher cortex presence frequencies indicative of early stage reduction activities near the raw material source. This precise expectation was not met. Cortex type at Topsy is overwhelmingly waterworn (especially among biface thinning flakes). This suggests initial reduction activities at Topsy were located at gravel deposits adjacent to the site in the Buffalo River and its tributaries. This

patterned staging in tool production reveals a structured technological system involving specialized task groups. Low cortex presence at Clay Mine-Area 2 and Leftwich indicates a similar pattern. Fort Payne cortex types are more equitable within the two central Duck River Basin assemblages suggesting that procurement of local Fort Payne gravels was unimportant. Otherwise, the proportion of matrix/residual cortex would be much less, reflecting its more distant source. Fort Payne chert on central Duck River Basin Late Archaic sites appears to be derived from these distant sources where early stage reduction also occurred. Intermediate and late stage reduction of this Fort Payne chert occurred at Late Archaic central Duck River Basin sites. This is further evidence of staged reduction and structured procurement patterns conducted by specialized task groups.

Evidence of Fort Payne biface production is most prominent at Topsy and Clay Mine-Area 2. These assemblages exhibit the greatest proportion of Fort Payne chert. Within the debitage assemblages, Fort Payne frequencies are highest among biface thinning flakes. In addition, these two assemblages display exclusively Fort Payne chert bifaces. Predominance of Fort Payne chert is not unexpected at the Topsy location, but such high proportions at Clay Mine-Area 2 suggest keying on a more distant but preferred first-line resource.

Debitage type analyses demonstrated high proportions of biface thinning flakes at Topsy and Clay Mine-Area 2. Contingency analysis substantiates the statistically nonsignificant differences between Topsy and Clay Mine-Area 2 evidenced by low proportions of cortex presence and early reduction stage (decortication) debris (Amick 1982:35). Debitage

assemblages from these two sites indicate intermediate to late stage biface manufacturing activities.

This evidence is supported by biface trajectory analysis at Topsy (Amick 1982:33-35). A "thinning index" continuum modeled after Johnson's (1979, 1981a) biface trajectory analyses was constructed. Evaluation of the values produced by the Topsy biface assemblage suggested that it represented an intermediate biface reduction trajectory segment. This conclusion was based upon Johnson's (especially 1981a) results as well as considerations of local resource variability and discrete characteristics of the biface assemblage (e.g., haft modification, failure types, thermal alteration evidence). Bifaces in the Clay Mine-Area 2 assemblage are typically finished projectile point/knife forms displaying little resharpening evidence. Many of these specimens show distinctively patterned haft snaps (Amick 1983:3). The Clay Mine-Area 2 bifaces are also characterized by a high degree of stylistic uniformity. Refitting attempts demonstrated that many of the biface thinning flakes conjoined with the bifaces. This suggests production of these finished biface forms from intermediate stage preforms at the site. These preforms were presumably derived from Fort Payne sources beyond the Inner Nashville Basin such as the Topsy location. The Clay Mine-Area 2 biface assemblage implies late intermediate stage biface reduction. Extreme late stages of the trajectory characterized by extensive resharpening, retouch, and resultant blade exhaustion marked by high edge angles are absent. Clay Mine-Area 2 and Topsy seem to represent rather short intermediate to

late segments of the reduction trajectory. The Clay Mine-Area 2 trajectory segment appears to be later and shorter than Topsy.

Biface production at Leftwich displays definite contrast to Topsy and Clay Mine-Area 2. Differences are primarily related to the high proportions of Ridley chert in the Leftwich assemblage. This is particularly conspicuous among the biface thinning flakes. In this aspect, Leftwich shows greater affinities to the Middle Archaic Cedar Creek assemblage than the Late Archaic assemblages. The mutual proximity of Cedar Creek and Leftwich to extensive Ridley chert residuum deposits in the adjacent Pleistocene terraces and uplands may partially explain assemblage similarities. However, there appear to be fundamental differences between Middle and Late Archaic biface production techniques.

Early stage bifaces within Inner Basin Middle Archaic assemblages invariably display evidence of flake blank production. That is, bifaces are produced from flakes. This is particularly striking in the Clay Mine-Area 1 assemblage where bifaces characteristically display flake curvature, positive bulbs of percussion, and dorsal surface cortex. The production of bifaces from flake blanks is a conservative technique of raw material utilization. Conservation is expressed through two interrelated aspects, (1) less raw material is required and less waste is produced, and (2) fewer flake removals are required and fewer failures occur. In addition to raw material conservation, flake blank techniques require less flintknapping proficiency. This suggests a lesser degree of craft specialization among Middle Archaic central Duck River Basin groups. However, the local production of bifaces from flake

blanks may result from the limited size of Inner Basin raw materials. The small size of local resources may simply preclude the employment of bifacial core techniques.

Evidence at the Topsy Site suggests that bifacial core techniques are equally important as flake blank techniques for Late Archaic biface manufacture (Amick 1982:33). Informal impressions of the Clay Mine-Area 2 and Leftwich biface assemblages indicate a similar employment of bifacial core techniques. Core reduction strategy allows the production of larger finished forms and greater flexibility in flake removal sequence(s) and biface shape(s). The use of this strategy by regional Late Archaic groups implies a lack of lithic resource stress. Because greater skills are required to execute these techniques and raw materials are obtained from beyond the Inner Basin, craft specialization and task group performance are inferred for central Duck River Basin Late Archaic groups. In addition, bifacial core techniques represent a technological adaptation to extensive logistical mobility.

> In terms of economy, bifacial cores rank high, ... In bifacial cores the wasteful stage of core preparation took place at the quarry. Once the striking platforms were established, the majority of flakes drawn from it were usable. Bifacial cores were thus well adapted for industries that must frequently be maintained far from the quarry (MacDonald 1968:66) . . . .

The Leftwich assemblage presents a complex case which may be the result of repeated occupations. The presence of two distinct projectile point types (Ledbetter and Benton Stemmed) within the component is evidence of this as well as the vertically diffuse nature of the deposits compared to other local buried components. The Fort Payne debris indicates late stage reduction while the Ridley material reflects

a long trajectory segment providing evidence of all reduction stages. This may imply long-term residential occupation at Leftwich requiring exploitation of locally abundant Ridley chert to supplement depleted Fort Payne supplies or temporary unavailability of extralocal Fort Payne sources. Overall, the three Late Archaic assemblages appear to express categorical rather than graded variability and show common underlying patterns of biface manufacture typical of craft specialization and task group organization.

Middle Archaic

The Middle Archaic group is comprised of four assemblages, Clay Mine-Area 1, Cedar Creek, Cave Spring, and Bench. Interassemblage variability among this group is more homogeneous than among the Late Archaic assemblages. Outstanding characteristics of the Middle Archaic assemblages include the high proportion of local cherts and wide range of reduction stages represented. Bench and Cave Spring show a great deal of similarity. Clay Mine-Area 1 is the most dissimilar while Cedar Creek expresses general likeness to all the Middle Archaic assemblages and Leftwich.

Cave Spring and Bench represent Eva-Morrow Mountain phase occupations in Cheek and Cannon Bends, respectively. Despite differences in chert type variability, these assemblages reveal similar chert exploitation and reduction strategies. Proportions of Fort Payne chert are lowest within these assemblages, particularly among biface thinning flakes. The immediately available low grade local chert is the predominant raw material in each assemblage. These chert types are

Ridley and Carters for Cave Spring and Bench, respectively. The proximity of these sites (about 8 km) expressing exclusive inverse Ridley-Carters frequencies demonstrates the physical property equality of the two cherts as well as highly circumscribed and expedient local lithic resource exploitation patterns. Both assemblages exhibit debris reflecting a full trajectory of biface production from local chert. Bifaces recovered at Cave Spring are primarily Fort Payne suggesting relatively high mobility and "gearing up" activities. Bench produced relatively few bifaces (n = 10), the majority of which are Carters. Successful refitting experiments demonstrate that the Carters debitage and bifaces at Bench probably represent a single manufacturing episode. The absence of expended Fort Payne bifaces at Bench, which would produce a pattern analogous to Cave Spring, may simply be a result of limited areal sampling at Bench.

Cedar Creek and Clay Mine-Area 1 represent Sykes-White Springs phase assemblages. Cedar Creek shows more frequent similarities than differences to the Middle Archaic group. In addition, general affinities to Leftwich, located about one kilometer upstream, are seen in the Cedar Creek assemblage. As noted in the previous section, biface production from flake blanks of local chert distinguishes the Middle Archaic technology in the central Duck River Basin. This quality differentiates Cedar Creek from Leftwich. The Cedar Creek assemblage is characterized by high proportions of Ridley chert, high frequencies of Fort Payne bifaces, and a long trajectory segment.

The Clay Mine-Area 1 assemblage exhibits the highest degree of dissimilarity to all other assemblages, but retains many traits

characteristic of the other Middle Archaic assemblages. The distribution of chert types is most equitable among the four Middle Archaic assemblages, but Clay Mine-Area 1 displays the highest proportions of Fort Payne chert within this group. The primary source of Clay Mine-Area 1 dissimilarity to other assemblages appears to be a relatively high frequency of waterworn cortex-bearing Fort Payne debris. Unusually high proportions of waterworn cortex (48.28%, n = 14) are even present among the Fort Payne biface thinning flakes. It appears that much of the debris at Clay Mine-Area 1 reflects biface production from small local Fort Payne gravels. Ridley chert exploitation is less important compared to other Middle Archaic assemblages. The Clay Mine-Area 1 focus on local Fort Payne gravels provides debris which contrasts greatly with the other assemblages, particularly Clay Mine-Area 2. Despite this apparent contrast, it is suggested that underlying patterns of local resource circumscription and expediency are characteristic of the Clay Mine-Area 1 assemblage. The diversity in chert type exploitation patterns among the Middle Archaic assemblages reflects flexibility and expediency in lithic exploitation strategy. Absence of distinct "staging" in manufacture, extremely circumscribed local resource exploitation, and internally heterogeneous assemblages reflective of long trajectory segments characterize the Middle Archaic assemblages. These qualities reflect a lack of specialized task group organization and a high degree of residential mobility and technological expediency.

Analytical Alternatives

Evaluation of the synthesis provided above must be considered. The primary emphasis of this evaluation concerns the assessment of whether chronology adequately and accurately dimensions the observed interassemblage variability. Alternative dimensions include sampling problems and reconsideration of middle-range theory notions such as assemblage grain, site specialization, site function, and assemblage content variability.

Binford (1978a:483-497, 1980:17-18) has suggested that implications regarding settlement system organization can be inferred from assemblage grain. The degree of resolution between assemblage characteristics and the specific events producing the assemblage varies along a continuous scale from good (fine-grained) to poor (coarse-grained). Among the assemblages in this study, Bench and Clay Mine-Area 2 appear the most fine-grained. Topsy, Cedar Creek, and Leftwich seem coarse-grained, while Cave Spring and Clay Mine-Area 1 are intermediate. These relationships do not appear to be functionally related to absolute sample size or areal extent of the excavations. Undetermined dimensions of intrasite distributional variability, repeated occupation, and mixing are the most probable conditioners of the observed degree of resolution. Binford's formulations of assemblage grain ostensibly refer to complete assemblages only. It is suggested that the derivation of assemblage grain characteristics from assemblage samples may lead to inference problems. Consequently, considerations of mobility, length of occupation, site function, and serial differentiation of events (seasonality) are not inferred from the assemblage grain patterns.

Although assemblage grain is rejected as a useful measure of settlement system organizational strategy, technological parameters provide a substitute. Underlying strategies of lithic reduction sequences are less sensitive to distortion by sampling. Trajectory length, reduction stage, and resource utilization patterns are more robust measures than specific event resolution of fundamental organizational strategies.

The problem of intrasite distributional variability affects site specialization and site function interpretations also. However, manufacturing trajectory segment and length provide critical evidence for these interpretations. Evaluating whether the seven assemblages can be regarded as a single organizational system or if real chronological differences exist is the essential problem. Consideration of site function and degree of specialization are important to this evaluation. Long trajectory length and procurement of local materials with little evidence of staged manufacture among the Middle Archaic assemblages suggests a low degree of site specialization. The expedient technology displayed by these assemblages combined with little evidence of site specialization indicates highly mobile residential groups. The absence of special-purpose limited activity assemblages implies a low degree of task group organization and labor differentiation.

The Late Archaic assemblages appear to differ from the Middle Archaic interassemblage variability pattern. Leftwich exhibits numerous similarities to the Middle Archaic assemblages, but low cortex and high biface thinning flake frequencies demonstrate closer relationships to the Late Archaic Topsy and Clay Mine-Area 2 assemblages. Leftwich is a long trajectory assemblage which may be the result of repeated

occupations rather than technological expediency. Topsy and Clay Mine-Area 2 are extremely similar in assemblage content. Both assemblages represent intermediate to late stage segments of the reduction trajectory. The density of debris and site location suggest a residential function possibly combined with special-purpose occupations. Clay Mine-Area 2 is more difficult to assess, but because of a very limited segment of biface manufacture, special-purpose logistical use seems most likely. The Late Archaic assemblages exhibit a pattern of more clearly delineated site types. These site types appear to be the result of site specialization. Site specialization is related to greater labor differentiation, less expedient technology, greater task group organization, and more logistical settlement strategies.

Greater interassemblage content redundancy among the Middle Archaic group and greater interassemblage content discrimination among the Late Archaic group demonstrates chronological differences. System change through time appears to be a more viable determinant of the observed interassemblage variability than considerations of site location and function. However, differentiating culture change from annual range and regional settlement system positioning changes requires larger samples and supporting evidence. Sample size within assemblages needs to be larger in some cases and the inclusion of a greater number of assemblages is critical for model assessment and growth. The consideration of more diverse site types and locations (particularly uplands, rockshelters, and Western Outer Basin sites) is appropriate given the current interassemblage variability data. Supporting evidence of hypothesized trends in organizational change is necessary. This

auxillary data is especially needed in the areas of subsistence, environment, and demography. A limited consideration of these data is presented in the following chapter. Assemblage content variability among the Middle Archaic sample appears graded while the Late Archaic sample seems categorical. This evidence supports the hypothesis that Late Archaic groups were more logistically organized than Middle Archaic groups in the central Duck River Basin.

CHAPTER VII

THE MODEL SYNTHESIS: INTERASSEMBLAGE VARIABILITY RECONCILED

In order to interpret the observed interassemblage variability and apparent culture change between Middle and Late Archaic times in the central Duck River Basin, a broader framework is necessary. Primary concerns are understanding the factors of environmental change and demographic process. Demonstration of environmental and demographic trends with specific local data is emphasized. Expected and observed patterns of subsistence and settlement parameters are then presented. Subsistence pattern discussions focus on resource exploitation strategies. Settlement system considerations stress the extent of mobility/sedentism variability. Intra- and interregional archaeological data are incorporated in the settlement-subsistence considerations. Implications for social organization change are ultimately derived from these discussions. Overall appraisal of the explanatory ability of the model and suggestions for further research conclude the chapter.

Environmental Change

> The delineation of variation in the natural environment both through time and space, is extremely important for understanding the variability in the archaeological record . . . .
> Furthermore, understanding the exact nature of environmental and biological changes is essential in reconstructing prehistoric subsistence patterns (McMillan and Klippel 1981:240).

In agreement with the philosophy expressed in the citation above, literature and data pertinent to evidence of local environmental variability are reviewed. This discussion forms a baseline for further

interpretation of land-man relationships. Deevey and Flint (1957) were the first to coin the term "hypsithermal interval" to refer to a warming and drying climatic trend during the mid-Holocene. Numerous syntheses of regional prehistoric cultural chronology in North America have recognized the hypsithermal interval (e.g., Brose 1979:5; Stoltman 1979: 714; Walthall 1980:57; McMillan and Klippel 1981:221). Although there is some inconsistency in climatic nomenclature, this is not as disturbing as inconsistency among the temporal frameworks cited for this warming and drying trend. In addition, the effect of these climatic changes on local flora and fauna differs across regions. Consequently, a local model of environmental change during the Archaic period is developed for the central Duck River Basin.

Regional palynological, sedimentological, and paleozoological studies confirm the mid-Holocene existence of a hypsithermal interval in Middle Tennessee. Delcourt's (1979) pollen and plant macrofossil analyses of sediment cores from the eastern Highland Rim provide a local record of vegetation change during the past 25,000 years. Although Delcourt's time scale is rather gross for archaeological applications, she suggests a warming and drying climatic trend during 8000-5000 years B.P. (Delcourt 1979:271). This inference is based on decreased frequencies of mesophytic forest taxa during this interval followed by a revival of the mesic deciduous forest after 5000 years B.P. In addition, Delcourt (1979:267) notes uniform low sedimentation rates at this time. Brakenridge's (1982, 1984) geomorphological study of the Duck River floodplain provides further sedimentological evidence of the hypsithermal interval. He notes a pattern of floodplain stability and

soil formation caused by reducted trunk stream flooding during 7200-6500 years B.P. (Brakenridge 1982:69-70). This is inferred to be a drier climatic interval characterized by expansion of "cedar glade" xeric forest vegetation in the central Duck River Basin. Klippel and Parmalee (1982) report paleozoological data from Cheek Bend Cave, located within a few kilometers of the central Duck River Basin sites. Based on habitat sensitive insectivore remains, they infer a drier climate and more open grassy upland environment between 8000 and 5000 years B.P. (Klippel and Parmalee 1982:455-456). Dry conditions are viewed as ameliorating by 5000 years B.P. The consistency of these three independent studies substantiates the existence of drier conditions during Middle Archaic times in Middle Tennessee. The effect these conditions had on local flora and fauna is more directly relevant to questions of human adaptation.

Deterioration of upland mesic habitat appears to be the most basic effect. This pattern has been recognized by palynologists (Delcourt 1979) and archaeologists alike (Klippel and Parmalee 1982; Bense 1983) in the Midsouth. Upland desiccation may have significantly altered the local distribution of plant and animal species. Most important of these species is the white-tailed deer (Odocoileus virginianus) which served as the nucleus of Archaic period subsistence economies in Eastern North America (Ford 1977). Reconstruction of deer habitat/population dynamics during the Archaic period in Middle Tennessee is based on wildlife management studies conducted in the southeastern Ozarks (Segelquist and Green 1968; Segelquist et al. 1969) and archaeological discussions of

deer habitat/population dynamics reconstruction (Smith 1974, 1975:17-42; Raab 1976:62-65).

The preferred food source of the white-tailed deer in the Midsouth is the oak mast crop (Collins and Murry 1961:52; Segelquist and Green 1968:336; Segelquist et al. 1969:514-515; Coblentz 1970:539). Acorns are abundant during the fall and winter months in upland hardwood forests. This is the predominant forest type of the Highland Rim and Outer Nashville Basin. Mid-Holocene drying trends are noted to have caused decreased frequencies of hardwood species, such as oaks, on the eastern Highland Rim (Delcourt 1979:271). This undoubtedly led to oak mast crop production decline in the Highland Rim and Outer Nashville Basin physiographic sections. Gage (1979) has recognized significant interspecific competition between prehistoric man and deer for acorns as a common food resource. This may have influenced prehistoric populations in Middle Tennessee. Interspecific competition is expected to have increased during times of poor oak mast crop production such as the hypsithermal interval. Reduction in preferred food resource abundance and increased competition for this resource may have resulted in deer population decline in the Outer Nashville Basin and Highland Rim.

