THE LITHIC TECHNOLOGY OF A LATE WOODLAND OCCUPATION ON THE DELAWARE BAY: KIMBLE'S BEACH SITE (28CM36A), CAPE MAY COUNTY, NEW JERSEY

by

JAMES P. KOTCHO

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ABSTRACT OF THE THESIS

The Lithic Technology of a Late Woodland

Occupation on the Delaware Bay:

Kimble's Beach Site (28CM36A),

Cape May County, New Jersey

by **JAMES P KOTCHO**

Thesis Director:

Craig S. Feibel

This study aims to identify technological practices of Native American people who lived at the Kimble's Beach site (28CM36A) during the Late Woodland period (ca. 800/900-1650 AD) of Eastern prehistory. This site is located in the northern portion of the Cape May Peninsula along the margin of the Delaware Bay in New Jersey. It was jointly excavated by Rutgers University and Stockton State College in the period 1995-1998. The study is limited to the excavations at the Beach Face locus, which is the modern beach face. The site was in an upland location 400-500 m from the bay during the Late Woodland period.

Data collected from chipped stone debitage recovered from the beach face are compared with data collected from the debitage derived from experimentally replicated small triangular projectile points and several types of scrapers found in the assemblage to identify tool making behavior represented at the site. Sullivan and Rozen's flake types derived from the debitage of the tool making experiments and experimental bipolar and freehand reduction of alluvial chert pebbles were evaluated with discriminant analysis to determine if these reduction strategies may be distinguished by this data. Additional experimental work involved collecting and grading of chert and jasper gravels from the current beach face, heat treating a subset of split gravels, and conducting a reconnaissance for other lithic sources within a 10 km catchment area surrounding the site.

Selected attributes of the experimental debitage were assessed for their value to differentiate between reduction strategies, determine the proportion of biface and scraper manufacture, distinguish between starting forms for tool manufacture, identify biface reduction stages, determine the length of the biface trajectory, and to distinguish between hard hammer and pressure flakes. An experimental production rate for biface/uniface manufacture and general bipolar reduction of alluvial gravels was developed. A biface reduction sequence for production of triangular projectile points from alluvial chert and jasper gravels is proposed. Conclusions concerning the site function, mobility strategies employed, and any intrasite differences are discussed. A behavioral flow model that accounts for the choices that the Native American inhabitants of the Beach Face locus made in their use of lithic technology is presented. Recommendations for future research are given.

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CHAPTER 1

INTRODUCTION

This study aims to identify technological practices of Native American people who lived at the Kimble's Beach site (28 CM 36A) during the Late Woodland period (ca. 800/900-1650 AD) of Eastern prehistory. This site is located in the northern portion of the Cape May Peninsula along the margin of the Delaware Bay in New Jersey. The Kimble's Beach site (KBS) was jointly excavated by Rutgers University and Stockton State College during four summers in the period 1995-1998. The site extends approximately one km from the beach face at Kimble's Beach to inland portions, on both private property and the Cape May National Wildlife Refuge and Nature Conservancy property in several discrete loci. This study is restricted to the recovered lithic materials from the Beach Face (BF) locus only.

Data collected from chipped stone artifacts (CSA) and associated debitage (discarded flaking debris) recovered from the beach face are compared with data collected from experimentally replicated chipped stone tools and debitage to identify tool making behavior represented at the site. Sullivan and Rozen's flake typology (Sullivan and Rozen 1985; Sullivan 1987) data derived from the debitage of the tool making experiments and experimental bipolar and freehand reduction of alluvial chert pebbles conducted by Kenneth Mohney (2004) were statistically compared to determine if these reduction strategies may be distinguished by this data. Univariate and multivariate statistical analyses of data derived from debitage resulting from experimental tool manufacture were undertaken to determine if they may be used to infer behavior in the tool making process in the absence of CSA. The data from CSA and debitage recovered from the site were compared to the experimentally derived data to develop a behavioral flow model that accounts for choices in procurement, manufacture, use, reuse, and discard of lithic materials by the Native Americans whose activities produced the site record.

This research on the lithic technology, represented by the KBS artifacts, is the first published work on this site in any aspect. The amount and kind of data presented in this study may appear to be excessive, e.g. both charts and tables for a single attribute, but it is hoped this information may be used as a foundation for any future analysis of the KBS. In addition, this material can serve as a comparative data base for any regional studies of lithic technological organization in the future. Lastly, any comprehension analysis of chipped stone materials for an archaeological site on the Cape May Peninsula can only add to our knowledge of this poorly documented area of New Jersey.

Chapters 1 through 3 provide information on the theoretical foundation for the study of human behavior in technological organization, the geology and regional prehistory of the Cape May Peninsula, and the background of the KBS excavations and a discussion of the applicable site formation processes. Chapter One, *Behavior in Technological Organization*, discusses technological organization, issues of mobility and sedentism, expedient and curated technologies, opportunism, adaptation to local resource conditions, and the choices available to the inhabitants of Kimble's Beach in the procurement of lithic raw materials and the manufacture of stone tools. It further discusses two research strategies proposed by Schiffer (1976) that are utilized in this study. Chapter 2, *Geology and Regional Prehistory*, reviews the geological history of the

New Jersey, discusses the Coastal Plain in terms of geographic location and soils, and the Cape May Peninsula in terms of its location, topography, geologic features, major rivers, soils, current climate, and the lithic resources with potential for use in tool manufacture. The KBS is placed in the historical context of Native American occupation of New Jersey and the Cape May Peninsula, including that of Algonquian peoples who occupied the land in the Late Woodland period. Six of the best documented Late Woodland period sites on the Cape May Peninsula are considered. Chapter 3, *Site Background* , presents information on the history of the project, its location and size, a summary of recovered materials, and the excavation methodology employed at the beach face. The site formation processes, especially the transgression of the Delaware Bay and the salt marsh formation and migration that provides the stratigraphic context for the beach face locus. In furtherance of understanding site formation processes, the results of a study, for this project, made of aerial photographs to determine bay transgression rates over a 45 year period (1940-1995) are presented. Site maps of the beach face excavations and representative individual unit profiles are included. A discussion of the evidence for classifying KBS as a Late Woodland period occupation and a summary of the paleoecology of the KBS environs during this time is also found within the chapter.