In the Inner Nashville Basin, the mid-Holocene is marked by expansion of upland cedar glades and grassy habitat (Klippel and Parmalee 1982:456). Deer population may have increased in the Inner Nashville Basin during the hypsithermal interval because of increased cedar glade size and edge area development. Segelquist and Green (1968), Segelquist et al. (1969), and Coblentz (1970) have noted the

importance of cedar glade herbage and grasses as browse to the white-tailed deer when acorns are unavailable. It is difficult to determine differences in Middle Tennessee deer populations through time, but it is significant to note that during Middle Archaic times the Inner Nashville Basin may have been a relatively attractive location for peoples whose subsistence economies focused on the white-tailed deer.

Demographic Processes

Consideration of prehistoric demographic processes must begin on a theoretical level. There is significant diversity among researchers regarding the role and nature of demographic processes. The theoretical perspective adopted in this study obviously influences assumptions, methods, and conclusions. Consequently, the theoretical underpinnings and assumptions of demographic process employed in this study are made explicit.

The primary assumption is that population growth is the normal condition of humanity (Boserup 1965:11; Kunstadter 1972:348). This appears evident by global estimates of human population growth rates for the past million years (Deevey 1960; Hassan 1973:538). Despite potential for rapid population increase (Hassan 1973, 1975b, 1981; Wobst 1974), hunter-gatherer populations are recognized by many anthropologists as being maintained well below carrying capacity levels (Hayden 1972:205, 1975:11). Hunter- gatherer population is culturally regulated by three proximate causes: (1) small optimum group size (Hayden 1972; Hassan 1981:144-145), resulting as a process of social fission (Logan and Sanders 1976:33-35, 52-53); (2) low optimum

child/adult ratio, because of nutritional and economic burdens of children (Hassan 1981:146); and (3) prolonged optimum child-spacing interval, related to considerations of frequent spatial mobility (Lee 1972; Sussman 1972; Hassan 1981:147). However, much of the data on hunter-gatherer population dynamics are derived from groups living in marginal environments, and inferences must be viewed with caution. Population growth rates are acknowledged to be regionally and temporally variable (Cowgill 1975b:128; Cohen 1977:189), consequently, the use of population pressure in explanatory frameworks must rely on local data.

A second assumption involves the relationship of population growth and cultural change, particularly subsistence related technological change. Dumond (1965:302) has stated that "population growth is not a simple effect of cultural change but is both a cause and effect of that change." It is agreed that the relationship between population growth and cultural change is reciprocal and mutually interdependent (Cowgill 1975c:516; Hassan 1975b:46; Logan and Sanders 1976:33; Boserup 1981:ix). However, the rate of population growth is considered to be more a determinant of cultural change than a consequence of that change (Boserup 1965:11; Smith 1972:5; Cohen 1980:279). Therefore, it is recognized that demography has effects on ecology, settlement patterns, and social structure (Kunstadter 1972:314). These effects are discussed following the development of specific data on Archaic period demographic trends in the central Duck River Basin.

Numerous authors have recognized a general trend of population increase during the Archaic period of Eastern North America (Ford

1974:392-393, 1979:236; Cohen 1977:189; Brose 1979:3-5; Stoltman 1979:715; Walthall 1980:58). This notion is generally derived from subjective literature review. Recognition of potential variability in regional population trends requires the development of empirical methods of population assessment at the regional level. Cowgill (1975c:511) has noted that determining population densities from archaeological data is problematical, but that relative growth rates can be reliably established. Hassan (1978) has reviewed several archaeological sources and methods for obtaining prehistoric demographic data.

The method of determining relative population density in this study is based on the "parameter count" technique described by Cohen (1975:471-472, 1977:71-84, 1980:276). The number of units of some parameter (e.g. houses, sites, projectile points) are counted and considered representative of population at a point in time. Parameter counts are compared for two or more time periods to estimate relative population densities. Two major assumptions are made: (1) "there is a fixed (though often unspecified) relationship between units of the parameter and the number of individuals in the population" and (2) "contemporaneity can be established for the various units counted" (Cohen 1975:471). Primary sources of potential error are: (1) the assumption of a fixed relationship between population and the parameter, especially the diachronic stability of this relationship; (2) difficulty in establishing the degree of contemporaneity of the units; and (3) sampling error variability between time periods. As Cohen (1975:472) notes, these problems are further compounded with highly mobile hunter-gatherer groups which often generate low density scatters that are

difficult to locate. A "parameter count" method of population estimation has been successfully employed by Turner (1978) on the Virginia Coastal Plain.

The methods employed in this study attempt to alleviate potential error sources, but certain biases are acknowledged. The data are derived from figures provided by Klippel and Turner (1983). Projectile points/ knives are the parameter which is counted. This artifact class is recognized as chronologically sensitive, therefore, errors in establishing the degree of contemporaneity are minimized. This projectile point/knife sample was obtained by intensive systematic surface collection of Cheek and Cannon Bends in the central Duck River Basin. It is recalled that Cheek Bend represents typical Inner Nashville Basin habitat, while Cannon Bend is more characteristic of Outer Nashville Basin habitat. The area surveyed consists of 8-9 square kilometers in each bend. Nonsite survey methods (Thomas 1975) were employed minimizing errors induced by failure to recognize low density scatters and reliance on the site as unit of observation concept. The greatest potential error is the assumption of a constant relationship between projectile points/knives and population size through time. Organizational variability in technology or settlement-subsistence could alter this ratio. However, this bias is acknowledged and the assumption must be made in order to evaluate local demographic processes. Finally, sampling error variability is also acknowledged. In particular, the data set fails to account for upland locations, buried floodplain sites, and cave/rockshelter occupations. However, Klippel and Turner (1983)

have suggested that buried floodplain site patterns are not significantly different from surface site patterns.

An occupational intensity index is developed to represent relative population density. This index is derived from the number of projectile points/knives per square kilometer divided by the period duration in thousands of years. Projectile points/knives were assigned to temporal periods based on generally accepted morphological/chronological criteria. The Paleoindian period is conservatively estimated as two thousand years long (ca. 12000-10000 B.P.). Early Archaic is considered to be three thousand years (ca. 10000-7000 B.P.). The Middle Archaic duration is two thousand years (ca. 7000-5000 B.P.). Late Archaic/Early Woodland is considered to be three thousand years (5000-2000 B.P.). Figure 7.1 illustrates the results of these calculations. There appears to be an overall trend of Archaic population growth in the central Duck River Basin. However, growth rates vary between temporal periods, physiographic areas, and their interaction. Cheek Bend exhibits higher occupational intensity throughout the Archaic period. This may reflect a higher carrying capacity potential for patchy cedar glade environments (Cheek Bend) over homogeneous mixed mesophytic environments (Cannon Bend) in the Nashville Basin. Differences in occupational intensity are greatest between the two areas during the Middle Archaic period. Cannon Bend exhibits stable if not slightly declining population density while Cheek Bend occupational intensity nearly triples. It is suggested that this represents Middle Archaic population "packing" in the Inner Nashville Basin region. This concept is derived from Binford's (1983a:42-43, 50-51, 1983b:210-213) "packing model." Hunter-gatherers

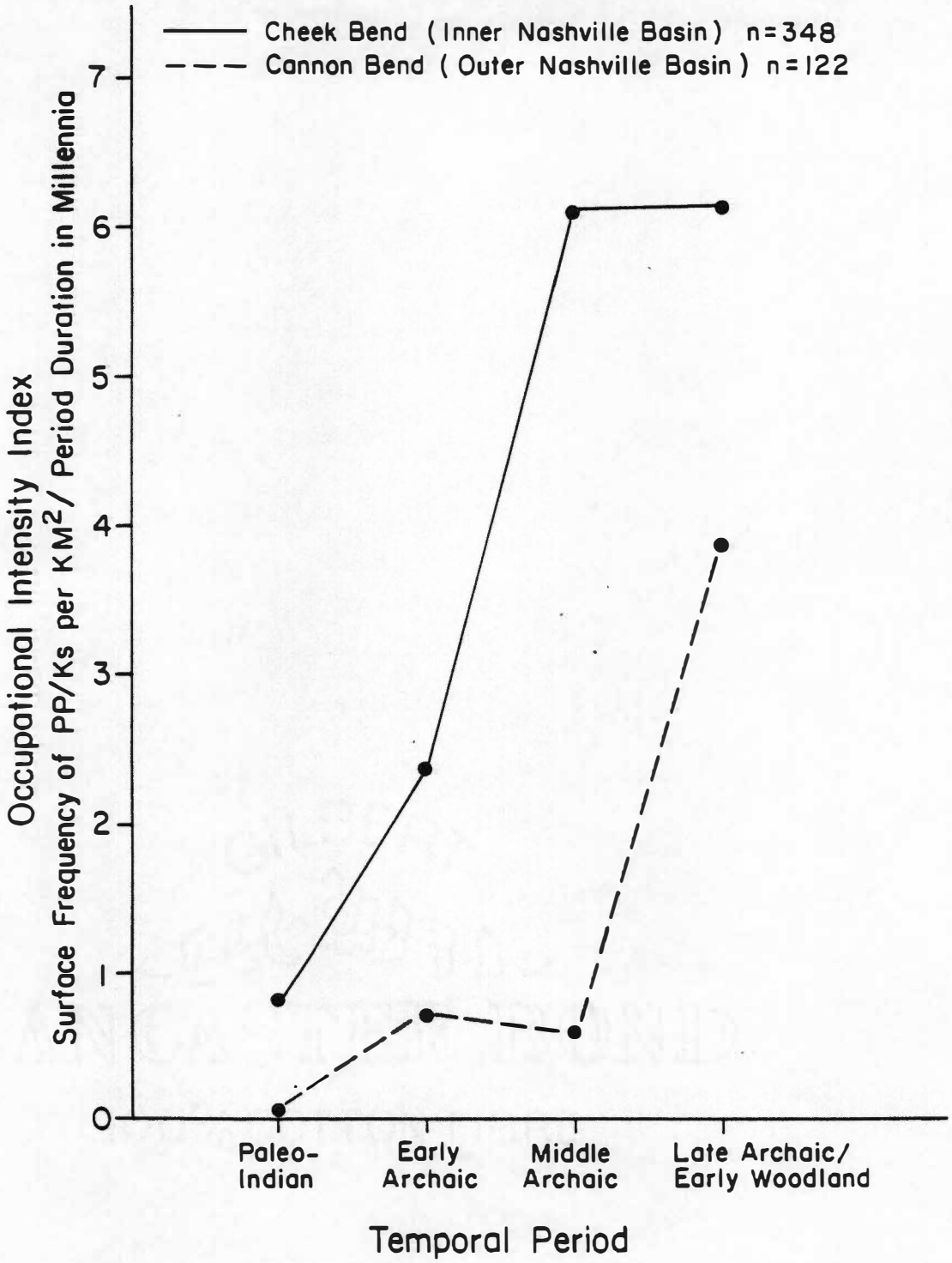

Figure 7.1. Relative occupational intensity (population density) of Cannon Bend versus Cheek Bend throughout the Archaic Period.

are recognized to operate under a settlement system type of alternative annual ranges. Binford (1983a:42) notes "this type land use pattern means that the 'population density' when viewed from a regional perspective is very small." Consequently, deterioration of white-tailed deer habitat in the Highland Rim and Outer Nashville Basin mesophytic forest, concomitant with enhancement of Inner Nashville Basin patchy habitat during the mid-Holocene, promoted more intensive land use of the Inner Nashville Basin by Middle Archaic peoples. Flexibility of regional population distributions is often dismissed by prehistorians who assume a saturated situation. This is a false assumption; "the fact is that the scale at which many archaeologists tend to think of land use by hunter and gatherer populations is not just amusing, it is totally misleading" (Binford 1983a:43).

The Late Archaic/Early Woodland growth rates exhibit a reversal of this trend. Occupational intensity hardly increases in Cheek Bend but it quadruples in Cannon Bend. It is suggested that this reflects ameliorating conditions in the hardwood forest coupled with cedar glade retreat. Focus of population expansion and occupational intensification is redirected to the Outer Nashville Basin and Highland Rim following the Middle Archaic period.

The pioneering work of Birdsell (1953, 1968, 1975) has empirically demonstrated that hunter-gatherer population density is extremely highly correlated with food resource density. The ecological potential for high food resource density (measured by rainfall) and its correlation to hunter-gatherer population density has been substantiated by other researchers (Hainline 1965; Martin and Reed 1981; Vorkapich 1981). The

relationship between population and resources has been expressed in many terms. Christenson (1980:36) considers resource diversity to be a greater factor in this relationship than resource density. Hayden (1981a:362) suggests that group size is related to resource density and the proportion of meat included in the diet. Although variability in the exact formulation of this relationship is acknowledged, it is accepted that "population is limited by resources and regulated by cultural mechanisms" (Hayden 1972:207). Hassan (1980:316) has described this limitation quite well:

> Population growth in preagricultural prehistoric times was on the average very slow. This was not a result of a biological low reproductive potential, but a consequence of the low potential for economic growth under hunting-gathering conditions. The hunters were not as much limited by their technology as by the limited yield of wild resources and the spatial scatter and seasonal variations in the availability and abundance of wild game and plants.

The relationship of resources to population density is an integral part of Binford's "packing model." Binford and Chasko (1976:142-143) suggest that demographic change is ultimately dependent upon variations of: (1) resource nucleation, (2) environmental change toward more mature ecosystems characterized by lower secondary biomass, and/or (3) population density thresholds leading to reduced effective resource space and increased plant resource dependence. These changes in resource base structure are expected to lead to shifts in labor organization and diet producing fertility changes and consequently demographic changes (Binford and Chasko 1976:142-143, see also Binford 1983a:50-51, 1983b:210-213). Changes in labor organization, subsistence, and fertility are considered later in this chapter.

Fluctuation in the population density: resource relationship can lead to system disequilibrium situations referred to as "stress" (Cohen 1977:4). Stress becomes more likely as a population nears maximum carrying capacity of the environment (Hassan 1978:76). Imbalance between population and resources has been termed "population pressure" (Smith 1972:7; Cohen 1977:50) and alternatively "resource stress" (Hayden 1981b:522). Stress in this study is considered to be

> nothing more than an imbalance between a population, its choice of foods, and its work standards, which forces the population either to change its eating habits or to work harder (or which, if no adjustment is made, can lead to the exhaustion of certain resources) (Cohen 1977:50, emphasis omitted).

The primary causes of stress are decreases in resource diversity, density, and/or stability (Hayden 1981a:413). This decrease in the food base is generally related to climatic deterioration (Hassan 1975b:45). In addition to stress resulting from external environmental sources, internal environmental factors may also contribute to system disequilibriums.

> It may well be that the size and density of hunter-gatherer groups was limited because their social organization, which at first appears so mobile and stress-free, is relatively inefficient at minimizing the impact of growing population on existing role definitions and on existing privacy and control needs (Cohen 1980:298).

Environmental and demographic evidence provided for Archaic times in the central Duck River Basin indicates stressful conditions. Food resource base deterioration and population increases during the Middle Archaic required mitigating responses. Population packing in the Inner Nashville Basin appears to have been one such response. Subsistence,

settlement, and social organization provide further areas of inquiry concerning response to stress and cultural change.

> Granting that stresses of various types are sources of motivation for change in the past (and the present), the challenge for theory building is to identify the character of the stress as related to various modes of organizational change (Goodyear 1981:533).

Consideration of regional stress, responses, and organization changes follows.

Subsistence Strategy

Three interrelated subsistence strategies have been recognized to result from stresses caused by population pressure/environmental change. These are intensification of subsistence techniques, broadening the spectrum of exploitable resources, and including less nutritious and less desirable ("second-line") food items in the diet. Although discussion of these strategies is separate, it is emphasized that they are interrelated.

The dependent relationship of intensive subsistence techniques on population growth was popularized by Boserup (1965). She has noted a positive relationship between population density and the intensity of the food supply system (see also Boserup 1981:15-31). Boserup (1965:43) defines intensification as the more frequent use of a given area of land which also requires more labor output. The relationship of population to subsistence strategy has primarily concerned agriculturalists (Smith 1972:6) and measurement of subsistence strategy is often confused with subsistence means. These distinctions are critical and operationalization is imperative (see Logan and Sanders 1976:37

regarding this point and for an alternative view). Land-use patterns are considered to be subsistence strategies. Subsistence means are regarded as the diversity of resources exploited, these are discussed later.

Intensive land-use is characterized by increased expediture of labor and more dense coverage of a spatially limited range. This strategy is opposed by extensive land-use which is characterized by minimal labor expediture and coverage of a wide spatial range. These definitions appear to agree with Boserup (1965:43). Dumond (1965) also recognized the relationship of population growth to subsistence strategy intensification. The primary means of increasing the subsistence output are expansion to new territory and, if environmentally circumscribed, intensification tactics (Dumond 1965:311, 1972a:325-326, 1972b:286, 306; see also Logan and Sanders 1976:33-35).

An important consequence of intensive subsistence strategies is increasing the diversity of food resources which are exploited. Flannery (1965) first coined the phrase "broad spectrum revolution." Since that time, it has been suggested that "broad spectrum depression" may be more appropriate (Binford 1983b:212). Increasing the diversity and amount of resource exploitation is recognized to be a response to stress (Hassan 1978:77-80; Hayden 1981a:416, 1981b:523). Exploitation of a diversity of resources is considered to increase resource stability and is thus viewed as an adaptive strategy during periods of resource stress (Hayden 1981a:398-403, 1981b:523). Cleland (1976) has alternately characterized subsistence economies as focal and diffuse, this generally corresponds with the narrow and broad spectrum notion.

Christenson (1980:34-37) suggests that "niche width" (proportional evenness of species) must be considered in addition to simple resource diversity (numbers of species). Among preagricultural groups, Christenson (1980:36-37) proposes the following model.

> At low densities a population will specialize upon a few low-cost resources. The food niche will be narrow and of low diversity, and the efficiency of labor in subsistence will be high. As the population grows, the use of these first resources will be intensified and new higher-cost resources will be added. The food niche is now broader and more diverse, and the efficiency of labor in subsistence is lower.

It is suggested that this model accurately describes Early to Middle Archaic times in the Inner Nashville Basin.

An important corollary of diverse "broad spectrum" resource exploitation is the increased use of calorically dense, but less nutritious and less desirable ("second-line") food items. Hayden (1981a:416) refers to these as "microedibles." These resources are typically smaller, more stationary food sources which often require labor intensive procurement tactics (Smith 1972:9-10; Cohen 1975:472-474, 1977; Boserup 1981:33; Binford 1983a:50, 1983b:211-213). An excellent example of such resources include aquatic molluscs. The poor nutritional value of shellfish suggests that they are not a preferred food item (Parmalee and Klippel 1974; Osborn 1977:172). As such, the intensity of aquatic mollusc exploitation is suggested to measure the degree of stress existing among Archaic period groups in the central Duck River Basin. It is emphasized that aquatic resource exploitation patterns differ between coastal and inland areas.

Although data on regional subsistence strategies are rather limited at the present, some interesting patterns are emerging. Hofman (1983)

reports on abundant shellfish remains at the Ervin Site (40MU174). This site is located near Duck R.M. 171 and is Middle Archaic in age. Three radiocarbon dated components are associated with the shell midden at Ervin: Eva-Morrow Mountain dated at 6645±185 B.P. (GX-9082), White Springs-Sykes at 6115±205 B.P. (GX-8918), and White Springs-Sykes/Benton at 5765±200 (GX-8917) (Hofman 1984). Klippel and Turner (1983) have reported on a similar midden, the Hayes Site (40ML139) located near Duck R.M. 177. Hayes possesses three radiocarbon dated components: White Springs-Sykes dated at 5870±165 (GX-9081), Benton at 5245±230 (GX-9315), and Ledbetter at 4270±155 (GX-9080). Aquatic resource exploitation is marked among the two Middle Archaic components. In contrast, the Late Archaic Ledbetter component exhibits an absence of shellfish with increased focus on white-tailed deer. Klippel and Turner (1983) suggest this represents post-hypsithermal climatic amelioration and recovery of upland environments. It is asserted here that population packing in the Inner Nashville Basin caused by environmental changes associated with the hypsithermal interval led to subsistence stress illustrated by local Middle Archaic shellfish exploitation. The return to a more limited spectrum economy during Late Archaic times demonstrates that increasing resource diversity is reversible under stable environmental conditions (Hayden 1981b:523; Dunnell 1981:533; see also Ford 1977:156 regarding principles of living systems).

Subsistence trends are expected to vary substantially across regions. However, similar Middle Archaic diffuse patterns have been noted by Ford (1977:171-174) and Brose (1979:5). Narrow spectrum economies have been suggested for Late Archaic peoples by Winters

(1974:x), Ford (1977:174-175), and Walthall (1980:38-40). Nonetheless, it is stressed that subsistence strategies are expected to be highly localized adaptations.

Settlement Systems

Aspects of settlement systems are highly interrelated and complex variables to decipher. Discussion of settlement systems centers around mobility. The types and relative degree of mobility are important considerations. Residential versus logistical mobility are particularly significant distinctions. Theoretical implications are compared to the observed patterning for evaluation and further inference. Archaeological data from previous studies of the central Duck River Basin and adjacent regions are contrasted with this study.

Binford's (especially 1978a, 1980, 1982) development of settlement organizational principles focuses on the roles of residential and logistical mobility. These notions have been extensively employed in this analysis. Despite considerable attention by recent prehistorians, the concept of mobility requires dimensioning. Borrowing from the population movement models of Harrison and Boyce (1972:131), four spatial components are recognized: distance, magnitude, orientation, and direction. Reher and Frison (1980:121-135) have used lithic raw material analysis to determine similar components of mobility. Unfortunately, lithic resource distributions are not limited enough to allow accurate determination of these components in Middle Tennessee. The frequency of moves and duration of occupations are critical temporal components of mobility. Measuring the relative degree of group

sedentism is dependent upon these variables. It is usually in the context of relative sedentism or degree of habitation permanence that mobility is discussed archaeologically. As such, mobility and sedentism form endpoints of an oversimplified movement continuum. In addition to the components of mobility noted above, the distinction between residential and logistical forms of mobility must be considered (Harris 1977:407; Hitchcock 1982:258; Kelly 1983:278).

> Residential mobility consists of the movement of a co-resident group including both producers and dependents, from one location to another. Logistical mobility is characterized by either the producers of the group ranging out from a location for subsistence procurement purposes while dependents stay at home, or a specialized group leaving a residential location for purposes of carrying out a specific task, visiting, or environmental monitoring (Hitchcock 1982: 258).

This distinction is critical, since as Harris (1977:407) notes, significantly different demographic and socioeconomic implications result.

In this analysis, it is proposed that Middle Archaic groups exhibited high rates of residential mobility and low rates of logistical mobility. Furthermore, these patterns are suggested to display a reversal during Late Archaic times. Primary constraints on mobility are the differential availability of resources in time and space. Mobility increases as resources become sparse, limited in diversity, and unpredictable leading to lower caloric intake (Hassan 1973:535-536; Binford and Chasko 1976:90; Harris 1977:407-409; Hayden 1981a:378). Decreasing resource availability is correlated with a high frequency of residential mobility and a decreased average distance of moves (Kelly 1983:295). Resource deterioration associated with the hypsithermal

interval led to Middle Archaic population packing in the Inner Nashville Basin. Mobility options were reduced because of an increased number of groups in the habitat and competition for resource space.

Self-amplifying mutual feedbacks were established. The extent and duration of male logistical mobility was curtailed with an accompanying positive feedback effect on fertility. Binford and Chasko (1976:122) recognize this as the negative effect of "male absenteeism" on conception frequency. Reduced resource availability, population packing, and reduction of mobility options led to more frequent local resource exploitation. Male absenteeism was reduced, nuclear families were together for longer periods, the average interval between births was reduced, and population increased.

> At the same time the shift to a more localized but broader-spectrum pattern of resource exploitation demanded more frequent residential moves and a greater work input to the food quest, which was provided for by the larger population (Harris 1977:409).

Group size is recognized to be larger among more mobile bands (Hayden 1981a:379; Hitchcock 1982:251). Larger groups are expected to exhaust the foraging radius more rapidly and force more frequent group moves (Hayden 1981a:360). Cleland (1976:64) notes that the conflict between high mobility and maintenance of large tool inventories can be solved by the development of expedient technologies. Middle Archaic groups in the central Duck River Basin are implied to exhibit the characteristics discussed above.

Ancillary sites with increasing assemblage content homogeneity suggest increased sedentism during the Late Archaic period (see Binford 1982:20). An increased dependence on large fauna (i.e., white-tailed

deer) and less intensive exploitation of local resources suggests an increase in extensive logistical mobility (Binford 1980:10; Hunn 1982:23, 35, 37; Kelly 1983:296-298). Raw material procurement activities embedded in extended logistical trips provides further evidence of mobility pattern change. Increased degrees of logistical organization suggest greater magnitude of residential mobility (Binford 1982:20). However, the frequency of residential moves is reduced as a response to the need for maintaining extensive logistical mobility (Kelly 1983:301). Reduced frequency of residential mobility is associated with decreased local group size (Hayden 1981a:379; Hitchcock 1982:251-252). These characteristics are inferred for central Duck River Basin Late Archaic groups.

The Archaic period of eastern North America is regarded to reflect increasing regionalization of settlement-subsistence patterns (Muller 1978:285-286; Brose 1979:5). Nonetheless, a general trend of reduced mobility throughout the Archaic period is recognized (Ford 1974:392-393, 1977:172, 1979:236; Muller 1978:287; Brose 1979:5; Walthall 1980:70). Another hallmark of the Late Archaic period of Eastern North America is the marked increase in long distance trade. Ford (1977:176) suggests that this long distance trade facilitates two functions, the redeployment of resources and allocation of time, and regulation of the distribution of people between groups. These functions alleviate problems of increasing population.

> widespread utilization of particular non-local sources of stone for tool manufacture, combined with the localization of settlement-subsistence activities, suggests the development of some form of prehistoric exchange. In addition to the widespread distribution of specific lithological materials,

> there is a bewildering array of stylistic variations for functionally similar tool types within a single ecological region (Brose 1979:5).

Brose (1979:6-8) proposes that projectile point stylistic variation and lithological keying during the Late Archaic are results of ethnic subpopulations of the same culture. The development of ethnic boundary differentiation is suggested to "stabilize seasonally competitive interaction between otherwise economically self-sufficient groups" (Brose 1979:6). As such, exchange is considered to be a means of "subsistence insurance." Although these notions of Late Archaic exchange provide greater understanding of intraregional relationships, they are not readily applicable to the central Duck River Basin data. The magnitude of distance over which lithic materials are circulating in Middle Tennessee is simply not great enough to discount logistical task group extraction and presuppose trade mechanisms. The exact mechanisms of prehistoric stone procurement are indeterminable, but interassemblage patterning of central Duck River Basin Late Archaic sites is indicative of logistical procurement organization.

It is appropriate at this point to consider previous investigations of settlement patterning within the study area. Dickson's (1979:120, 126-129, see also 1976:609) study concluded that sites were randomly located in relation to the environment and that settlement patterns did not change through time. These deductions stem from several erroneous assumptions including: (1) environmental stability through time, particularly during the Middle Archaic period; (2) accuracy and representativeness of the field survey and sampling techniques; and (3) the appropriate selection and accurate measurement of analytical

attributes (see Dickson 1979:115-118). The demographic trends reported by Dickson (1979:122-123) suggest increasing population during the Archaic. However, failure to recognize environmental differences noted in this study cause fundamental inaccuracies in Dickson's conclusions.

Johnson (1977) has proposed an alternative solution to central Duck River Basin settlement patterning. His primary thesis is an objection to Dickson's conclusion of random site distribution and suggests that,

> The distribution of temporally diagnostic artifacts in the Columbia reservoir . . . has little relationship to contrasting environmental zones . . . . differential environmental exploitation should be reflected in the composition of the artifact assemblages from sites in contrasting environmental zones (Johnson 1977:142).

Johnson (1977:146-149) proceeds to demonstrate significant interassemblage patterning based on site location (e.g., floodplains, terraces, and uplands). Unfortunately, his conclusions are marred by two major flaws: (1) reliance on Dickson's (1976) data with the assumption that it is accurate and representative, and (2) misunderstanding of regional geologic and geographic parameters. In addition, he fails to consider temporal change. Nonetheless, Johnson's (1977:146-149) conclusions are stimulating. Quarrying of Fort Payne chert is suggested to have been an important upland activity (Johnson 1977:146). This is implied by high proportions of decortication flakes, early reduction stage bifaces, and cores. It appears more likely that this debris resulted from extraction and early stage reduction of Ordovician Ridley and Carters cherts which commonly occur in Inner Nashville Basin upland contexts. Ancient terrace gravels are available in the uplands adjacent to the valley slope/terraces and were probably

exploited as well. Although Johnson (1977:146-149) distinguishes assemblage patterning between floodplain and terrace sites, lack of geomorphological understanding suggests that these differences should be viewed cautiously.

Consideration of Middle and Late Archaic activities in the Fort Payne uplands of the Highland Rim and Outer Nashville Basin is greatly facilitated by Johnson's (1981a, 1981b, 1982) work near Yellow Creek in northeast Mississippi. Settlement patterns observed in the Yellow Creek uplands may not be representative of Fort Payne exploitation throughout the Highland Rim, but they provide the best available data. In addition, the similarity of the Topsy (40WY204) assemblage to assemblages from sites located on the Yellow Creek floodplain lends support to the notion of an analogous upland situation. Topsy (40WY204) is located on the narrow floodplain of the Buffalo River surrounded by Fort Payne uplands. Chert exploitation focused on Fort Payne river cobbles; procurement and initial reduction activities apparently occurred on the gravel bars with intermediate and late stage reduction being performed at the site (Amick 1982:35). Johnson (1983:35) reports an identical situation from sites 22TS1529, 22TS1530, and 22TS1531 on the narrow Yellow Creek floodplain adjacent to the Fort Payne uplands.

Johnson (1981a, 1981b, 1982) has proposed a Fort Payne upland settlement pattern shift from Middle to Late Archaic times. During the Middle Archaic,

> different steps in the biface production trajectory were performed in different locations. Quarrying and preliminary shaping were carried out in the immediate vicinity of the outcrops (Class IA) while the bifaces were completed elsewhere (Class III). Note that this trajectory is incomplete,

> stopping short of utilization and rejuvenation (Johnson 1981a: 175, see also 1981b:175, 1982:192).

Johnson (1981a:175, 1981b:175-177, 1982:192) has variously characterized the Middle Archaic upland settlement pattern as structured and exhibiting narrow site specialization evidenced by short trajectory segments. In contrast, the Late Archaic displays simplification of upland settlement patterning with less site specialization characterized by small long trajectory sites. It has been suggested that "the simplification of the upland pattern which marks the Late Archaic occupation of the Yellow Creek area may be the result of an increasing emphasis on floodplain resources" (Johnson 1981b:175). The Late Archaic shift to the river bottoms is considered to reflect a greater reliance on native cultigens and to foreshadow later horticultural adaptations (Johnson 1981b:175-177). However, the paucity of regional subsistence data emphasizes the speculative nature of this conclusion.

The comparison of Yellow Creek and central Duck River settlement patterns is difficult to assess. Several alternative explanations can be produced. More structured Middle Archaic settlement patterning in the Fort Payne uplands may reflect a logistical strategy. This may suggest that central Duck River Basin Middle Archaic sites have been misinterpreted. On the other hand, this may reflect settlement organization differences based upon local environmental parameters. Greater logistical organization might be expected in the deteriorating hardwood forest of the Highland Rim during the hypsithermal interval. All Middle Archaic assemblages in Middle Tennessee cannot be expected to resemble those in the Inner Nashville Basin. Short trajectory

assemblages may also reflect expedient technology and short occupation spans determined by high frequencies of residential site movement and consequent settlement instability. Correspondingly, the greater extent of Late Archaic logistical mobility and greater stability of residential locations may have allowed longer occupation spans at logistically used sites resulting in long trajectory assemblages. Alternatively, the greater scale of Late Archaic residential mobility may have promoted differential use of a place because of its "different economic potential relative to the sequence of base camp moves" (Binford 1982:12). Reoccupation of sites for different purposes could produce longer trajectory assemblages. Finally, the Yellow Creek upland data may not be representative of the Highland Rim. The position of this chert abundant location adjacent to thousands of square kilometers of extremely chert resource poor Coastal Plain to the south and west may produce unique settlement patterning. Overall, comparison to the Yellow Creek data is inconclusive.

Jefferies (1982b) has recently described Middle to Late Archaic transition in Southern Illinois. Although regional resource configurations are again distinct from the central Duck River Basin, Jefferies' interpretations are intriguing. Middle Archaic occupations are characterized by intensive and diversified activity suggesting a wide range of tasks, and a diverse food resource inventory including heavy reliance on aquatic resources. This is viewed as a response to environmental conditions caused by the hypsithermal interval. Seasonal variability of Middle Archaic settlement is more restricted and increased sedentism with year-round occupations is suggested.

Amelioration of upland conditions following the hypsithermal interval allowed more intensive exploitation of these areas by Late Archaic groups and attendant greater population dispersal. The differences between Jefferies' (1982b) and Johnson's (1981a, 1981b, 1982) interpretations of Middle to Late Archaic transition and those presented in this study emphasize the consideration of local environmental conditions/configurations and variety in adaptive responses.

Social Organization

Changes in social organization egalitarianism are correlated with population density and mobility. The degree of political and social organization complexity and integration seem directly correlated with population density. Development of occupational specialization and task groups also appears related to population density. However, the interrelated division of labor parameter seems more directly correlated with mobility and subsistence factors. Consideration of the degree to which populations are bounded units is also important.

Logan and Sanders (1976:32) have noted that "as a society increases in size, it must change its structure in order to function as a social system." The correlation of increasing social/political organization complexity with population density increases has been empirically demonstrated by Birdsell (1957) and Carneiro (1967). This relationship exhibits mutual reinforcement. Hassan (1975b:38) suggests that increased social coherence enhances further population growth because of better resource management and redistribution systems. Increases in population are expected to result in increased complexity of social

integration and political coherence (Logan and Sanders 1976:33). The nature of this relationship has been expressed in various terms, but is usually considered to be a result of subsistence changes associated with population growth (Dumond 1965:307-313, 1972b:306; Harner 1970:68-69). Population pressure due to a scarcity of subsistence resources leads to competition, therefore, the evolution of land control mechanisms and organization occurs (Harner 1970:68-69). Evolution of greater social structure complexity is marked by political integration, political complexity, and class stratification (Harner 1970:76-84). Among egalitarians, political centralization characterized by ranking develops (Dumond 1972b:306). Smith (1972:9) has suggested that status differentiation, decline in egalitarianism, and culture change and differentiation can be expected among hunter-gatherer groups experiencing population pressure.

Occupational specialization and task group development are also associated with population increase. Dumond (1972a:327) suggests this may originate with subsistence related duties. Cowgill (1975c:516) notes that the circulation of goods and services, redistribution, and at least part-time specialization were probably major factors influencing culture change and demographic trends before the development of agriculture. Sedentary residence, differential access to goods, and competition encourage economic organizational change toward occupational specialization (Logan and Sanders 1976:47). Specialization, competition, and expansion of redistributive networks result in mutual positive feedbacks increasing the complexity and institutionalization of political controls and the degree of social stratification or ranking

(Logan and Sanders 1976:48-49). The role of sedentism in occupational specialization is also stressed by Hitchcock (1982:252):

> The rise of specialized social and economic roles with sedentism would reinforce trends toward increasing social complexity. Organizational changes in labor, especially in terms of an increase in complexity, have social consequences, including the rise of economic specialists.

Harris (1977:411) also equates social differentiation with sedentary trends.

A primary attribute of economic organization is the division of labor by sex and age. Labor differentiation appears more directly related to mobility parameters, but environmental/subsistence factors are also influential. Mobile foragers exhibit a high degree of sexual egalitarianism and little chore differentiation (Draper 1975:78, 90). This lack of sexual specialization reflects a practical need for mobile groups to retain a higher degree of organizational flexibility. As groups become more sedentary, labor time increases and tasks become more differentiated (Hitchcock 1982:250). Increased sedentism is characterized by increased rigidity of defined sex roles, decreased female mobility relative to males, and greater importance of child labor (Draper 1975:78-100). Hayden (1981a:405-406) indicates that the degree of sexual division of labor is less pronounced in harsher habitats but varies directly with the subsistence importance of hunting. In terms of division of labor by age, it is suggested that "more work is done by more people in harsher environments" (Hayden 1981a:407) and "the degree to which subadults participate in subsistence activities reflects the exploitation pressure being placed on the resource base" (Hayden 1981a: 406; also see Lee 1968:36-40). As sexual labor differentiation

increases with sedentism, male absenteeism increases (Draper 1975:102-103). Binford and Chasko (1976:122) recognize male absenteeism as a primary form of cultural regulation of fertility for sedentary groups.

Brose's (1979:6) proposal of ethnic boundary differentiation during the Late Archaic period suggests bounded territorial homogeneous population units. Wobst (1976, 1977, 1978:307; also see Binford 1973) has suggested that bounded units are likely to evolve only under very unusual ecological circumstances and then only in a weakly developed form. Residential group flexibility, mutual resource use, and multiple resource exploitation make it difficult to determine bounded territorial units (Hunn 1982:19). Kunstadter (1972:346) states that small hunter-gatherer populations are usually heterogeneous populations with permeable boundaries. Populations within the same geographic space may exhibit distinct gene pools, different mate selection patterns, different migration patterns, and different environments and selective pressures.