Chapter 4, *Methodology*, discusses the research design in terms of technological organization, the core technology employed by the Kimble's Beach knappers, the manufacture of tools (bifaces and unifacial scrapers), and the employment of attribute analysis of debitage to answer specific research problems. A summary of major historical trends in lithic studies is provided. The goals of the stone tool and debitage analysis are discussed, as well as the procedures used in the analysis of these materials.

A biface reduction sequence for the manufacture of small triangular projectile points from alluvial gravels is proposed. The mechanism and results of a 20 percent sample of the recovered beach face debitage, which provided data to guide the development of this research study, are treated in this chapter. Two proposed methodologies, the Sullivan and Rozen (SRT) flake typology (Sullivan and Rozen 1985; Sullivan 1987) and Patterson's (1978, 1982, 1990) log-linear model, to classify debitage as resulting from tool manufacture, generalized core reduction, or bipolar reduction are presented. The nominal, ordinal, and ratio attributes used in the debitage analysis are discussed as to their proposed value in answering research questions. The methods used in this study to measure or to determine the states or categories of these attributes are presented. The procedures and details of the lithic experiments, which included collection and grading of alluvial gravels, heat treatment of a subset of the gravels, and the experimental tool manufacture episodes, are discussed.

Chapter 5, *Analysis of the Experimental Debitage,* contains the results of the analysis of the debitage derived from the experimental tool manufacture. Statistical methods used in this study are presented. An evaluation of the effectiveness of the log-linear model and SRT flake categories to classify debitage resulting from different reduction strategies of alluvial chert and jasper gravels are presented. The results of the debitage analysis in regards to the proposed research problems are discussed.

Chapter 6, *Analysis of Beach Face Lithic Artifacts*, presents the results of the analysis of CSA, debitage, and other lithic materials and the application of the experimental results to the debitage recovered from the BF locus. Data from the analysis of chipped stone tools, cores, non-flaked lithic tools, and raw materials is presented. The results of the attribute analysis of experimentally produced debitage as applied to the debitage recovered from the BF locus are presented and discussed. Conclusions regarding the results of the attribute analysis and the analysis of the flaked and non-flaked lithic materials are discussed.

Chapter 7, *The Lithic Technology of Kimble's Beach* , presents the conclusions of this study. A behavioral flow model that accounts for the choices that the Native American inhabitants of Kimble's Beach made in their use of lithic technology to meet their needs for lithic raw materials and the manufacture of tools is presented. A summary of raw material procurement, reduction strategies employed, heat treatment, biface manufacture, and tool types for KBS are contained in this chapter. Conclusions concerning the site function, any intrasite differences, and mobility strategies are discussed. Finally, recommendations for future directions in research on the KBS are given.

Behavior in Technological Organization

The study of human behavior in technological organization has been the focus of a growing body of archaeological research in the last three decades (Hegmon 2003:215-16; Nelson 1991:57; Schiffer, et al. 2001:729). The emphasis in lithic studies has shifted from technical issues of lithic manufacturing (Callahan 1979; Cotterell and Kamminga 1979; Cotterell and Kamminga 1987; Crabtree 1972; Magne and Pokotylo 1981; Odell 1989) to an examination of how humans organize their technological behavior (Bamforth 1986; Bamforth 1991; Binford 1979; Carr 1994a; Kelly 1992; Nelson 1991). Schiffer (1976:4) has proposed "...that the subject matter of archaeology is the relationship between human behavior and material culture in all times and places." Carr and Bradbury (2001:127) suggest that the study of lithic technology through an organizational approach may provide new understandings of patterns of behavior in prehistoric groups.

This study drew on elements of behavioral archaeology (Schiffer 1976; 2001), technological organization (Nelson 1991), experimentation (Callahan 1979; Crabtree 1975; Shott 1994), and analysis of chipped stone tools and flaking debris or debitage (Andrefsky Jr. 1998; 2001a; Magne 2001). This is a holistic approach (Larson 1994) which combines the separate analysis of stone tools and debitage, along with raw material availability, production stages, and activities. Ingbar (1994:50) proposed that these analyses, coupled with consideration of raw material sources, are essential to understanding stone age technological organization. These multiple avenues of investigation are indicative of a view that problems can often be most effectively addressed by the integration of theoretical orientations and multiple analytical techniques or sources of evidence (see review of the current state of theory in North American archaeology in Hegmon 2003 ; Nelson 1991:58; Schiffer, et al. 2001:167).

Nelson (1991:57) defined technological organization as "... the selection and integration of strategies for making, using, transporting, and discarding tools and the materials needed for the manufacture and maintenance." Technological strategies may be viewed "...as problem solving processes that are responsive to conditions created by the interplay between humans and their environment (Nelson 1991:58)." Organization of technology studies examine how economic or social variables impact these strategies. This study examined the relationship of locally procured cryptocrystalline gravels from the Delaware Bay margins, and the technology to exploit this resource. Implicit in the analysis and conclusions is an adherence to the economic principle of least effort and maximization of cost/benefit ratios (see Winterhalder and Smith 2000) in the procurement and utilization of lithic resources (Binford 1979; Brantingham 2003; Riel-Salvatore and Barton 2004).