Regional archaeological syntheses suggest a trend toward less egalitarian society throughout the Archaic period. More pronounced division of labor and economic/craft specialization is suggested during the Late Archaic period (Winters 1974:x; Ford 1979:236). Static/traditional division of labor is characteristic of focal subsistence economies (Cleland 1976:62), such as the Late Archaic of the central Duck River Basin. Ford (1977:174) suggests that more people participated in broad spectrum subsistence activities during the Middle Archaic. Although adult males continued to hunt, adult females and children increased gathering activities to include a greater variety of

resources (e.g., freshwater mussels and gastropods). This may have occurred during the Middle Archaic period in the central Duck River Basin. Perlman (1981:26) infers that Late Archaic focus on particular lithological materials in the James River Valley of Virginia reflects better redistribution systems indicative of less egalitarian conditions. A similar conclusion is applicable to the Late Archaic evidence from the central Duck River Basin.

Discussion and Summary

In general, the inferences derived from the interassemblage lithic analysis are corroborated by independent environmental and demographic data and their theoretical implications. The interrelated nature of the many variables discussed is emphasized. The lithic analysis suggests a more logistically organized settlement system during Late Archaic times in the central Duck River Basin. Less frequent residential mobility and more extensive logistical mobility are inferred. The scale of residential mobility may have increased. Technology is characterized by labor differentiation. Less expedient organization marked by structured task groups and craft specialization is apparent. Egalitarianism decreases as political and social organization increases in complexity and integration.

The Middle Archaic period is determined by the lithic analysis to reflect high rates of residential mobility and expediently organized technology. Stresses derived from population packing in the Inner Nashville Basin and resource deterioration (particularly in the Outer Nashville Basin and Highland Rim) associated with the hypsithermal

interval affected Middle Archaic organizational strategies. Mobility was restricted and broad spectrum subsistence economies developed. Residential groups may have increased in size. Egalitarianism and low degrees of labor differentiation allowed the flexibility required to maintain high mobility.

The development of a model of changing organizational strategies in this study emphasizes the utility of lithic raw material variability analysis. Any consideration of prehistoric lithic technology must begin with a solid understanding of regional resource configurations. Accurate identification methods and distributional measures are critical. Analysis of debitage and biface reduction trajectories is also important to understanding the interaction of technology and settlement. Linking the static observations of lithic interassemblage variability to the dynamic processes of cultural behavior is a critical and difficult task. This is essential for the development of anthropologically meaningful investigations. Hopefully, more middle-range research will be conducted regarding cultural site formation processes in the future. This study is a testimony to the importance of such research. It is believed that this investigation has contributed greatly toward understanding Middle and Late Archaic cultures in the central Duck River Basin. Consideration of additional assemblages from within and adjacent to the study area is recommended for further resolution of the patterns observed.

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APPENDICES

APPENDIX A

CHERT RESOURCE SURVEY SITES

Table A.1. Compendium of 1:24,000 Geologic Quadrangles (GQ) and Mineral Resource Summaries (MRS) employed in the lithic resource survey.

Quadrangle Name	GQ Number	Year Published	GQ Author(s)[a]	MRS Author(s)[a]
Belfast	72-NW	1964	N,B	B
Campbells Station	65-NW	1964	J	B
Carters Creek	64-NW	1963	A	F
Chapel Hill	71-NW	1963	N,M	L
Columbia	57-SE	1964	N,G,M	E,L
Farmington	71-SW	1963	N	L
Glendale	64-SW	1963	N,M	E
Godwin	57-NE	1963	C	F
Gordonsburg	50-SW	1964	D,K	D
Greenfield	50-NE	1965	N,M	M
Henryville	51-NW	1965	K,I	H
Lewisburg	65-NE	1963	N,J	L
Mt. Joy	50-SE	1965	N,B,M	M
Mt. Pleasant, Tenn.	57-SW	1964	M,N	F

Table A.1. (continued)

Quadrangle Name	GQ Number	Year Published	GQ Author(s)[a]	MRS Author(s)[a]
Rally Hill	64-NE	1963	N,M	E
Riverside	42-NE	1962	N,K	D,B
Topsy	42-NW	1963	N,K	D,B
Verona	64-SE	1963	N	L
Williamsport	57-NW	1964	N,B,M	F

[a] Author key: A - Alexander, Frank M.; B - Barnes, Robert H.; C - Burwell, H.B.; D - Colvin, John M., Jr.; E - Hershey, Robert A.; F - Jewell, John W.; G - Kirkby, James P.; H - Larson, Lawrence T.; I - Lounsbury, Richard E.; J - Luther, Edward T.; K - Marcher, Melvin V.; L - McCary, Charles E.L.; M - Miller, Robert A.; N - Wilson, Charles W., Jr.

Table A.2. Chert survey location descriptions.

Formation	Geologic Quadrangle	Location	U.T.M. Coordinates (Zone 16) Northing	Easting	Elevation (m AMSL)	Source Type[a]	Chert Presence
Carters	Campbells Station	ls 4	382,100	1,738,900	238	a	No
Carters	Lewisburg	ls 6	384,200	1,757,200	250-256	a	No
Carters	Lewisburg	ls 7	360,850	1,755,200	262	a	No
Carters	Rally Hill	ls 1	491,500	1,775,300	256	a	Yes
Carters	Rally Hill	ls 2	483,000	1,774,400	244	a	No
Carters	Rally Hill	ls 3	494,000	1,743,900	226-232	a	No
Carters	Rally Hill	ls 4	484,800	1,745,000	226-232	a	No
Carters	Rally Hill	ls 5	474,600	1,747,600	250	a	Yes
Carters	Glendale	ls 2	410,900	1,737,800	238	a	Yes
Carters	Glendale	Oc 2	406,200	1,712,200	207	e,f	Yes
Carters	Glendale	Oc 3	406,000	1,723,300	226	e,f	Yes
Carters	Glendale	Oc 4	431,000	1,721,500	195	c	Yes
Carters	Glendale	Bunker prop.	439,000	1,720,700	189-201	e	Yes

Table A.2. (continued)

Formation	Geologic Quadrangle	Location	U.T.M. Coordinates (Zone 16) Northing	Easting	Elevation (m AMSL)	Source Type[a]	Chert Presence
Carters	Glendale	Oc-2175-A	436,400	1,719,500	201-207	e	Yes
Hermitage	Columbia	Oh-1	447,700	1,682,700	183-189	a	No
Hermitage	Godwin	Oh 2	458,800	1,687,900	183-189	a	No
Bigby-Cannon	Godwin	1s 6	455,200	1,669,400	204	a	No
Bigby-Cannon	Godwin	1s 7	455,000	1,671,800	213	a	No
Ridley	Farmington	1s 2	443,400	1,785,200	207	a	Yes
Ridley	Farmington	1s 3	442,100	1,789,500	207	a	Yes
Ridley	Farmington	1s 4	441,600	1,789,500	204-207	a	No
Ridley	Farmington	1s 5	441,900	1,790,100	210	a	Yes
Ridley	Farmington	1s 6	424,700	1,779,000	207-210	a	No
Ridley	Farmington	1s 8	421,100	1,788,600	216	a	Yes
Ridley	Farmington	1s 9	419,350	1,789,600	219	a	Yes
Ridley	Farmington	1s 10	410,300	1,792,500	219	a	No

Table A.2. (continued)

Formation	Geologic Quadrangle	Location	U.T.M. Coordinates (Zone 16) Northing	Easting	Elevation (m AMSL)	Source Type[a]	Chert Presence
Lebanon	Farmington	1s 10	410,300	1,792,500	219	a	No
Lebanon	Rally Hill	1s 6	471,700	1,745,000	233-238	a	No
Lebanon	Glendale	Strath#2	427,100	1,736,000	201-207	g	Yes
Carters	Godwin	1s 8	462,800	1,693,700	174	a	No
Carters	Columbia	1s 4	446,200	1,701,500	189	a	Yes
Carters	Columbia	1s 5	435,300	1,698,800	195-201	a	Yes
Carters	Columbia	Oc 1	436,700	1,697,300	207-213	e	Yes
Carters	Campbells Station	1s 1	390,100	1,708,700	216	a	No
Carters	Campbells Station	1s 2	394,600	1,716,600	209	a	Yes
Carters	Campbells Station	1s 3	391,300	1,738,500	236	a	Yes
Murfreesboro	Farmington	Om 1	437,900	1,793,300	192	c	Yes
Ridley	Rally Hill	1s 7	464,100	1,771,500	226	a	No
Ridley	Verona	1s 1	439,400	1,752,500	204	a	No

Table A.2. (continued)

Formation	Geologic Quadrangle	Location	U.T.M. Coordinates (Zone 16) Northing	Easting	Elevation (m AMSL)	Source Type[a]	Chert Presence
Ridley	Verona	1s 2	412,100	1,768,700	210-213	a	No
Ridley	Verona	1s 3	413,800	1,755,000	238	a	No
Ridley	Verona	1s 4	405,150	1,758,100	223-226	a	No
Ridley	Verona	40MU40	424,300	1,744,000	186	c,e,f,g	Yes
Ridley	Verona	Leftwich	430,300	1,741,600	186-192	b,e,g	Yes
Ridley	Verona	Milltown	434,800	1,766,500	198-204	e,g	Yes
Ridley	Verona	Strath#3	428,400	1,744,000	201-204	e,g	Yes
Ridley	Glendale	Cave Spring	422,900	1,733,200	171-183	d	Yes
Ridley	Glendale	Strath#1	424,000	1,733,500	183-195	e,g	Yes
Ridley	Lewisburg	1s 1	397,500	1,766,200	213	a	No
Ridley	Lewisburg	1s 2	394,500	1,768,300	213	a	Yes
Ridley	Lewisburg	1s 3	389,900	1,764,500	219	a	No
Ridley	Lewisburg	1s 4	389,000	1,769,700	223	a	No

Table A.2. (continued)

Formation	Geologic Quadrangle	Location	U.T.M. Coordinates (Zone 16) Northing	Easting	Elevation (m AMSL)	Source Type[a]	Chert Presence
Ridley	Lewisburg	1s 5	388,100	1,768,900	213	a	No
Ridley	Farmington	1s 1	443,600	1,784,850	207	a	Yes
Bigby-Cannon	Campbells Station	1s 5	371,150	1,714,850	285	a	No
Bigby-Cannon	Campbells Station	Obc 1	371,700	1,721,300	268-274	c	Yes
Leipers-Catheys	Columbia	1s 1	448,900	1,687,800	229	a	No
Leipers-Catheys	Godwin	1s 7	455,000	1,671,800	213	a	No
Leipers-Catheys	Mt. Pleasant, TN	1s 5	418,350	1,637,100	229	a	No
Leipers-Catheys	Campbells Station	Olcy 1	371,400	1,721,700	287-293	c	Yes
Brassfield	Columbia	Sbr 1	427,100	1,684,100	268	a,b	Yes
Fort Payne	Carters Creek	ch 9	461,450	1,719,300	287	a,b	Yes
Fort Payne	Glendale	ch 1	446,000	1,709,600	262	a,b	Yes
Fort Payne	Belfast	ch 8	365,000	1,780,900	320	a,b	Yes
Fort Payne	Campbells Station	Mfp 1	375,800	1,734,700	299	e	Yes

Table A.2. (continued)

Formation	Geologic Quadrangle	Location	U.T.M. Coordinates (Zone 16) Northing	Easting	Elevation (m AMSL)	Source Type[a]	Chert Presence
Fort Payne	Campbells Station	Mfp 2	388,200	1,715,900	335	b,e	Yes
Fort Payne	Lewisburg	ch 8	362,700	1,764,800	354	a,b	Yes
Fort Payne	Lewisburg	ch 9	361,700	1,766,000	360	a,b	Yes
Fort Payne	Mt. Pleasant, TN	ch 8	430,250	1,628,700	265	a,b	Yes
Fort Payne	Godwin	ch 2	469,700	1,678,900	186-195	a,b	Yes
Fort Payne	Godwin	ch 3	472,900	1,688,300	213-229	a,b	Yes
Fort Payne	Godwin	ch 9	462,200	1,674,600	265	a,b	Yes
Fort Payne	Godwin	ch 10	475,900	1,676,300	265	a,b	Yes
Fort Payne	Godwin	ch 11	477,900	1,688,150	277	a,b	Yes
Fort Payne	Godwin	ch 12	473,350	1,690,200	219	a,b	Yes
Fort Payne	Godwin	ch 13	455,700	1,670,400	256	a,b	Yes
Fort Payne	Williamsport	ch 4	467,000	1,640,200	236	a,b	Yes
Fort Payne	Williamsport	ch 5	462,050	1,651,700	233	a,b	Yes

Table A.2. (continued)

Formation	Geologic Quadrangle	Location	U.T.M. Coordinates (Zone 16) Northing	Easting	Elevation (m AMSL)	Source Type[a]	Chert Presence
Fort Payne	Williamsport	ch 6	461,700	1,652,000	226	a,b	Yes
Fort Payne	Williamsport	ch 7	461,500	1,653,200	256	a,b	Yes
Fort Payne	Williamsport	ch 8	460,900	1,652,300	232	a,b	Yes
Fort Payne	Williamsport	ch 9	460,400	1,652,500	244	a,b	Yes
Fort Payne	Williamsport	ch 10	460,000	1,653,650	244	a,b	Yes
Fort Payne	Williamsport	ch 11	458,850	1,653,550	271	a,b	Yes
Fort Payne	Williamsport	ch 12	466,600	1,659,450	251	a,b	Yes
Fort Payne	Williamsport	ch 13	456,650	1,652,400	259	a,b	Yes
Fort Payne	Williamsport	ch 14	462,800	1,653,600	256	a,b	Yes
Fort Payne	Williamsport	ch 15	460,000	1,654,000	250	a,b	Yes

[a] Source type key: a - matrix (quarry/road-cut); b - residual (quarry/road-cut); c - matrix (natural surface outcrop-e.g. bluffs, boulders); d - matrix (caves, sinks); e - residual (natural surface); f - alluvial gravel; g - terrace gravel.

APPENDIX B

CHERT TYPE ILLUSTRATIONS

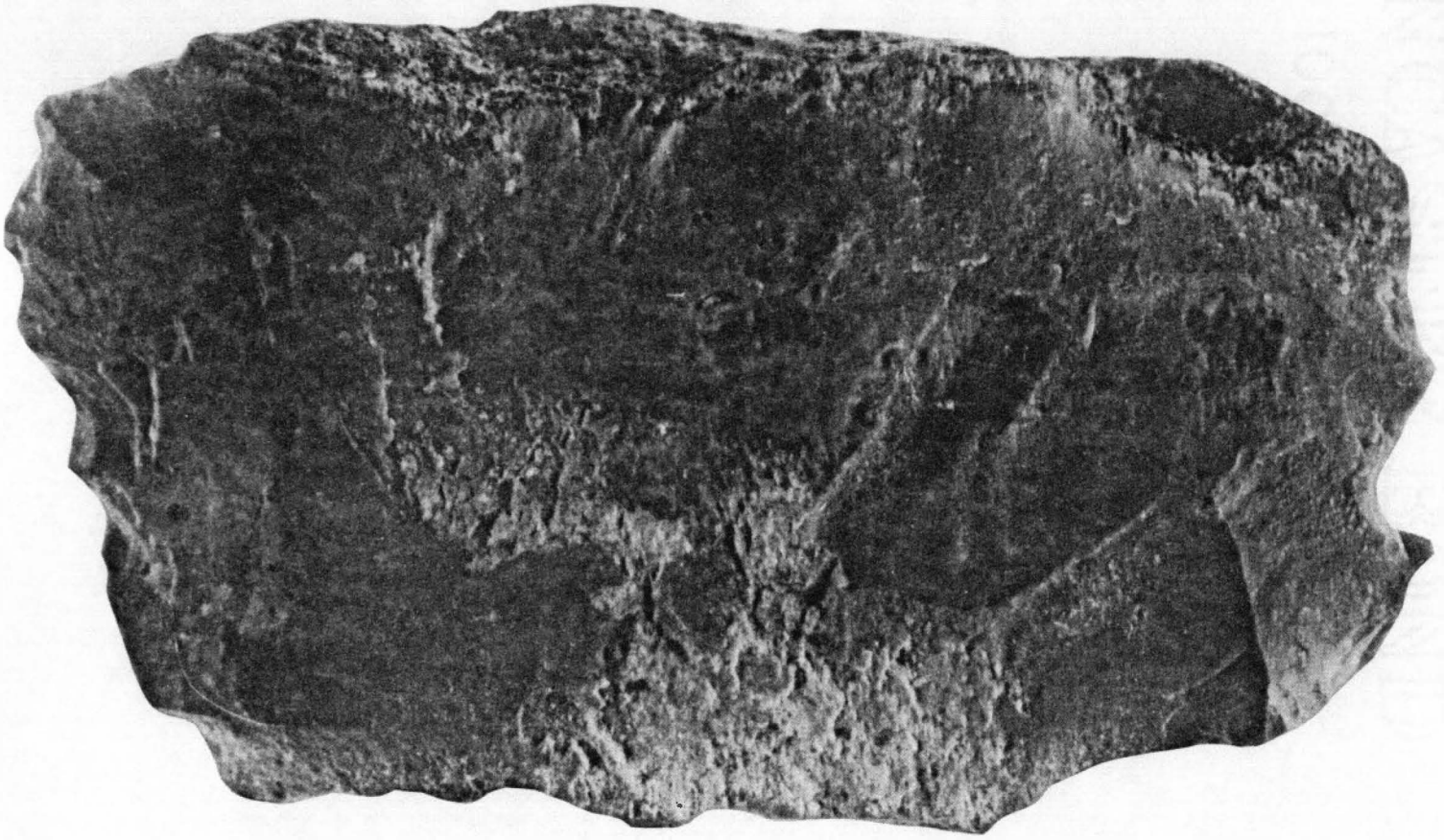

Figure B.1. Murfreesboro chert (4.4X).



Figure B.2. Ridley chert (3.86X).