A significant consideration in many studies of the organization of technology has been the issue of mobility (see studies in Andrefsky Jr. 2001b; Kelly 1994:132). To some degree, this study is also concerned with mobility, as it examines the proposition that sedentism or semi-sedentism was an adaptive strategy in southern New Jersey, and is applicable to settlements at Kimble's Beach (Stewart 1995:194). This study attempts to integrate considerations of the availability of lithic resources (environmental conditions), expedient and opportunistic tool making (technological strategies), and spatial variation within the KBS and its environs (activity distribution). All of these preceding levels of study have implications for the assessment of behavioral choices in the organization of technology.

Binford's (1980) *forager/collector* dichotomy has been a widely used concept in mobility studies (Kelly 1992:45). Binford (1980:15) proposed two kinds of mobility: *logistical mobility* and *residential mobility*. In *logistical mobility*, a group positions itself residentially to exploit a major resource, coupled with daily or overnight forays by groups who bring more distant resources back to the residence. These people make fewer residential moves and are termed *collectors*. Those who follow the strategy of *residential mobility* move frequently to take advantage of the availability of resources more evenly distributed within a daily foraging radius. *Foragers* consume their resources and replenish them daily, while *collectors* often use storage features to extend the availability of a particular resource.

Sedentism is often viewed by archaeologists as one end of a mobility continuum, with high residential mobility on the opposite end (Kelly 1992:50). In North America sedentism is often, but not always, associated with the adoption of horticulture (Odell 1994; Stewart 1995), but evidence of gardening has not been documented for the Outer Coastal Plain of New Jersey (Grossman-Bailey 2001; Mounier 1982; Stewart 1998c). However, the abundance of coastal and wetland resources is considered a prime candidate to account for a sedentary settlement system (Kelly 1992:52), or at least one that is semisedentary within a relatively limited territory (Stewart 1995:194; Stewart 1998d).

The use of expedient and curated tool technologies can be viewed as an indicator of mobility strategies employed by a group (Binford 1979; Bleed 1986; Kelly 1988). Curation is a strategy that anticipates the use of certain tools under conditions without the time or resources available to manufacture them (Binford 1979:263). Transport, maintenance, reliability, recycling, and caching may be all or some of the features of a curated technology (Nelson 1991:62). Available raw materials are either non-existent, limited, of poor quality, or poorly known. Expedient tools generally have little time invested in manufacture or retouch, and are discarded where used. These tools are informal with individual flakes and cores used as needed (Nelson 1991:80-81). Although manufactured, used, and discarded at the area of need, expedient tools are the result of planning and part of the organization of technology. In an expedient technological strategy, activities are either positioned near the raw material supply, or the raw materials are stockpiled close by for easy access. Curated tools are most often made of non-local high- quality cryptocrystalline materials, while expedient tools are usually made of local materials of varying quality. Explicit in curation is the anticipation of the need for use at certain locations, while expediency anticipates that at the area of use there will be sufficient resources and time available for manufacture (Nelson 1991:64). A curated technology is considered to be an indicator of a mobile group, and expedient technology that of a more sedentary group (Kelly 1992:55). However, Kelly (1992:55) cautions that there is no direct one to one relationship between these technologies and mobility, and that such variables as tool function, raw material type and distribution, hafting, and risk all effect technological choices.

In addition to curation and expediency, a third technological behavior is practiced in response to immediate, unanticipated situations (Nelson 1991:65). This is opportunistic technological behavior, or as referred to by Binford (1979:267), the use of "situational gear." This behavior arises when a situation presents itself that was unplanned for, but offers potentially high returns that must be taken advantage of immediately. These tools are manufactured and used at the time and place of need without any forethought involved. Curation and expediency are the result of planning, while opportunistic behavior is spontaneous. Curation, expediency, and opportunism may be practiced separately or in concert as part of the totality of an organization of technology (Nelson 1991:65-66) .

Technological behavior is viewed as adaptive to the local resource conditions, as well as economic and social strategies (Nelson 1991:57). Among the variables of technological plans are the staging of manufacture, the use, and the reuse of tools (Ingbar

1994:50; Nelson 1991:57). These are the specific areas of behavior that I concentrated on in this study. Nelson (1991:57) concluded that "... studies of technological organization expand our view of tool function to include variables of technological strategies.” Technological strategies may be viewed as problem solving processes that respond to circumstances resulting from the interaction between people and their surroundings (Nelson 1991:58). Organization of technology is a useful approach to provide insights into prehistoric lifeways since technology is viewed as playing a "dynamic role" in the adaptation of a culture to its physical and social environment (Carr and Bradbury 2001:127).

The Late Woodland residents of Kimble’s Beach were faced with choices related to the procurement of raw materials and the manufacture of lithic tools in an area (site catchment area with a radius of 10 km) whose lithic resources consisted entirely of river worn gravels from the margins of the Delaware Bay. Among the lithic manufacturing techniques evidenced at Kimble’s Beach are testing of raw material, the use of bipolar technology to prepare gravels for processing, the production and reduction of flake blanks or split halves in biface manufacture, and heat treatment to improve the flaking quality of raw materials. The prehistoric knappers also chose whether to conduct testing and initial processing at the beach face source area, or to transport raw materials from the source area to the site for these activities. These available tactics required the assessment of many causal factors that influenced the technical choices made by the prehistoric and modern flintknappers (Schiffer et al. 2001:732)

Schiffer (1976:4-9) proposed that there were four research strategies an archaeologist could pursue to derive questions to elicit human behavior from the archaeological record. This study falls within the realms of Strategy 1 and Strategy 2. The former is in the idiographic component of archaeology and the latter within the nomothetic component (9). Strategy 1 "...is concerned with using material culture that was made in the past to answer specific descriptive and explanatory questions about the behavior and organizational properties of past cultural systems" (Schiffer 1976:5). This strategy is implemented through the analysis of the CSA, with special attention paid to the identification of raw materials, tool types, and remnants of the biface reduction sequence. This data was designed to provide insight into the site function and raw material exploitation.

Strategy 2 research "...pursues general questions in present material culture in order to acquire laws useful for the study of the past" (Schiffer 1976:6). Laws are defined not as immutable statements, but rather relational statements, "...which function (in conjunction with other information) to explain or predict empirical phenomenon" (Schiffer 1976:4). The major component of this aspect of the overall research design for this study, is the use of experimental archaeology in which the interaction of selected controlled variables is observed. A flintknapping experiment was undertaken, which utilized locally obtained gravels from the Delaware Bay to manufacture triangular bifaces and unifacial tools. The main variables controlled were raw materials, choice of percussor, technological approaches, final product, and heat treatment. Additionally, flake attribute variables were evaluated for ease of assessment, replicability, and discriminatory power (Kelly 1994:134). The results of this experiment provided answers (or developed laws as defined by Schiffer) to questions in the identification of reduction sequences, differing debitage signatures of biface, uniface, and bipolar core reduction, and discrimination between flake and split pebble halves as a starting point in the biface reduction sequence. Lithic technologies in New Jersey generally have not been examined and reported with scientific approaches such as this (Stewart 1986b:44). This observation appears as valid today as when originally published.

A behavioral chain, depicted in a flow model (see Figure 7.4, Chapter 7), is presented to indicate the sequence of activities (life history) for lithic artifacts in systemic context (structure of the past) as opposed to structure of the present (archaeological record). The systemic context of the past is different from that of the archaeological present. Unlike the relatively static structure of archaeological contexts, functioning cultural systems of the past were dynamic, with energy inputs and outputs resulting in changes in quantitative, spatial, relational and formal variables (Schiffer 1976:42-43). This behavioral chain models the transformation of the systematic past into the present archaeological record by tracing the procurement, manufacture, use, reuse, and discard of lithic materials.

Odell (1994:72) observed it is often difficult to do research in technological organization in some areas due to a paucity of prior research into the culture history and paleo-environmental conditions of the area. Certainly the lament of Kraft and Mounier (1982:168) concerning the paucity of scientific inquiry into the Late Woodland period in New Jersey, and reiterated by Mounier (1982:163-164) for southern New Jersey in particular, matches Odell's observation. In the last 23 years this situation has been little alleviated. Grossman-Bailey (2001:69) in her review of archaeology on the Outer Coastal Plain of New Jersey found that of the 992 site reports she examined, only 14 involved major data recovery or excavations, and only 28 excavated sites were described.

The last review of the site reports at the New Jersey State Museum (NJSM) files, in May of 2008, produced only 61 sites for Cape May County, of which 45 were prehistoric sites. Of this group of prehistoric sites, only four sites were rigorously investigated and published as a result of three cultural resource projects (Mounier 1997; Pagoulatos 1992; Stanzeski 1996). These sites are on the Atlantic coast in the northeast corner of the peninsula (Figure 2.2). The Kimble's Beach site is the only site scientifically excavated on the Delaware Bay side of the peninsula. The goal of this study is that this research will improve our basic knowledge of adaptations on the Cape May Peninsula, which will be eventually integrated into a systematic study of technological organization on the Outer Coastal Plain of New Jersey, and the Cape May Peninsula in particular.

CHAPTER 2

GEOLOGY AND REGIONAL PREHISTORY

Location of New Jersey

New Jersey is located within the Middle Atlantic Region of the Eastern United States (Figure 2.1). Its political borders are delineated by natural features, except in the north. It is bounded on the west by the Delaware River, on the south-southeast by the Delaware Bay and the Atlantic Ocean, and on the east by the Hudson River and the Atlantic Ocean. The northern boundary is a diagonal line that runs in a southeasterly direction from the Delaware River to the Hudson River.

The state length is 166 miles (267 km) from the intersection of its northern border and the Delaware River to the southern tip of the Cape May Peninsula. It is narrowest portion is 32 miles (56 km) between the head of the Raritan Bay and the Delaware River at Trenton. The portion of New Jersey north of this line is a relatively square shape with a distance of 55 miles (89 km) in a northwest to southeast direction and 65 miles (106 km) from northeast to southwest. The area of the state south of the Trenton-Raritan Bay line is 100 miles (161 km) in length from the Raritan Bay to the Delaware Bay and is 57 miles (92 km) in width slightly south of a line between Camden and Atlantic City (Kummel 1940). The land area of the state is 7,836 square miles (Hammond 1972).

Physiographic Provinces of New Jersey

There are four major geomorphic provinces in the state of New Jersey (Figure 2.2). They are, from north to south, the Appalachian Ridge and Valley, the New Jersey

Figure 2.1. Middle Atlantic Region. This map shows the location of the Kimble's Beach site (Maps.Com 2004).