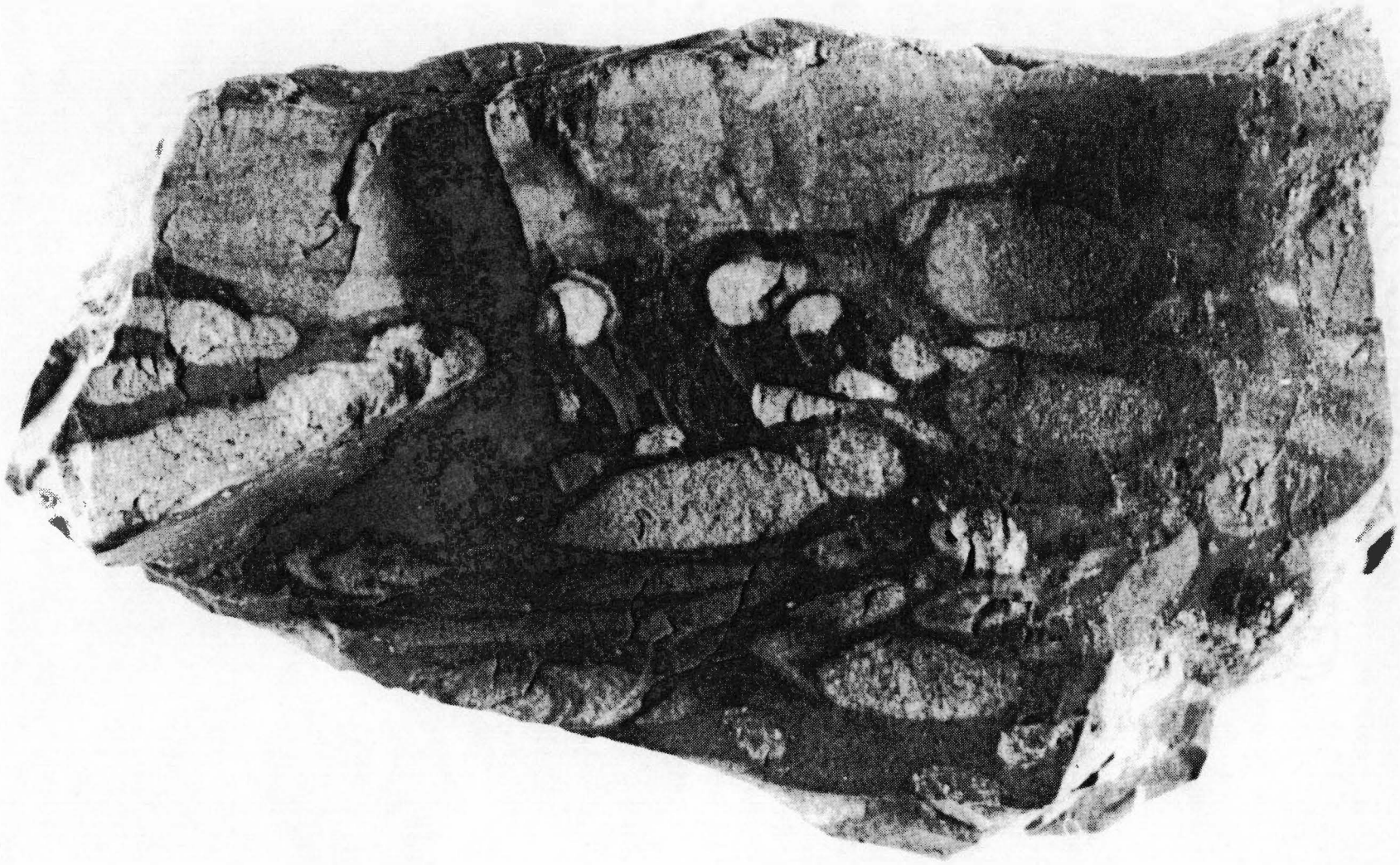

Figure B.3. Ridley Chert (3.58X).

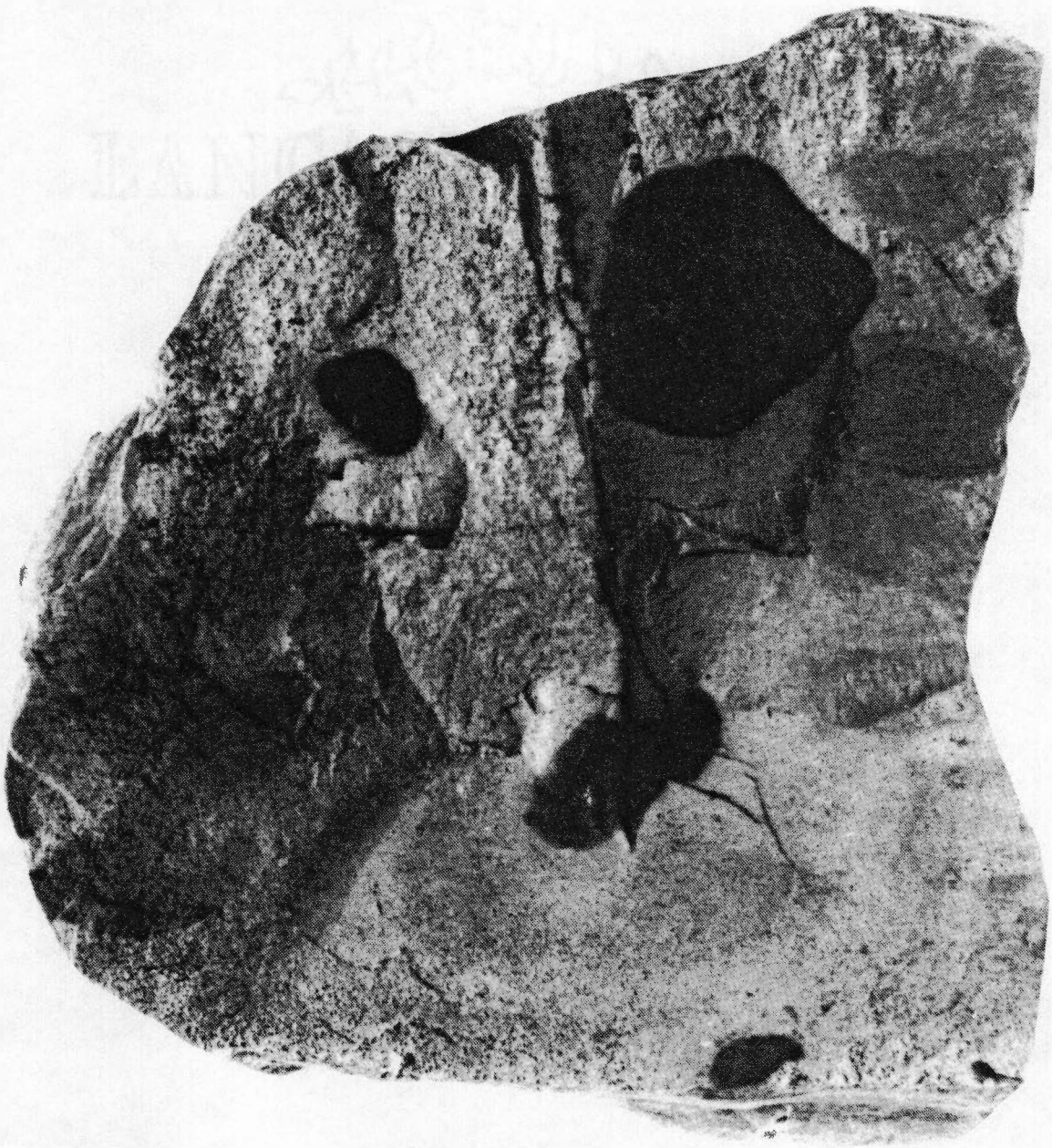

Figure B.4. Ridley chert (3X).



Figure B.5. Ridley chert (4.4X). Striking platform is incipient fracture plane (left) perpendicular to bedding.

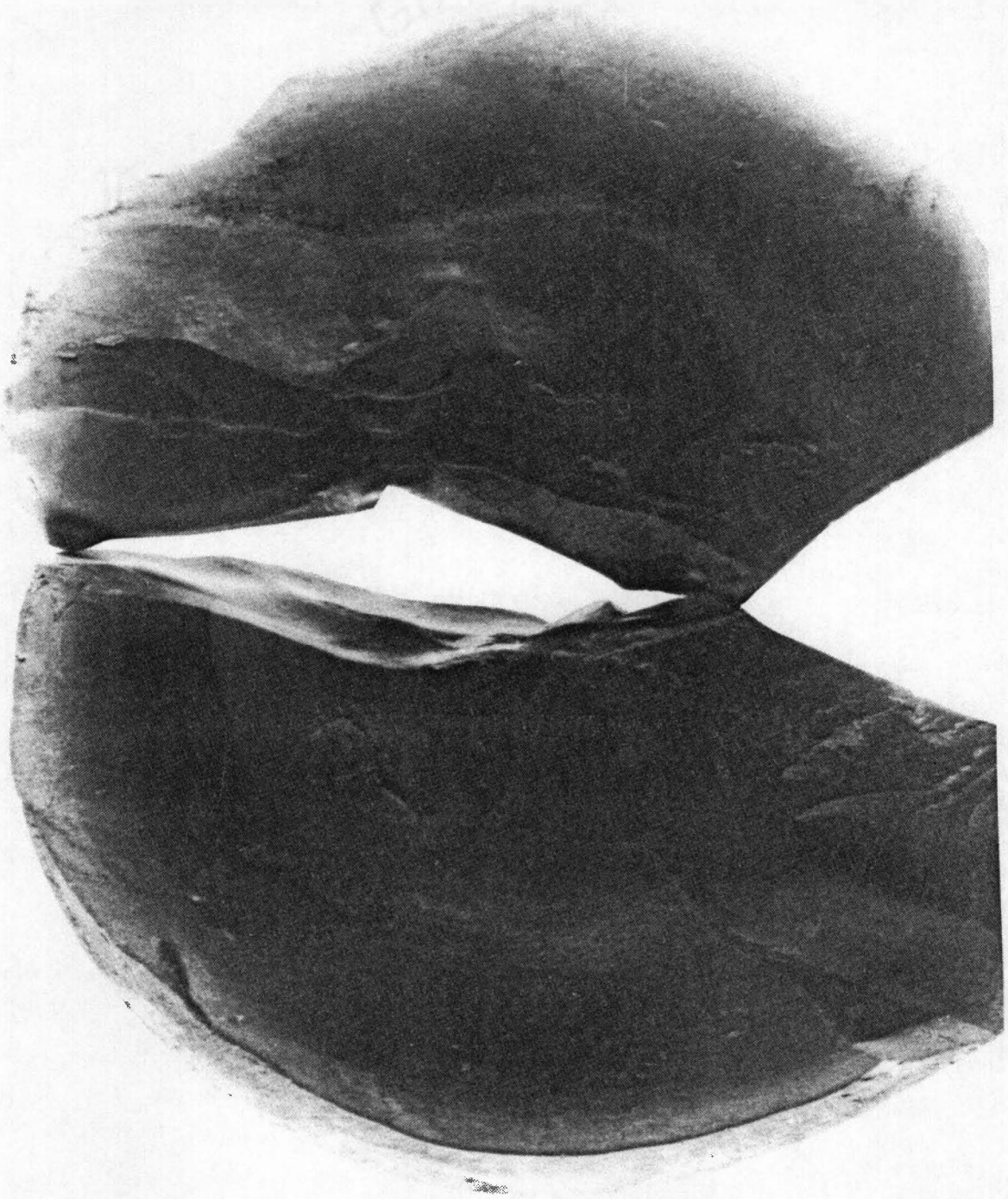

Figure B.6. Ridley chert (2.5X). Bottom specimen is thermally altered.



Figure B.7. Carters chert (2.28X).



Figure B.8. Carters chart (3X).

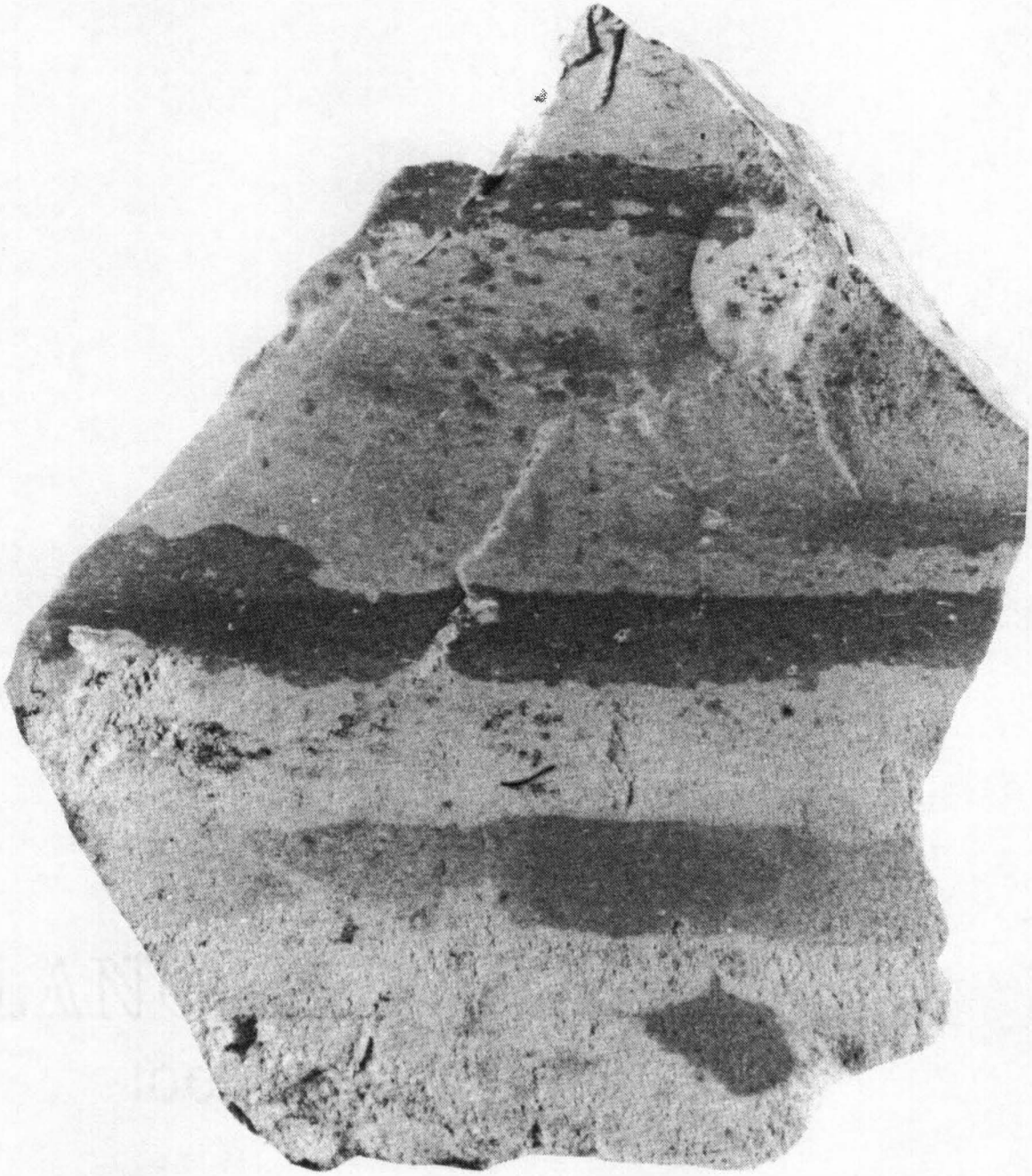

Figure B.9. Carters chert (2.83X).

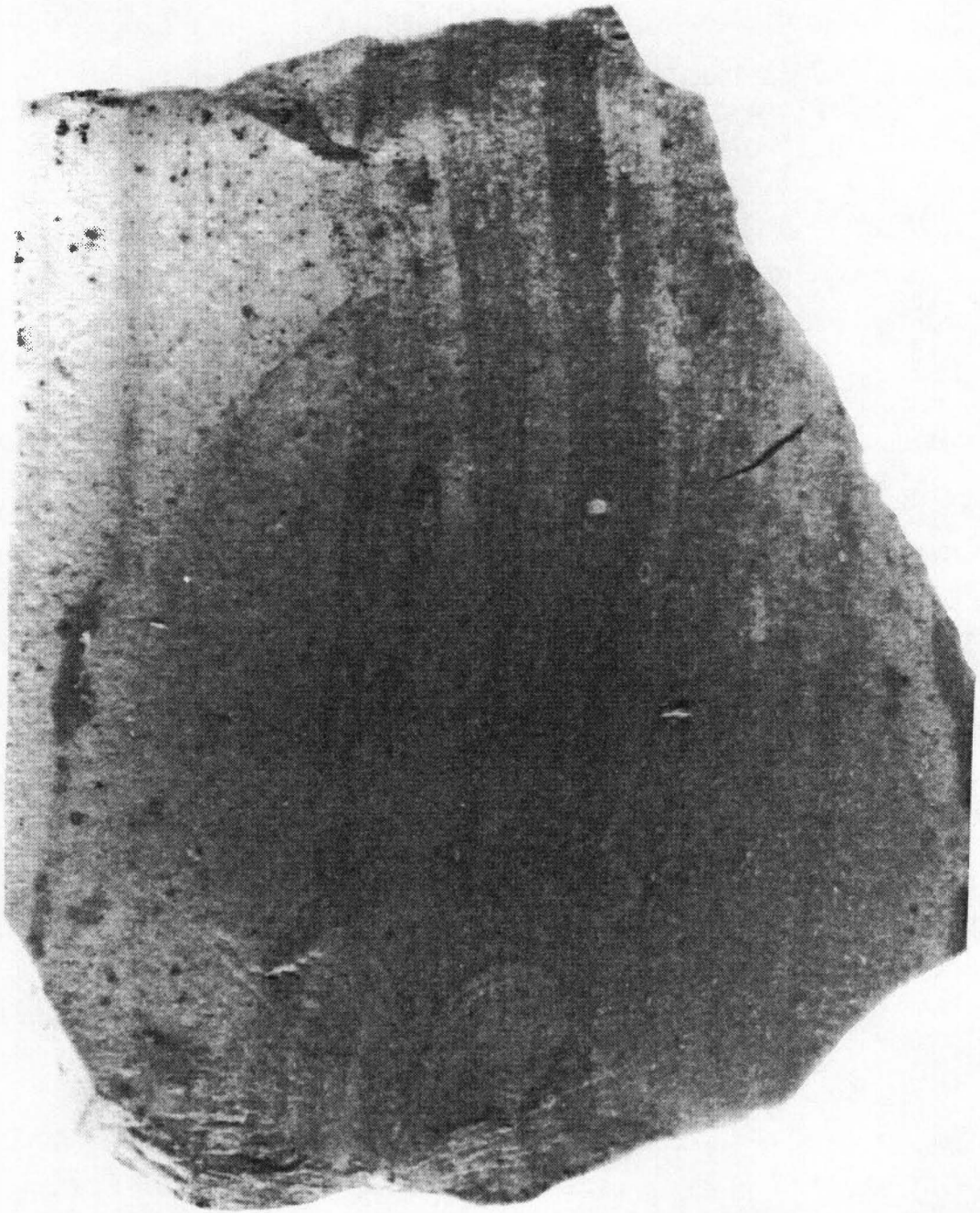

Figure B.10. Carters chert (4X).



Figure B.11. Bigby-Cannon chert (1.9X). Vitreous texture, gray-banded, section parallel to bedding plane.

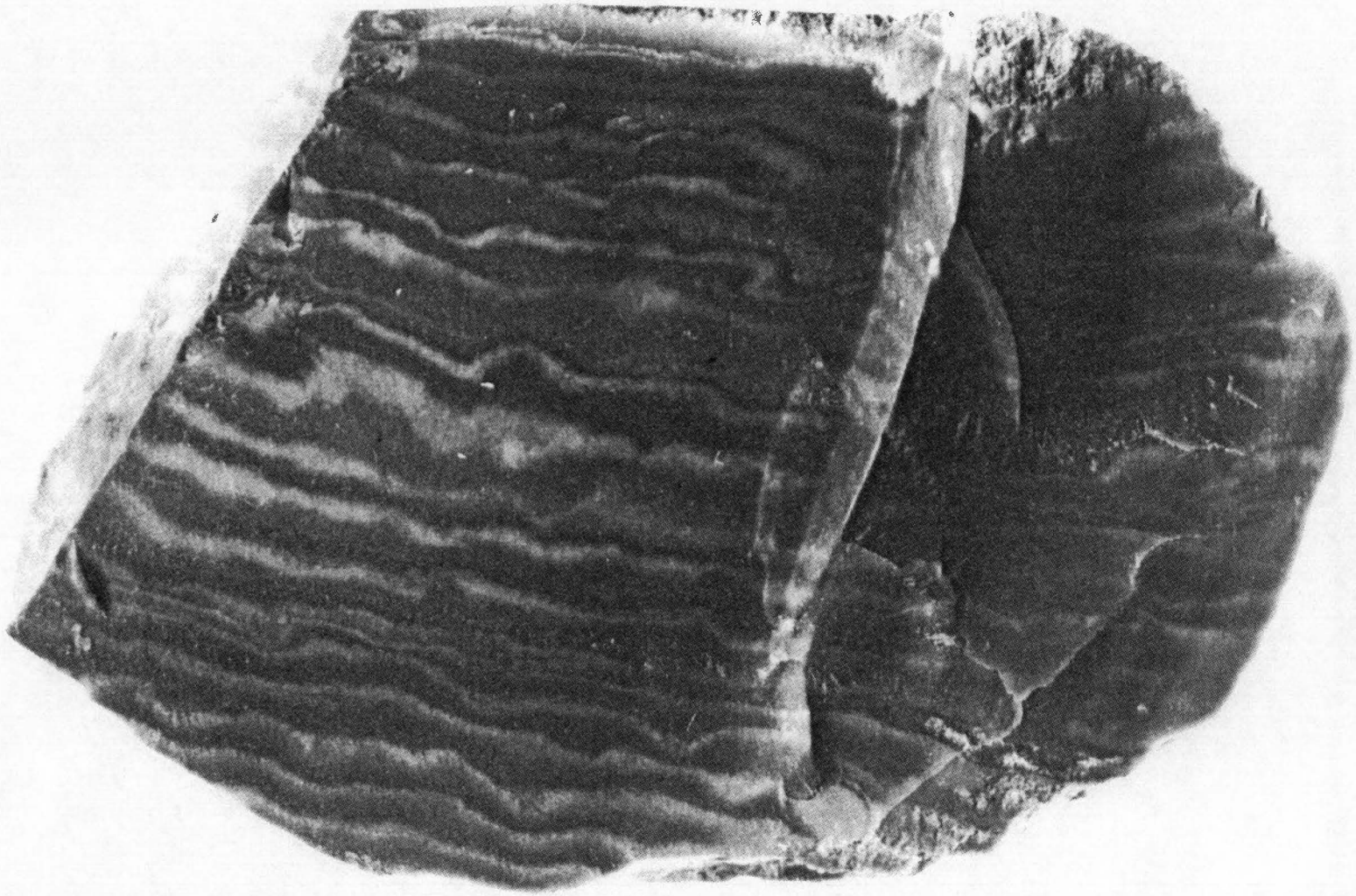

Figure B.12. Bigby-Cannon chert (2.56X). Fine-medium texture, gray-banded, perpendicular section.

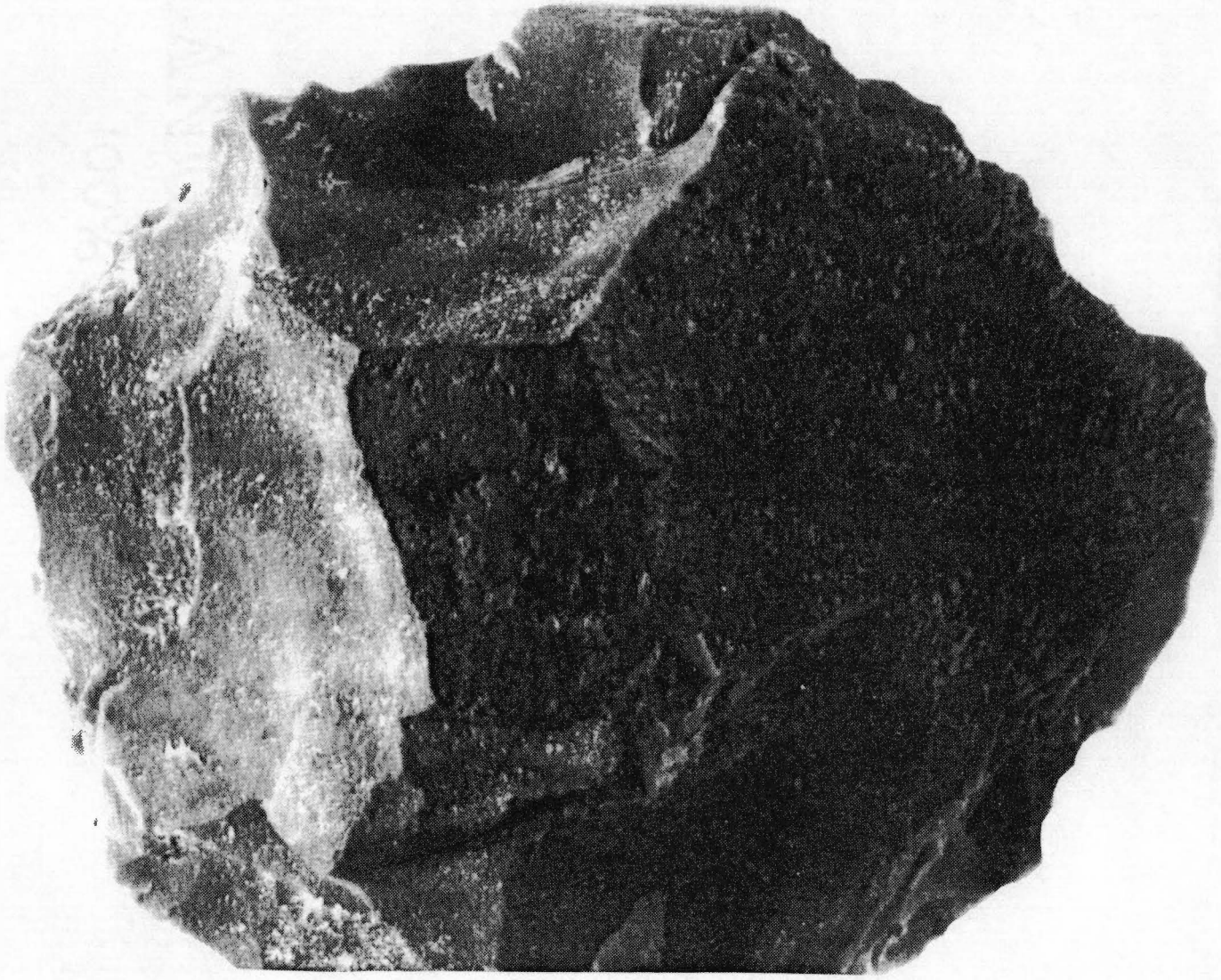

Figure B.13. Bigby-Cannon chert (2.43X). Coarse texture, brown banded, waterworn cobble.



Figure B.14. Leipers-Catheys chert (4.4X).

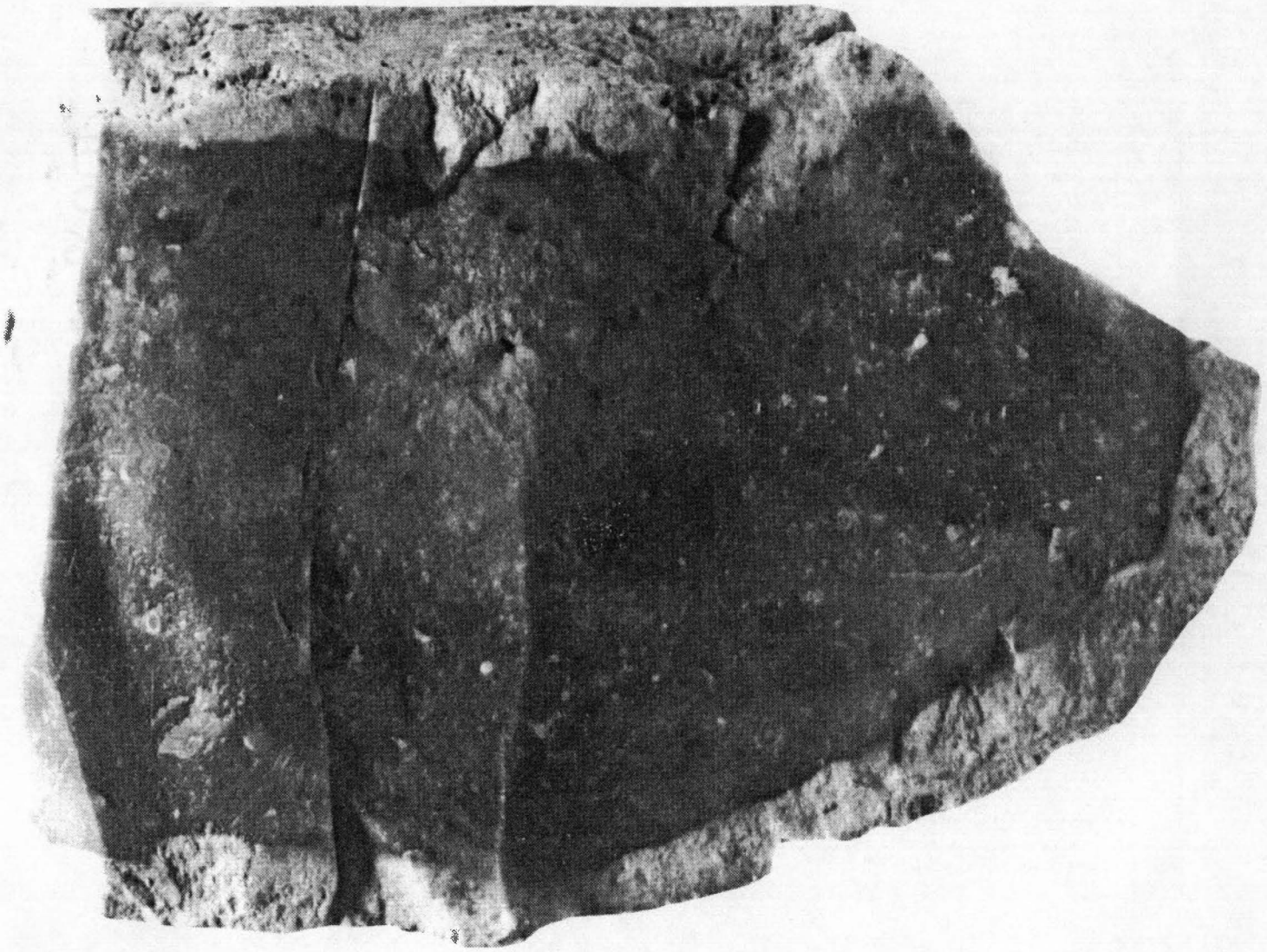

Figure B.15. Brassfield chert (3.25X).

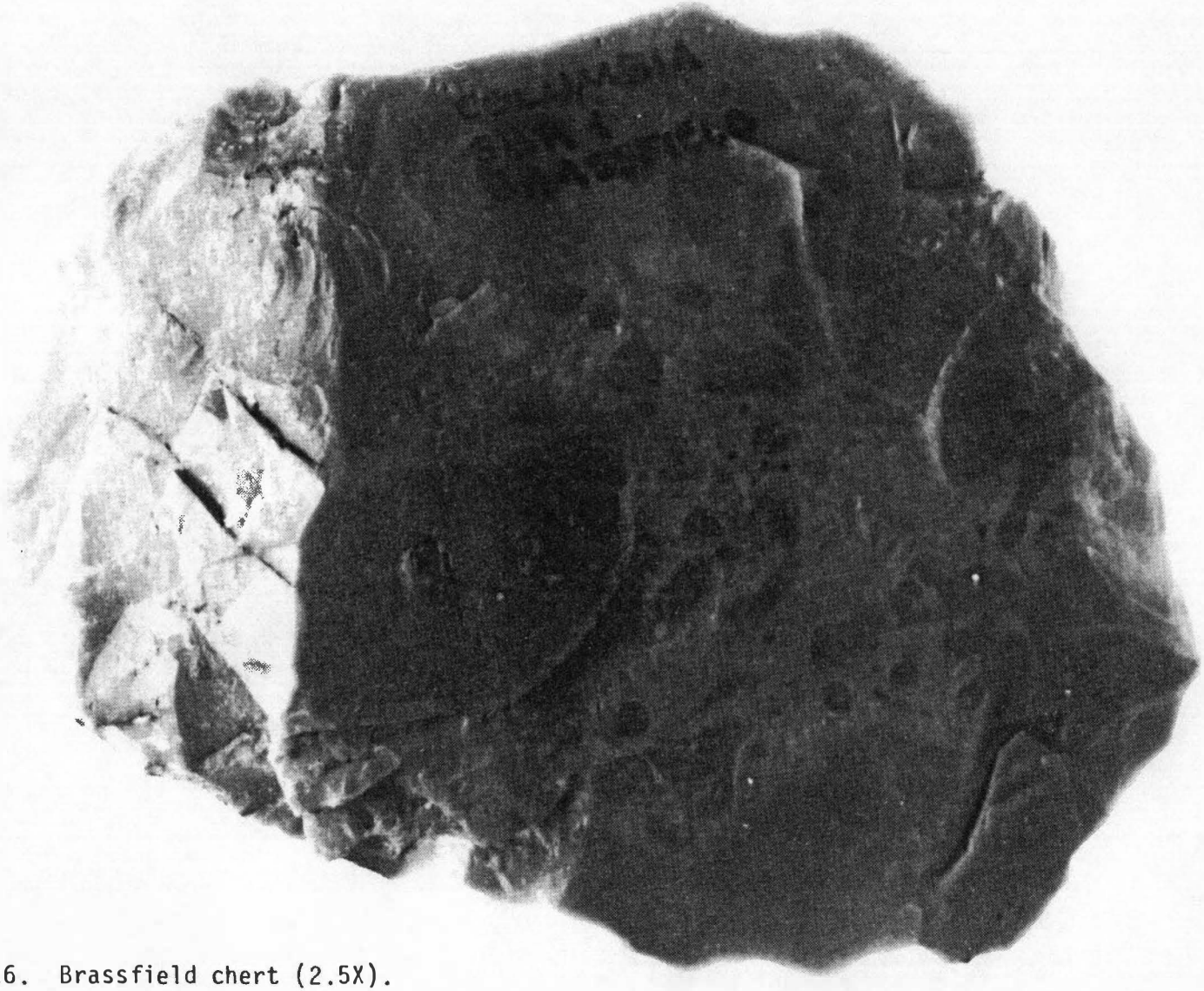

Figure B.16. Brassfield chert (2.5X).



Figure B.17. Fort Payne laminated chert (4X).

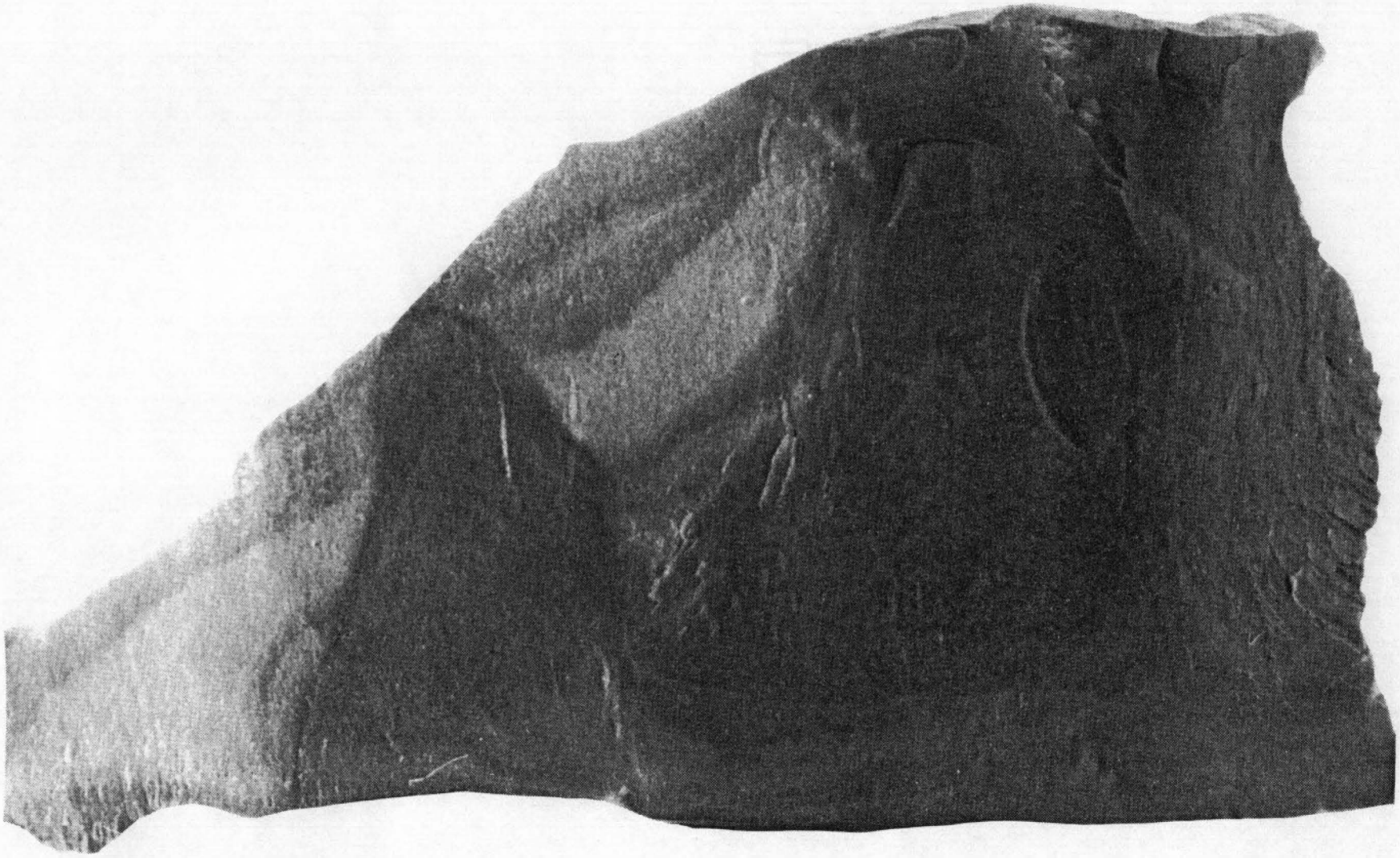

Figure B.18. Fort Payne laminated-mottled chert (3.38X).