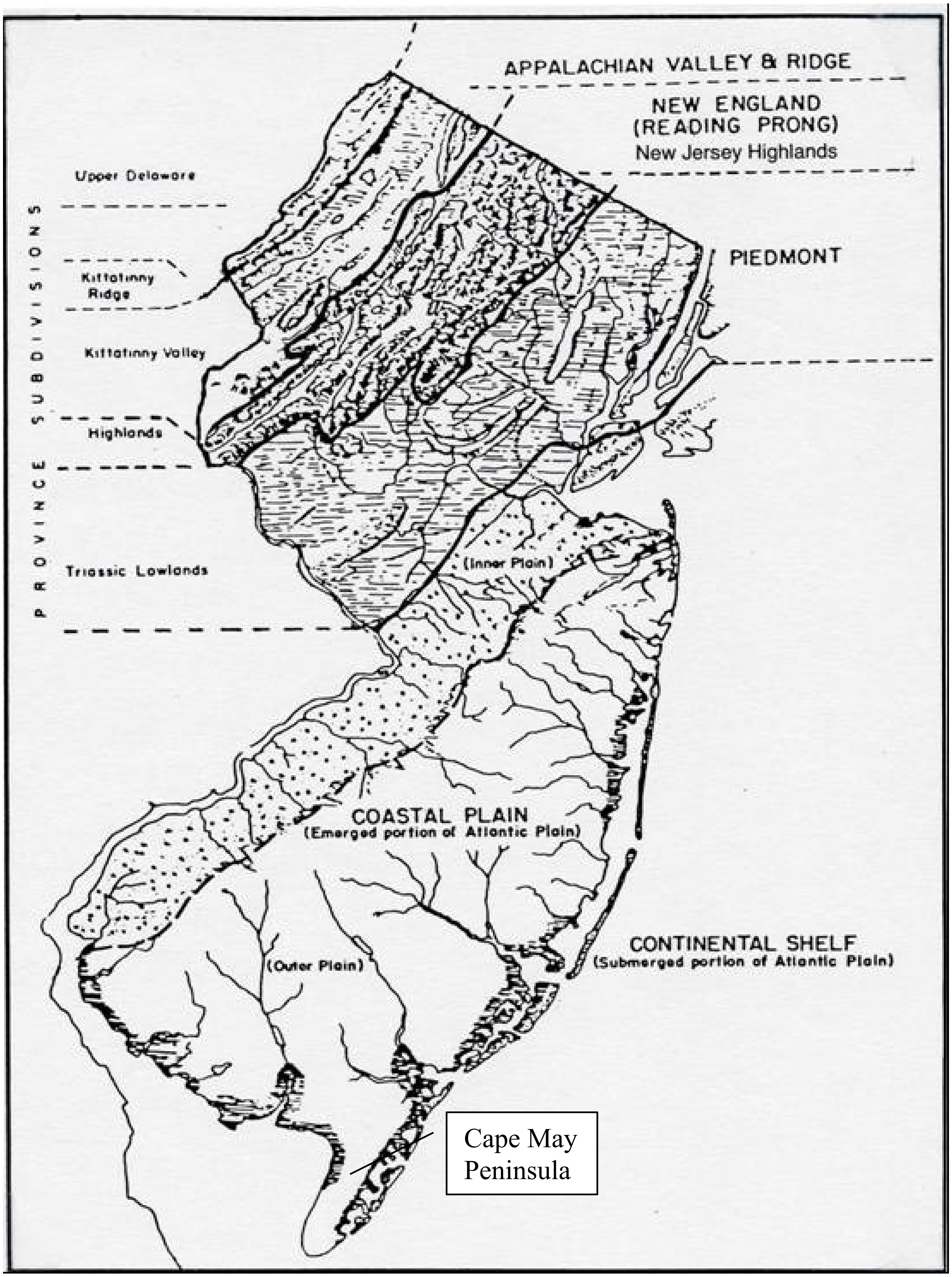


Figure 2.2. Geomorphic provinces of New Jersey (Wolfe 1977). Location of Cape May Peninsula is shown.

Highlands, the Piedmont, and the Coastal Plain. The latter is subdivided into the Inner Coastal Plain (ICP) and the Outer Coastal Plain (OCP) (Kummel 1940; Widmer 1964; Wolfe 1977). The Kimble's Beach site is located in the OCP on the Cape May Peninsula.

In addition to geographic diversity, New Jersey has one of the most complete geological records of the 50 states. It contains a rock record that spans a period slightly less than two billion years, except for the Carboniferous and Permian periods of 225 to 350 million years ago (Wolfe 1977).

In the Quaternary, three major glacial episodes impacted New Jersey (Kummel 1940; Salisbury and Knapp 1917). The youngest, the Wisconsian glacial, covered the northern third of the state at its maximum at 18,000 years ago. Much of the evidence of the earlier two glacial episodes, the oldest Kansan, and the intermediate, Illinoian, was erased during this advance (Wolfe 1977). The maximum glaciation in the state extended south to a curved line that connects the present towns and cities of Perth Amboy, Plainfield, Summit, Morristown, Dover, Hackettstown, and Belividere. The deposits of sand, gravel, clay, and boulders that cover most of the area north of this line are the results of glacial action (Kummel 1940). The Coastal Plain was the recipient of widespread deposits of gravel, sand, and clay during the interglacial stages (Wolfe 1977).

Coastal Plain

The Coastal Plain accounts for three-fifths of the land in New Jersey. It comprises all of the land in the state, south of New York Bay and the Raritan River estuary, and east of a line from New Brunswick to Trenton (Wolfe 1977). The Coastal

Plain in New Jersey is part of a belt that stretches south from the Raritan Bay to Mexico. It extends northeast of the Raritan Bay to parts of Staten Island, Long Island, the islands of southern New England, and all of Cape Cod. The Coastal Plain extends 100 miles beyond the present coast and becomes the Continental Shelf, which terminates in a steep escarpment, the Continental Slope. As recently as the last glacial maximum (18,000 BP), up to 80 miles of the Continental Shelf was exposed subaerially, and the coastal plain was double its present extent (Kummel 1940; Salisbury and Knapp 1917; Wolfe 1977).

The Coastal Plain has two subdivisions, the Inner Coastal Plain (ICP) and the Outer Coastal Plain (OCP) (Figure 2.2). The demarcation between these two subdivisions is a cuesta, which is a unique topographic and geologic formation formed of Cretaceous sand and marl. It extends east-west (actually southwesterly) from south of NY Harbor, to its terminus near Mullica Hill on the Raccoon Creek in Salem County. The land north and west of the steeper slope of the cuesta drains into New York Bay, the Raritan River, and Delaware River. The area south and east of the gentler slope drains into the Atlantic Ocean or the Delaware Bay (Widmer 1964). One of the resistant outcrops of rock, characteristic of a cuesta (Academic Press 1992), is referred to locally as "cuesta quartzite." This material was most often utilized by indigenous peoples occupying the adjacent areas of the ICP and OCP from Paleo-Indian through Late Woodland times, but it also has been found in more distant locales throughout the state (Jack Cresson, personal communication 2006).

There is little relief on the majority of the Coastal Plain, especially on the OCP. The highest elevation of the Coastal Plain is 122 m (400 feet) near the Piedmont, but most of it is less than 61 m (200 feet), with the southern half less than 30.5 m (100 feet).

As a result of this relatively low elevation, streams that flow in the region do not cut any deep valleys, but rather flow in open valleys that are only slightly lower than the surrounding lands (Kummel 1940:20).

The Coastal Plain is formed of Cretaceous, Tertiary, and Quaternary age materials (Kummel 1940; Wolfe 1977). However, in most areas the formations of the two earlier ages are concealed by Quaternary materials, which were deposited as a result of glacial melting during the warm interglacial periods. South of New Jersey, these unconsolidated sand and gravel deposits are lumped together as the Columbia Formation, although they are actually a series of formations. In New Jersey this practice has been replaced by reference to three distinct formations. They are, in order of oldest to youngest; the Bridgeton, Pennsauken, and Cape May (Salisbury and Knapp 1917:3). The first of these warming trends, the Aftonian interglacial, which separated the Nebraskan and Kansan glaciations, produced the Bridgeton Formation. The Pennsauken Formation is dated to the Yarmouth, the second interglacial which separates the Kansan and Illinoian glaciations. It is the thickest formation on the Coastal Plain, with the exception of the Miocene age Cohansey Formation. The Cape May Formation, which rims the coastline below 50 feet in elevation, is the youngest, and is dated to the Sangamon, or fourth interglacial period, which separates the latest Wisconsian and the preceding Illinoian glacial episodes (Widmer 1964:134-135). The Cape May Formation forms a continuous border along the coast from the Raritan Bay on the Atlantic side to Trenton on the Delaware Bay (Salisbury and Knapp 1917:164). These gravel resources of the Cape May Peninsula derive from the glacial meltwater transport processes related to these three formations. The Beacon Hill Gravels, which top the tallest hills of the Coastal Plains, are thought to be the residue of stream deposits made in the early Tertiary (Wolfe 1977:125).

Marine sedimentation was responsible for the formations which underlie the Pleistocene age formations on both the ICP and OCP. However, these formations were laid down at different geological periods. The sands, gravels, silts, and clays, which comprise the sediments of the ICP, were products of the Cretaceous . On the OCP, sediments of gravels and quartz sands were deposited during the Tertiary and Quaternary periods. This differing depositional history resulted in markedly different soils in these two subprovinces (Kummel 1940; Salisbury and Knapp 1917).

The subsoils of ICP are chiefly clays and loams, while those of the OCP are coarse quartz sands that extend to a depth of 2,300 feet near Atlantic City. As a result, the soils of the ICP are generally finer and have better water retention than those of the OCP, with a resulting higher fertility level. The soils of the OCP are predominately droughty, which results in a low available water capacity and the leaching of nutrients from the soil, although the soils along the Delaware Bay shoreline tend to be more clayey than the rest of this subprovince. These factors lead to predominately infertile soils in the OCP. The soils of both subprovinces tend to be highly acidic, with those of the OCP ranging from extremely acidic (PH <4.5) to very strongly acidic (PH 4.5-5.0). The high acidity and general infertility of the OCP soils limits the type and quantity of vegetation (Ator et al. 2003; Kummel 1940; Markley 1977; Mounier 1978).

The northern part of the Cape May Peninsula contains the southernmost portion of the pine barrens of New Jersey. The pine barrens consists of relatively flat land between the Atlantic coast and the Delaware River valley to the west. It consists of 1.25

to 1.4 million acres of sandy, acidic, and very unfertile soils. In New Jersey, the pine barrens constitute the majority of the OCP. In the Late Woodland times, the pine barrens stretched from Monmouth County south approximately 90 miles to Cape May Court House, which is less than 10 km from Kimble's Beach, and was 40 miles in width in many places (Boyd 1991:2).

The soils of the pine barrens are extremely permeable and highly acidic. Due to its high degree of porosity, water drains downward rapidly, leaving the surface dry and leached of nutrients. The sandy soils of the pine barrens are largely composed of quartz or silica (often greater than 90 percent). The soils of the pine barrens developed from the sandy, sedimentary deposits that characterize the OCP in New Jersey (Boyd 1991:6-7).

Cape May Peninsula

The political subdivision of New Jersey, Cape May County, comprises the entire Cape May Peninsula, which is the southern tip of New Jersey (Figure 2.2). The peninsula has an area of 69,077 hectares (170,688 acres) with 93 km (58 mi) of shoreline (Markley 1977). It is approximately 14.5 km (9 miles) along an east-west axis from the KBS on the Delaware Bay to the Atlantic coast (U.S.G.S. 1984a). It is bounded by the Atlantic Ocean on the east and south and the Delaware Bay on the west. The Tuckahoe River in the north and West Creek in the northwest form most of its northern political border, and is roughly equivalent to the northern geographic extent of the peninsula.

The Cape May Peninsula falls wholly within the OCP. The topography is characterized by gentle slopes with the highest elevation in the peninsula being 55 feet

(16.8 m) (Markley 1977). In a 10 km (6.1 mi) radius from the KBS, the highest elevations are 7.6 m (25 ft) near the eastern or Atlantic coast of the peninsula. The bulk of the terrain within this radius is 20 m or less in elevation (U.S.G.S. 1984a).