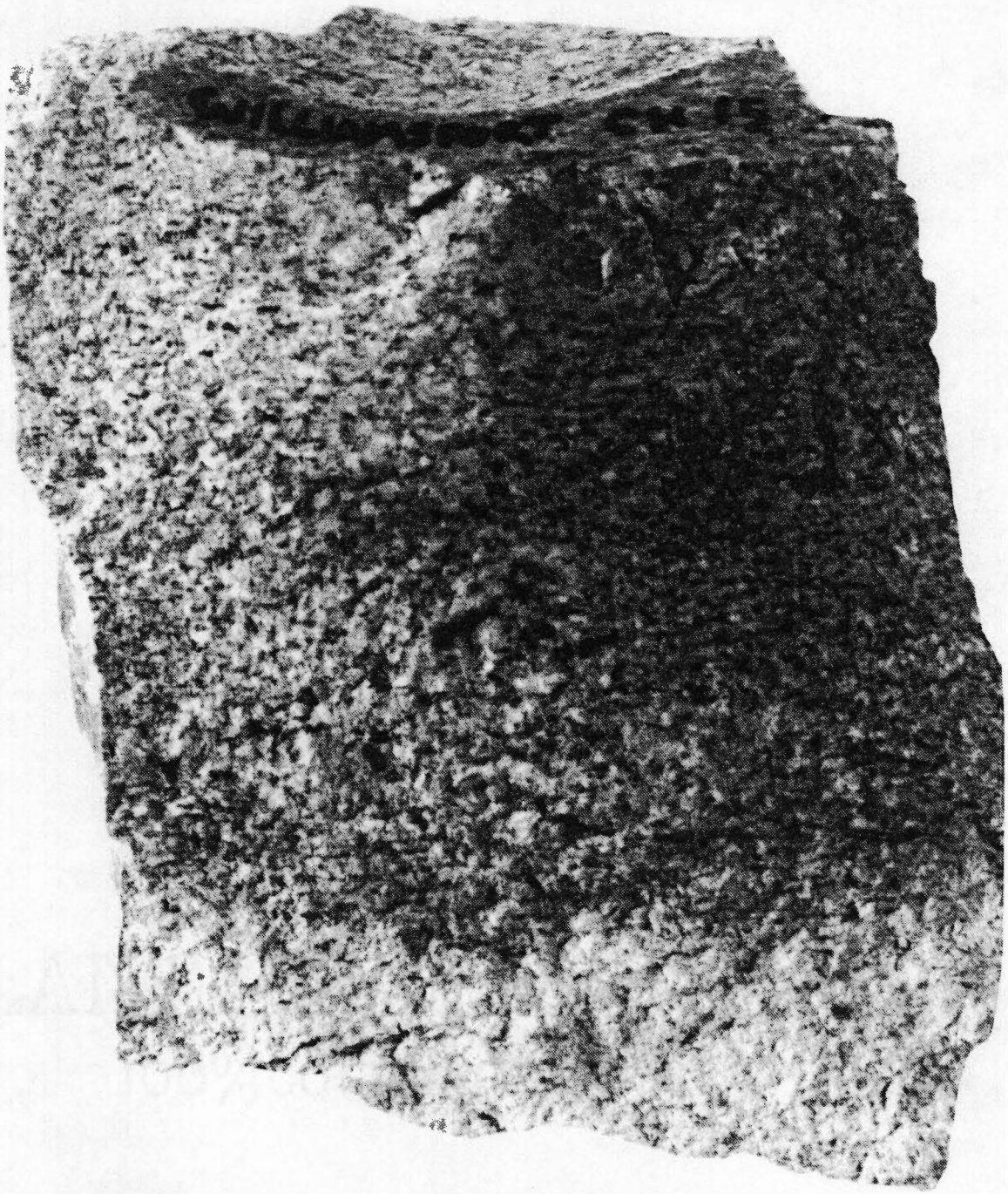

Figure B.19. Fort Payne pepper-and-salt speckled chert (2.42X).

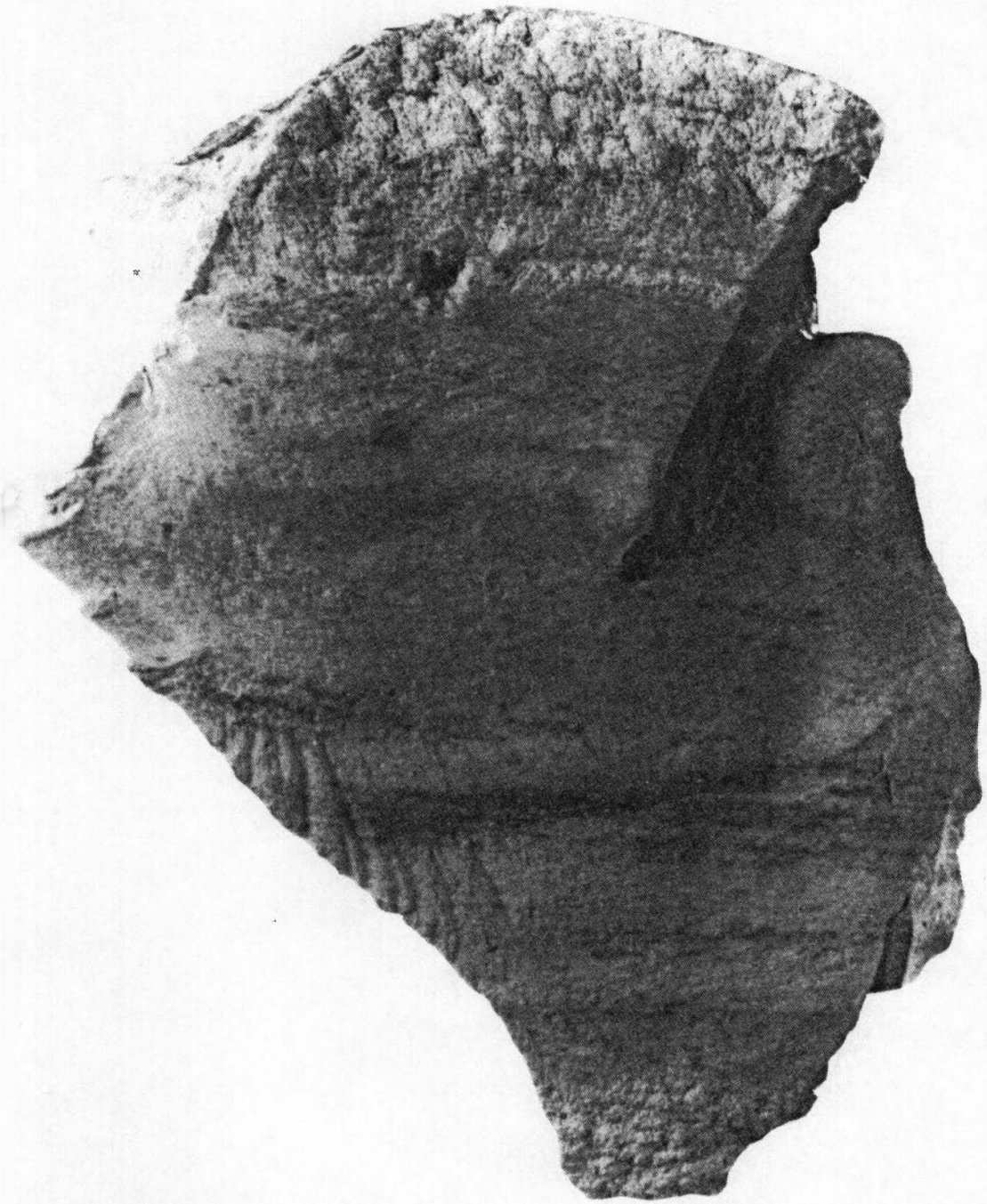

Figure B.20. Fort Payne pepper-and-salt speckled chert (1.42X).



Figure B.21. Fort Payne crinoidal chert (3.5X). Section parallel to bedding plane.



Figure B.22. Fort Payne fibrous chert (4.1X).



Figure B.23. Fort Payne fibrous chert (5.75X). Partially translucent.

APPENDIX C

GRAVEL COLLECTION SITES

Table C.1. Gravel collection location descriptions.

Formation	Geologic Quadrangle	Location	U.T.M. Coordinates (Zone 16) Northing	Easting	Elevation (m AMSL)
Ridley	Farmington	Duck R.M. 183	432,600	1,779,900	189
Pierce	Verona	Duck R.M. 179	435,400	1,765,400	180
Ridley	Verona	Duck R.M. 171	440,900	1,751,100	178
Ridley	Rally Hill	Duck R.M. 167	451,800	1,743,900	177
Ridley	Glendale	Duck R.M. 150	428,700	1,724,300	174
Lebanon	Glendale	Duck R.M. 146	429,500	1,713,200	171
Carters	Campbells Station	Fountain Cr.M. 11	398,800	1,718,700	189
Leipers	Gordonsburg	Swan Cr.M. 17	432,000	1,583,100	195
Leipers-Catheys	Mt. Pleasant, TN	Bigby Cr.M. 13	421,600	1,632,600	174
Bigby-Cannon	Williamsport	Duck R.M. 114	476,200	1,637,000	158
Fort Payne	Henryville	Buffalo R.M. 103	393,200	1,559,500	223
Fort Payne	Riverside	Buffalo R.M. 98	393,100	1,542,600	204
Wayne/Brassfield	Topsy	Buffalo R.M. 81	387,100	1,496,000	180

Table C.2. Summary statistics of chert gravel collections from the Inner Nashville Basin-Duck River.

Location	Elevation (m AMSL)	Geologic Formation	Units (1 m dia.)	n	Abundance (n/units)	Mean Weight (g)	C.V. Weight
Duck R.M. 183 (Big Rock Cr.)	189	Ridley	4	262	66	66.5	51.7
Duck R.M. 179	180	Pierce	2	56	28	43.7	47.2
Duck R.M. 171 (Flat Cr.)	178	Ridley	6	292	49	72.6	85.2
Duck R.M. 167	177	Ridley	3	112	37	60.8	59.1
Duck R.M. 150 (Fountain Cr.)	174	Ridley	5	470	94	70.2	64.2
Duck R.M. 146	171	Lebanon	6	81	14	48.4	56.2
Totals	a	---	26	1273	49	66.6	187.2

[a] Stream gradient = 0.30 m/km

Table C.3. Summary statistics of chert gravel collections from the Western Outer Nashville Basin.

Location	Elevation (m AMSL)	Geologic Formation	Units (1 m dia.)	n	Abundance (n/units)	Mean Weight (g)	C.V. Weight
Fountain Cr.M. 11	189	Carters	3	315	105	93.0	133.3
Swan Cr.M. 17	195	Leipers	3	374	125	94.8	114.4
Bigby Cr.M. 13	174	Leipers-Catheys	3	382	127	147.0	180.3
Duck R.M. 114	158	Bigby-Cannon	3	368	123	153.2	221.8
Totals	a	---	12	1439	120	123.2	169.1

[a] Average stream gradient = 0.91 m/km

Table C.4. Summary statistics of chert gravel collections from the Western Highland Rim-Buffalo River.

Location	Elevation (m AMSL)	Geologic Formation	Units (1 m dia.)	n	Abundance (n/units)	Mean Weight (g)	C.V. Weight
Buffalo R.M. 103	223	Fort Payne	3	146	49	168.8	170.9
Buffalo R.M. 98	204	Fort Payne	3	263	88	254.6	140.4
Buffalo R.M. 81	180	Wayne/Brassfield	3	508	169	159.6	110.3
Totals	a	---	9	917	102	188.3	139.2

[a] Stream gradient = 1.22 m/km

Table C.5. Chert type composition of gravel collections from the Inner Nashville Basin-Duck River.

Location	Chert Type						Totals
	Murfreesboro	Ridley	Carters	Bigby-Cannon	Brassfield	Fort Payne	
Duck R.M. 183 (Big Rock Cr.)	---	5 (1.9)	1 (0.4)	---	---	256 (97.7)	262
Duck R.M. 179	---	4 (7.0)	---	---	---	53 (93.0)	57
Duck R.M. 171 (Flat Cr.)	---	6 (2.1)	---	---	---	287 (97.9)	293
Duck R.M. 167	---	15 (13.4)	14 (12.5)	---	---	83 (74.1)	112
Duck R.M. 150 (Fountain Cr.)	1 (0.2)	12 (2.5)	5 (1.1)	---	---	453 (96.2)	471
Duck R.M. 146	---	1 (1.2)	6 (7.4)	---	---	74 (91.4)	81
Totals	1 (0.08)	43 (3.37)	26 (2.04)	---	---	1206 (94.51)	1276

Table C.6. Chert type composition of gravel collections from the Western Outer Nashville Basin.

Location	Chert Type						Totals
	Murfreesboro	Ridley	Carters	Bigby-Cannon	Brassfield	Fort Payne	
Duck R.M. 114	---	---	4 (1.1)	1 (0.3)	5 (1.4)	358 (97.3)	368
Bigby Cr.M. 13	---	---	---	---	---	382 (100.0)	382
Fountain Cr.M. 11	---	---	18 (5.7)	---	---	297 (94.3)	315
Swan Cr.M. 17	---	---	---	---	---	374	374 (100.0)
Totals	---	---	22 (1.64)	1 (0.07)	5 (0.37)	1311 (97.91)	1339

Table C.7. Chert type composition of gravel collections from the Western Highland Rim-Buffalo River.

Location	Chert Type						Totals
	Murfreesboro	Ridley	Carters	Bigby-Cannon	Brassfield	Fort Payne	
Buffalo R.M. 103	---	---	---	---	---	146 (100.0)	146
Buffalo R.M. 98	---	---	---	---	---	263 (100.0)	263
Buffalo R.M. 81	---	---	---	---	2 (0.4)	506 (99.6)	508
Totals	---	---	---	---	2 (0.22)	913 (99.78)	915

Table C.8. Mean values for metric attributes of Inner Nashville Basin-Duck River gravels by chert type.

Chert Type	n	Length (mm)	Width (mm)	Thickness (mm)	Maximum Projection Sphericity-Form[a]	Weight (g)
Ridley	45	64	41	26	0.64	75.1
Carters	25	71	45	27	0.61	82.8
Fort Payne	1206	62	39	24	0.62	65.8
Totals	1276	62	39	24	0.62	66.6

[a] Defined by Sneed and Folk (1958:118).

Table C.9. Chert type diversity of gravel collections from the Inner Nashville Basin-Duck River.

Location	Types Present	Maximum Diversity	Evenness	Diversity
Duck R.M. 183	3	.477	.109	.052
Duck R.M. 179	2	.301	.033	.110
Duck R.M. 171	2	.301	.013	.044
Duck R.M. 167	3	.477	.155	.326
Duck R.M. 150	4	.602	.050	.083
Duck R.M. 146	3	.477	.068	.142
Totals	4	.602	.183	.110

Table C.10. Chert type diversity of gravel collections from the Western Outer Nashville Basin.

Location	Types Present	Maximum Diversity	Evenness	Diversity
Duck R.M. 114	4	.602	.040	.067
Bigby Cr.M. 13	1	---	---	---
Swan Cr.M. 17	1	---	---	---
Fountain Cr.M. 11	2	.301	.029	.095
Totals	4	.602	.081	.049

Table C.11. Chert type diversity of gravel collections from the Western Highland Rim-Buffalo River.

Location	Types Present	Maximum Diversity	Evenness	Diversity
Buffalo R.M. 103	1	---	---	---
Buffalo R.M. 98	1	---	---	---
Buffalo R.M. 81	2	.301	.023	.007
Totals	2	.301	.023	.007

Table C.12. Chert quality (texture) composition of gravel collections from the Inner Nashville Basin-Duck River.

Location	Texture Type					Totals
	Vitreous	Fine	Medium	Coarse	Desilicified	
Duck R.M. 183	---	121	75	30	34	260
(Big Rock Cr.)		(46.5)	(28.8)	(11.5)	(13.1)	
Duck R.M. 179	---	25	16	5	11	57
		(43.8)	(28.1)	(8.8)	(19.3)	
Duck R.M. 171	---	110	67	31	68	276
(Flat Cr.)		(39.9)	(24.3)	(11.2)	(24.6)	
Duck R.M. 167	---	50	5	4	52	111
		(45.1)	(4.5)	(3.6)	(46.8)	
Duck R.M. 150	---	172	30	39	220	461
(Fountain Cr.)		(37.3)	(6.5)	(8.5)	(47.7)	
Duck R.M. 146	---	27	---	1	49	77
		(35.1)		(1.3)	(63.6)	
Totals	---	505	193	110	434	1242
		(40.66)	(15.54)	(8.86)	(34.94)	

Table C.13. Chert quality (texture) composition of gravel collections from the Western Outer Nashville Basin.

Location	Texture Type					Totals
	Vitreous	Fine	Medium	Coarse	Desilicified	
Duck R.M. 114	1	104	154	12	90	361
	(0.3)	(28.8)	(42.7)	(3.3)	(24.9)	
Bigby Cr.M. 13	---	134	142	31	57	364
		(36.8)	(39.0)	(8.5)	(15.7)	
Swan Cr.M. 17	---	74	136	26	116	352
		(21.0)	(38.6)	(7.4)	(33.0)	
Fountain Cr.M. 11	---	130	99	26	60	315
		(41.3)	(31.4)	(8.3)	(19.1)	
Totals	1	442	531	95	323	1392
	(0.07)	(31.78)	(38.17)	(6.83)	(23.22)	

Table C.14. Chert quality (texture) composition of gravel collections from the Western Highland Rim-Buffalo River.

Location	Texture Type					Totals
	Vitreous	Fine	Medium	Coarse	Desilicified	
Buffalo R.M. 103	---	31	43	12	59	145
		(21.4)	(29.7)	(8.3)	(40.7)	
Buffalo R.M. 98	---	114	86	25	26	251
		(45.4)	(34.3)	(10.0)	(10.4)	
Buffalo R.M. 81	---	187	146	80	48	461
		(40.6)	(31.7)	(17.4)	(10.4)	
Totals	---	332	275	117	133	857
		(38.74)	(32.09)	(13.65)	(15.52)	

APPENDIX D

INTERASSEMBLAGE STATISTICAL DATA

Table 0.1. Artifact type frequencies for the seven assemblages.

Site	Artifact Type									
	Fire-cracked Rock	Hammerstones	Incipient Cores	Blocky Debris	Cores	Core Tools	Bifaces	Flake Tools	Debitage	Totals
Topsy (40WY204)	679 (20.91)	-	1 (0.03)	15 (0.46)	4 (0.12)	-	27 (0.83)	2 (0.06)	2519 (77.58)	3247 (18.29)
Clay Mine-Area 2 (40MU347)	41 (3.82)	4 (0.37)	6 (0.56)	110 (10.24)	16 (1.49)	-	46 (4.28)	17 (1.58)	834 (77.65)	1074 (6.05)
Leftwich (40MU262)	203 (8.18)	2 (0.08)	9 (0.36)	274 (11.04)	20 (0.81)	-	50 (2.02)	8 (0.32)	1915 (77.19)	2481 (13.98)
Clay Mine-Area 1 (40MU432)	17 (3.75)	-	7 (1.54)	26 (5.74)	12 (2.65)	-	18 (3.97)	11 (2.43)	362 (79.91)	453 (2.55)
Cedar Creek (40MU432)	174 (13.73)	-	5 (0.39)	107 (8.45)	8 (0.63)	2 (0.16)	16 (1.26)	27 (2.13)	928 (73.24)	1267 (7.14)
Cave Spring (40MU141)	347 (4.57)	-	29 (0.38)	1331 (17.55)	50 (0.66)	-	78 (1.03)	29 (0.38)	5721 (75.43)	7585 (42.73)
Bench (40MU433)	270 (16.41)	-	11 (0.69)	59 (3.59)	5 (0.30)	-	10 (0.61)	12 (0.73)	1278 (77.69)	1645 (9.27)
Totals	1731 (9.75)	6 (0.03)	68 (0.38)	1921 (10.82)	115 (0.65)	2 (0.01)	245 (1.38)	96 (0.54)	13557 (76.37)	17752

Table D.2. Diversity statistics for artifact type assemblage variability.