The rivers and streams of the Cape May Peninsula flow either to the Delaware Bay or the Atlantic Ocean. The width of the Delaware Bay slope is approximately half that of the Atlantic slope on the Cape May Peninsula. The Maurice River is the largest river that flows into the Delaware Bay. Although, it is actually not on the peninsula, the mouth is 16.5 km (10.2 mi) in a straight line northwest from Kimble's Beach and 22 km (13.7 mi) along the shore line (U.S.G.S. 1984a; U.S.G.S. 1984b). Its headwaters begin near Glassboro on the Atlantic slope and flow 53 km (33 mi) to the bay (Figure 2.8). The Tuckahoe River is the largest of the Cape May Peninsula and flows to the Atlantic Ocean. South from the Maurice River, several smaller streams flow to the Delaware Bay. They are, from north to south, West Creek, Dennis Creek, Goshen Creek, Bidwell and Dias Creeks (north and south of Kimble's Beach respectively), Green Creek, Fishing Creek, Cox Hall Creek, and Pond Creek (U.S.G.S. 1981; U.S.G.S. 1984a; Vermeule 1894:271-285). A comparison of the 1884, 15 minute series map from covering Cape May County, and the most recent 7.5 minute series (G.S.N.J. 1884; U.S.G.S. 1972b; U.S.G.S. 1977b; U.S.G.S. 1981) with similar coverage, indicates that there are numerous manmade mosquito ditches that drain the wetlands bordering the bay that were not present prior to the twentieth century, in addition to the Cape May Canal, which was dredged along the bed of the New England Creek (Dorwart 1996:228). Bidwell Creek, a third order stream (Waters 1996:116-117), also known as Bidwell Ditch, was created in the channel of a first order stream known as Wills Creek in the 1890's, fundamentally altering the marshes in the area and greatly diminishing the depth of Goshen Creek (Dorwart 1996:266).

The Cape May Formation, the youngest of the interglacial geological formations, blankets all of the Cape May Peninsula. Although it is found in many areas of the coastal plain, it is predominant on the Cape May Peninsula, hence its designation as the type area for the formation. It is found in all the southeastern draining streams and rivers of the peninsula, as well as those that drain into the Delaware Bay (Markewicz 1969; Salisbury and Knapp 1917; Wolfe 1977). The Cape May Formation ranges from a couple of feet to 130 feet in thickness. It is dominated by sand and gravel with small amounts of silt and clay (Markley 1977).

The current climate of the peninsula is humid and temperate, which is greatly influenced by the Delaware Bay in the west and the Atlantic Ocean to the east. The influence is greater in the southern part of the county and less so in the north. The climate is fairly uniform throughout the peninsula due to a lack of influencing physiographic features, except for the coastal influences. In the winter and early spring, winds are generally from the northwest, and in late spring and summer, from the southeast. Temperatures can range from a summer high of 55.5° C (100° F) in the south (Cape May Point) to a low of -19° C (-3° F) in the winter, while in the north (Belleplain) temperatures may vary from a summer high of 41.1° C (106° F), to a winter low of -30° C (-22° F). Temperatures do not stay low for long periods, and the ground seldom freezes below a depth of 30.5 cm (1 ft). Annual rainfall also varies from north to south with a range of 81-170 cm (32-67 in.) for the former and 66-145 cm (26-57 in.) for the latter (Markley 1977:45-46).

Proxy measures, including ice cores, tree rings, lake varve deposits, and pollen profiles, indicate that an essentially modern climate was established during the period 5700-3200 calibrated BP in the eastern United States (Anderson 2001; McWeeny and Kellogg 2001). Additionally, Hartzog's (1981:8-9) review of palynological studies in New Jersey, New York, and the Delmarva Peninsula concluded that the vegetation of the OCP was essentially modern and stable by 10,000 BP, though with a somewhat greater diversity in the past than today. This stands in contrast to the pattern of forest succession in northern New Jersey, New York, and New England in the first 5,000 years following the glacial maximum. The data suggests that the climate encountered by the inhabitants of the Kimble's Beach area during the Late Woodland period was essentially the climate of today.

One of the distinguishing features of the OCP is the periglacial landform, called a thermokarst or freeze-thaw basin. They vary from several meters in diameter to a few hectares in area. The depth of these features ranges from one to five meters. In aerial photographs their appearance greatly resembles bomb craters. Thermokarsts are distributed from South River to Cape May and from the Atlantic Ocean to the Delaware River. These features are particularly widespread across the Cape May Peninsula (Wolfe 1977:290-291). In the early Holocene period these features were filled with water and surrounded by vegetation, which attracted animals, which in turn attracted prehistoric hunters. Surveys by Bonifiglio and Cresson (Bonifiglio and Cresson 1981), and Cavallo and Mounier (Cavallo and Mounier 1981), indicate widespread exploitation of these features by peoples in the Paleo-Indian period through the Early and Middle Archaic periods on the OCP. There is little evidence that these features were exploited by the peoples of the Late Woodland period. It is most probable by this time these features were either filled or had lost their attractiveness to the hunters and foragers of the Late Woodland period (Mounier 1982).

The predominate upland soils series found east of, and adjacent to the KBS, are the Hammonton-Woodston-Klej (HaA, HbA, WmA, and KmA) association and Downer-Sassafras-Fort Mott (DoA, DpA, DrA, DrB, DsB, SaA, SaB, SbA, and FrB) association (Figure 2.3). The former are considered droughty with a loamy subsoil, and a predominately loamy and sandy substratum and are found on nearly level and gently sloping terrain. The latter are found on level terrain with well drained to poorly drained soils, and a dominant loamy subsoil and a sandy substratum (Markley 1977:3-4; Mueller 1997).