Site	Number of Types Present (s)	Maximum Diversity (H max.)	Diversity (H')	Evenness (J')
Topsy (40WY204)	7	.8451	.2622	.3103
Clay Mine-Area 2 (40MU347)	8	.9031	.3767	.4171
Leftwich (40MU262)	8	.9031	.3518	.3895
Clay Mine-Area 1 (40MU347)	7	.8451	.3671	.4344
Cedar Creek (40MU432)	8	.9031	.3954	.4378
Cave Spring (40MU141)	7	.8451	.3395	.4017
Bench (40MU433)	7	.8451	.3174	.3756

Table D.3. Maximally nonsignificant subsets of R x C G-test for assemblage variability.[a]

Subset Members	G-Statistic
Clay Mine-Area 1 (40MU347) Cedar Creek (40MU432)	69.94
Leftwich (40MU262) Cedar Creek (40MU432)	68.76
Leftwich (40MU262) Clay Mine-Area 1 (40MU347)	64.93
Clay Mine-Area 2 (40MU347) Leftwich (40MU262)	59.25
Cedar Creek (40MU432) Bench (40MU433)	54.66
Clay Mine-Area 2 (40MU347) Clay Mine-Area 1 (40MU347)	17.65

[a] G-statistic for entire set = 2001.99
Critical G-statistic = 73.7
df = 48, alpha = .01

Table D.4. Debitage type frequencies for the ten-way classification.

Site	Flake Type: Decortication		Intermediate Trimming and Other						Biface Thinning		Totals
	Primary	Secondary	Interior	Broken	Rejuvenation	Shatter	Bipolar	Blades	Large	Small	
Topsy (40WY204)	6 (0.24)	340 (13.40)	58 (2.30)	1451 (57.60)	4 (0.16)	-	-	-	198 (7.86)	462 (18.34)	2519 (18.58)
Clay Mine-Area 2 (40MU347)	13 (1.56)	127 (15.23)	65 (7.79)	391 (46.88)	-	5 (0.60)	-	-	225 (26.98)	8 (0.96)	834 (6.15)
Leftwich (40MU262)	18 (0.94)	427 (22.29)	307 (16.02)	813 (42.43)	8 (0.42)	5 (0.26)	-	-	146 (7.62)	191 (9.97)	1915 (14.13)
Clay Mine-Area 1 (40MU347)	19 (5.25)	162 (44.75)	33 (9.12)	103 (28.45)	-	5 (1.38)	3 (0.83)	-	37 (10.22)	-	362 (2.67)
Cedar Creek (40MU432)	15 (1.62)	241 (25.97)	80 (8.62)	613 (66.06)	3 (0.32)	-	1 (0.11)	-	18 (1.94)	37 (3.99)	928 (6.85)
Cave Spring (40MU141)	48 (0.84)	2034 (35.55)	1176 (20.55)	2068 (36.15)	3 (0.05)	-	-	2 (0.03)	65 (1.14)	325 (5.68)	5721 (42.20)
Bench (40MU433)	10 (0.78)	218 (17.06)	118 (9.22)	804 (62.91)	5 (0.39)	-	-	-	46 (3.60)	77 (6.03)	1278 (9.43)
Totals	129 (0.95)	3549 (26.18)	1837 (13.55)	6243 (46.05)	23 (0.17)	15 (0.11)	4 (0.03)	2 (0.01)	735 (5.42)	1100 (8.11)	13557

Table D.5. Diversity statistics for the ten-way debitage classification.

Site	Number of Types Present (s)	Maximum Diversity (H max.)	Diversity (H')	Evenness (J')
Topsy (40WY204)	7	.8451	.5258	.4444
Clay Mine - Area 2 (40MU347)	7	.8451	.5795	.6857
Leftwich (40MU262)	8	.9031	.6515	.7214
Clay Mine - Area 1 (40MU347)	7	.8451	.2995	.3544
Cedar Creek (40MU432)	8	.9031	.4921	.5449
Cave Spring (40MU141)	8	.9031	.5737	.6353
Bench (40MU433)	7	.8451	.5045	.5970

Table D.6. Three-way debitage classifications.

Sites	Flake Types: Decortication	Intermediate Trimming and Other	Biface Thinning	Totals
Topsy (40WY204)	346 (13.74)	1513 (60.06)	660 (26.20)	2519 (18.58)
Clay Mine-Area 2 (40MU347)	140 (16.79)	461 (55.28)	233 (27.94)	834 (6.15)
Leftwich (40MU262)	445 (23.24)	1133 (59.16)	337 (17.60)	1915 (14.13)
Clay Mine-Area 1 (40MU347)	181 (50.00)	144 (39.78)	37 (10.22)	362 (2.67)
Cedar Creek (40MU432)	256 (27.59)	617 (66.49)	55 (5.93)	928 (6.85)
Cave Spring (40MU141)	2082 (36.39)	3249 (56.79)	390 (6.82)	5721 (42.20)
Bench (40MU433)	228 (17.84)	927 (72.54)	123 (9.62)	1278 (9.43)
Totals	3678 (27.13)	8044 (59.33)	1835 (13.54)	13557

Table D.7. Maximally nonsignificant subsets of R x C G-test for three-way debitage variability.[a]

Subset Members	G-Statistic
Topsy (40WY204) Clay Mine - Area 2 (40MU347)	7.07

[a] G-statistic for entire set = 1254.87
Critical G-statistic = 26.2
df = 12, alpha = .01

Table D.8. Debitage assemblage cortex type frequencies.

Site	Cortex Type			Totals
	Matrix/Residual	Waterworn	None	
Topsy (40WY204)	45 (1.79)	494 (19.61)	1980 (78.60)	2519 (17.39)
Clay Mine-Area 2 (40MU347)	85 (10.20)	69 (8.28)	679 (81.51)	833 (5.75)
Leftwich (40MU262)	127 (6.63)	259 (13.52)	1530 (79.85)	1916 (13.22)
Clay Mine-Area 1 (40MU347)	52 (14.36)	189 (52.21)	121 (33.43)	362 (2.50)
Cedar Creek (40MU432)	139 (14.98)	187 (20.15)	602 (64.87)	928 (6.41)
Cave Spring (40MU141)	775 (13.54)	1349 (23.56)	3601 (62.90)	5725 (39.52)
Bench (40MU433)	159 (12.45)	119 (9.32)	999 (78.23)	1277 (8.81)
Totals	1382 (9.54)	2666 (18.40)	9512 (72.06)	14488

Table D.9. Maximally nonsignificant subsets of R x$_a$C G-test for debitage assemblage cortex variability.[a]

Subset Members	G-Statistic
Clay Mine - Area 2 (40MU347) Leftwich (40MU262)	23.64
Cedar Creek (40MU432) Cave Spring (40MU433)	5.85
Clay Mine - Area 2 (40MU347) Bench (40MU433)	3.53

[a] G-statistic for entire set = 963.99
Critical G-statistic = 26.2
df = 12, alpha = .01

Table D.10. Biface thinning flake assemblage cortex type frequencies.

Site	Cortex Type			Totals
	Matrix/Residual	Waterworn	None	
Topsy (40WY204)	9 (1.36)	62 (9.39)	589 (89.24)	660 (35.97)
Clay Mine-Area 2 (40MU347)	1 (0.43)	-	232 (99.57)	233 (12.70)
Leftwich (40MU262)	1 (0.30)	10 (2.97)	326 (96.74)	337 (18.36)
Clay Mine-Area 1 (40MU347)	-	21 (56.76)	16 (43.24)	37 (2.02)
Cedar Creek (40MU432)	2 (3.64)	3 (5.45)	50 (90.91)	55 (3.00)
Cave Spring (40MU141)	10 (2.56)	5 (1.28)	375 (96.15)	390 (21.25)
Bench (40MU433)	4 (3.25)	3 (2.44)	116 (94.31)	123 (6.70)
Totals	27 (1.47)	104 (5.67)	1704 (92.86)	1835

Table D.11. Maximally nonsignificant subsets of R x C G-test for biface thinning flake assemblage cortex variability.[a]

Subset Members	G-Statistic
Clay Mine - Area 2 (40MU347) Leftwich (40MU262) Cedar Creek (40MU432) Cave Spring (40MU141)	25.06
Clay Mine - Area 2 (40MU347) Leftwich (40MU262) Cave Spring (40MU141) Bench (40MU433)	23.23
Clay Mine - Area 2 (40MU347) Leftwich (40MU262) Cedar Creek (40MU432) Bench (40MU433)	22.82
Topsy (40WY204) Leftwich (40MU262) Cedar Creek (40MU432)	21.58
Clay Mine - Area 2 (40MU347) Cedar Creek (40MU432) Cave Spring (40MU141) Bench (40MU433)	17.66
Leftwich (40MU262) Cedar Creek (40MU432) Cave Spring (40MU141) Bench (40MU433)	14.18
Topsy (40WY204) Cedar Creek (40MU432) Bench (40MU433)	11.57

[a] G-statistic for entire set = 155.71
Critical G-statistic = 26.2
df = 12, alpha = .01

Table D.12. Fort Payne debitage assemblage cortex type frequencies.

Site	Cortex Type			Totals
	Matrix/Residual	Waterworn	None	
Topsy (40WY204)	45 (1.79)	494 (19.62)	1979 (78.59)	2518 (38.87)
Clay Mine-Area 2 (40MU347)	32 (4.83)	45 (5.40)	585 (88.37)	662 (10.22)
Leftwich (40MU262)	11 (1.40)	113 (14.43)	643 (82.12)	783 (12.09)
Clay Mine-Area 1 (40MU347)	9 (4.17)	131 (60.65)	76 (35.18)	216 (3.33)
Cedar Creek (40MU432)	5 (1.35)	117 (31.54)	249 (67.12)	371 (7.86)
Cave Spring (40MU141)	75 (4.78)	571 (36.42)	922 (58.80)	1568 (24.21)
Bench (40MU433)	-	107 (28.46)	269 (71.54)	376 (5.80)
Totals	177 (2.73)	1578 (24.36)	4723 (72.91)	6478

Table D.13. Maximally nonsignificant subsets of R x C G-test for Fort Payne debitage assemblage cortex variability.[a]

Subset Members	G-Statistic
Topsy (40WY204) Bench (40MU433)	25.89
Topsy (40WY204) Cedar Creek (40MU432)	25.41
Cedar Creek (40MU432) Cave Spring (40MU141)	16.40
Topsy (40WY204) Leftwich (40MU262)	10.45
Cedar Creek (40MU432) Bench (40MU433)	8.12

[a] G-statistic for entire set = 561.27
Critical G-statistic = 26.2
df = 12, alpha = .01

Table D.14. Debitage assemblage chert type frequencies.

Site	Chert Types								
	Om	Ord	Oc	Obc	Sbr	Mfp	Msl	Indet.	Totals
Topsy (40WY204)	-	-	-	-	-	2518 (99.96)	-	1 (0.04)	2519 (18.57)
Clay Mine - Area 2 (40MU347)	-	142 (17.03)	3 (0.36)	23 (2.76)	-	633 (79.50)	1 (0.12)	2 (0.24)	834 (6.15)
Leftwich (40MU262)	1 (0.05)	1022 (53.34)	2 (0.10)	93 (4.85)	2 (0.10)	783 (40.87)	3 (0.16)	10 (0.52)	1916 (14.13)
Clay Mine - Area 1 (40MU347)	-	124 (34.25)	1 (0.28)	15 (4.14)	-	216 (59.67)	-	6 (1.66)	362 (2.67)
Cedar Creek (40MU432)	-	500 (53.88)	5 (0.54)	43 (4.63)	-	371 (39.98)	4 (0.43)	5 (0.54)	928 (6.84)
Cave Spring (40MU141)	-	4003 (68.12)	-	122 (2.13)	-	1568 (27.39)	7 (0.12)	25 (0.44)	5725 (42.21)
Bench (40MU433)	-	2 (0.16)	887 (69.30)	16 (1.25)	-	375 (29.30)	-	-	1280 (9.44)
Totals	1 (0.01)	5793 (42.71)	898 (6.62)	312 (2.30)	2 (0.01)	6494 (47.88)	15 (0.11)	49 (0.36)	13564

Table D.15. Diversity statistics for debitage chert type variability.

Site	Number of Types Present (s)	Maximum Diversity (H max.)	Diversity (H')	Evenness (J')
Topsy (40WY204)	1	.0000	.0000	1.0000
Clay Mine - Area 2 (40MU347)	5	.6990	.2512	.3594
Leftwich (40MU262)	7	.8451	.3800	.4497
Clay Mine - Area 1 (40MU347)	4	.6021	.3563	.5918
Cedar Creek (40MU432)	5	.6990	.3878	.5548
Cave Spring (40MU141)	4	.6021	.3012	.5002
Bench (40MU433)	4	.6021	.2948	.4896

Table D.16. Maximally nonsignificant subsets of R x C G-test for debitage assemblage chert variability.

Subset Members	G-Statistic
Leftwich (40MU262) Cedar Creek (40MU432)	0.10

[a] G-statistic for entire set = 9297.31
Critical G-statistic = 26.2
df = 12, alpha = .01

Table 0.17. Biface thinning flake chert type frequencies.

Site	Chert Types							Totals
	Ord	Oc	Obc	Sbr	Mfp	Msl	Indet.	
Topsy (40WY204)	-	-	-	-	600 (100.00)	-	-	660 (35.97)
Clay Mine - Area 2 (40MU347)	8 (3.43)	-	1 (0.43)	-	224 (96.14)	-	-	233 (12.70)
Leftwich (40MU262)	149 (44.21)	1 (0.30)	4 (1.19)	1 (0.30)	181 (53.71)	-	1 (0.30)	337 (18.36)
Clay Mine - Area 1 (40MU347)	7 (18.92)	-	1 (2.70)	-	29 (78.38)	-	-	37 (2.02)
Cedar Creek (40MU432)	16 (29.09)	-	3 (5.45)	-	34 (61.82)	2 (3.64)	-	55 (3.00)
Cave Spring (40MU141)	296 (75.90)	-	7 (1.79)	-	87 (22.31)	-	-	390 (21.25)
Bench (40MU433)	-	77 (62.60)	-	-	46 (37.40)	-	-	123 (6.70)
Totals	476 (25.94)	78 (4.25)	16 (0.87)	1 (0.05)	1261 (68.72)	2 (0.10)	1 (0.05)	1835

Table D.18. Diversity statistics for biface thinning flake chert type variability.

Site	Number of Types Present (s)	Maximum Diversity (H max.)	Diversity (H')	Evenness (J')
Topsy (40WY204)	1	.000	.0000	1.000
Clay Mine - Area 2 (40MU347)	3	.4771	.0769	.1612
Leftwich (40MU262)	5	.6990	.3397	.4860
Clay Mine - Area 1 (40MU347)	3	.4771	.2621	.5494
Cedar Creek (40MU432)	4	.6021	.4064	.6750
Cave Spring (40MU141)	3	.4771	.2675	.5607
Bench (40MU433)	2	.3010	.2871	.9538

Table D.19. Maximally nonsignificant subsets of R x C G-test for biface thinning flake assemblage chert variability.[a]

Subset Members	G-Statistic
Clay Mine - Area 2 (40MU347) Clay Mine - Area 1 (40MU347)	13.11
Leftwich (40MU262) Cedar Creek (40MU432) Bench (40MU433)	12.76
Leftwich (40MU262) Clay Mine - Area 1 (40MU347) Cedar Creek (40MU432)	9.48
Cave Spring (40MU141) Bench (40MU433)	2.14

[a] G-statistic for entire set = 868.64
Critical G-statistic = 16.8
df = 6, alpha = .01

Table D.20. Biface assemblage chert type frequencies.

Site	Chert Types				Totals
	Ord	Oc	Mfp	Msl	
Topsy (40WY204)	-	-	27 (100.00)	-	27 (11.02)
Clay Mine - Area 2 (40MU347)	-	-	46	-	46 (18.78)
Leftwich (40MU262)	19 (38.00)	-	30 (60.00)	1 (2.00)	50 (20.41)
Clay Mine - Area 1 (40MU347)	2 (11.11)	-	16 (88.89)	-	18 (7.35)
Cedar Creek (40MU432)	4 (25.00)	-	11 (68.75)	1 (6.25)	16 (6.53)
Cave Spring (40MU141)	24 (30.77)	-	54 (69.23)	-	78 (31.84)
Bench (40MU433)	-	6 (60.00)	4 (40.00)	-	10 (4.08)
Totals	49 (20.00)	6 (2.45)	188 (76.73)	2 (0.82)	245

Table D.21. Maximally nonsignificant subsets of R x C G-test for biface chert type variability.[a]

Subset Members	G-Statistic
Topsy (40WY204) Cedar Creek (40MU432) Cave Spring (40MU141)	16.63
Topsy (40WY204) Clay Mine - Area 2 (40MU347) Clay Mine - Area 1 (40MU347) Cedar Creek (40MU432)	15.68
Leftwich (40MU262) Clay Mine - Area 1 (40MU347) Cedar Creek (40MU432) Cave Spring (40MU141) Bench (40MU433)	8.87

[a] G-statistic for entire set = 54.23
Critical G-statistic = 16.80
df = 6, alpha = .01

VITA

Daniel Scot Amick was born in Fort Dix, NJ on January 31, 1956. He attended North Kingstown High School in North Kingstown, RI and graduated in June 1974. In September 1974, he entered The University of Tennessee, Knoxville where he received a Bachelor of Arts degree with High Honors in March 1979. Anthropology was his major field of study with minors in German and Zoology.

During 1978, the author was employed as a survey archaeologist by the U.S. Army, Corps of Engineers, Nashville District under a one-year cooperative education program with The University of Tennessee. Since 1976, Mr. Amick has participated in various archaeological research in Tennessee, Mississippi, and Kentucky. In March 1979, he began study toward a Master's degree at The University of Tennessee, Knoxville. During that time he became affiliated with the Columbia Archaeological Project and was engaged as a senior research technician for that project. He was awarded the Master of Arts degree in Anthropology in June 1984.

Mr. Amick is a member of the Society for American Archaeology, Southeastern Archaeological Conference, Plains Anthropological Society, and Tennessee Anthropological Association.