The remainder of the areas surrounding the KBS are made up of Tidal marsh (TD, TM, and TS) associations and Pocomoke-Muck (Ps and MU) associations (Figure 2.3). The latter associations are organic throughout, nearly level, and very poorly drained with a loamy subsoil and a sandy substratum. The former are nearly level and very poorly drained. They are silty and mucky tidal flats which are flooded daily (Markley 1977:4-5). Downer sandy loam (DsB), the only gravel bearing soil found within the 10 km site catchment of KBS, has a gravely substratum 46-76 cm (18-30 in) below the surface. This gravel is predominantly rounded quartzose less than an inch in diameter (Markley 1977). Although this substratum could be exposed by natural elements or human efforts these gravels would not be suitable for tool making. A small area of the DsB soil (Figure 2.3) on the CMNWR, exposed by members of the Rutgers Field School in 1995, was examined by the author. The gravels in the exposures were less than 20 mm in

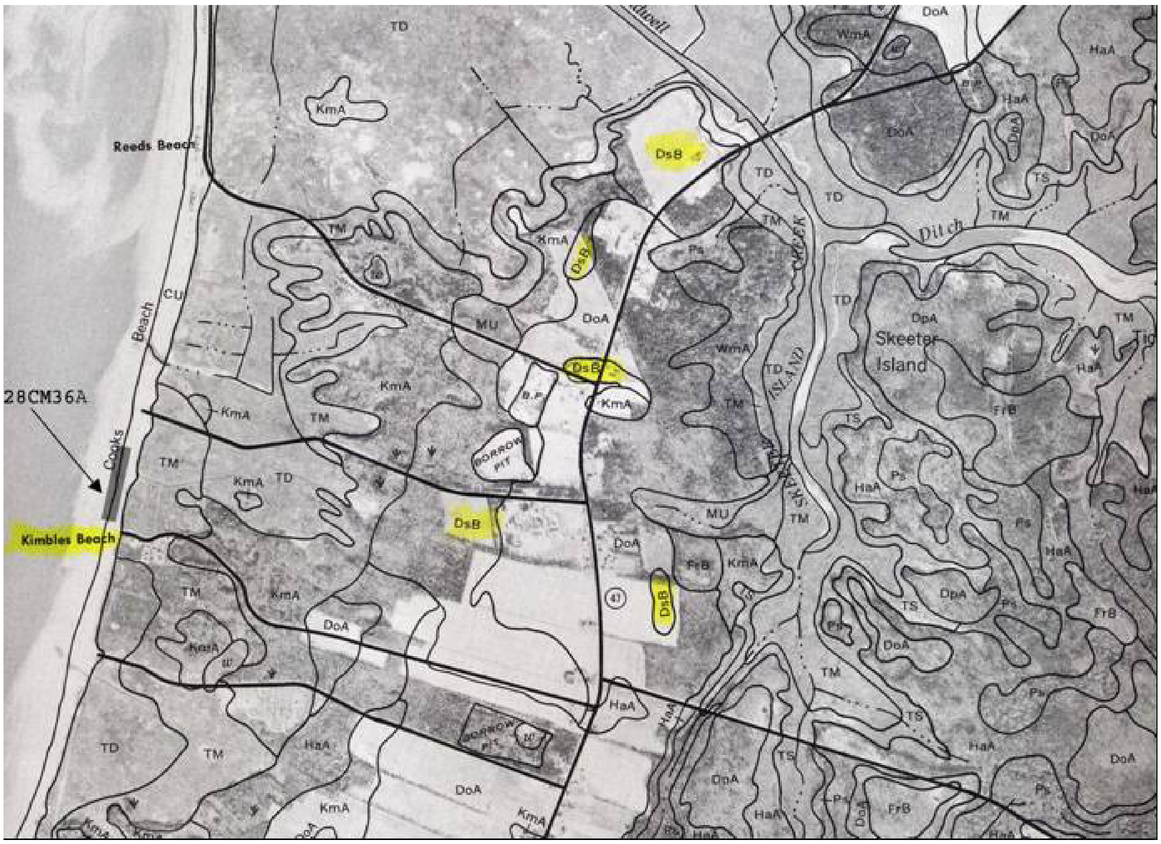


Figure 2.3. Soils in the vicinity of the Kimbl e's Beach site. After Markely (1977:Map 17). Location of the Beach Face locus is shown. Scale: 1 inch = 1666 feet.

diameter, which is generally considered too small to manufacture tools or to produce useful flakes (Callahan 1979; Crabtree 1972; Whittaker 1994). Indeed, a recent study of gravels in the vicinity of the Hickory Bluff site (7KC411), which is located on the coastal plain of Delaware on a bluff overlooking the St. Jones River in South Dover, utilized a minimum of 30 mm as a cutoff for usable clasts for the production of tools and flakes (Petraglia et al. 2002) .

Lithic Raw Material Sources

The OCP is an area that is particularly deficient in primary lithic outcrops of cryptocrystalline materials (Grossman-Bailey 2001; Kraft 2001; Marshall 1982). There are two primary lithic outcrops known on the OCP (Figure 2.4). The first is the aforementioned Cuesta Quartzite, which was found along this division of the ICP and OCP, from the vicinity of Mullica Hill to an area just south of Interstate Highway 195 (Custer et al. 1983; Grossman-Bailey 2001; Widmer 1964). The second is that of a localized outcrop of a silica-cemented quartzite with mollusk inclusions known as Cohansey Quartzite. This outcrop is in the vicinity of the mouth of the Mill Creek, where it flows into the Cohansey Creek at its tidehead near the community of Fairton in Cumberland County (Richards and Harbison 1942). Both of these outcrops were extensively utilized by local indigenous people from the Paleo-Indian to Late Woodland cultural periods (Cross 1941; Custer et al. 1983; Grossman-Bailey 2001; Kraft 2001). This paucity of primary sources is in marked contrast to the northern half of the state, which contains extensive outcrops of cryptocrystalline materials (see Lavin and Prothero 1981:Figure 1). LaPorta (1994) documented over 300 prehistoric chert quarries within

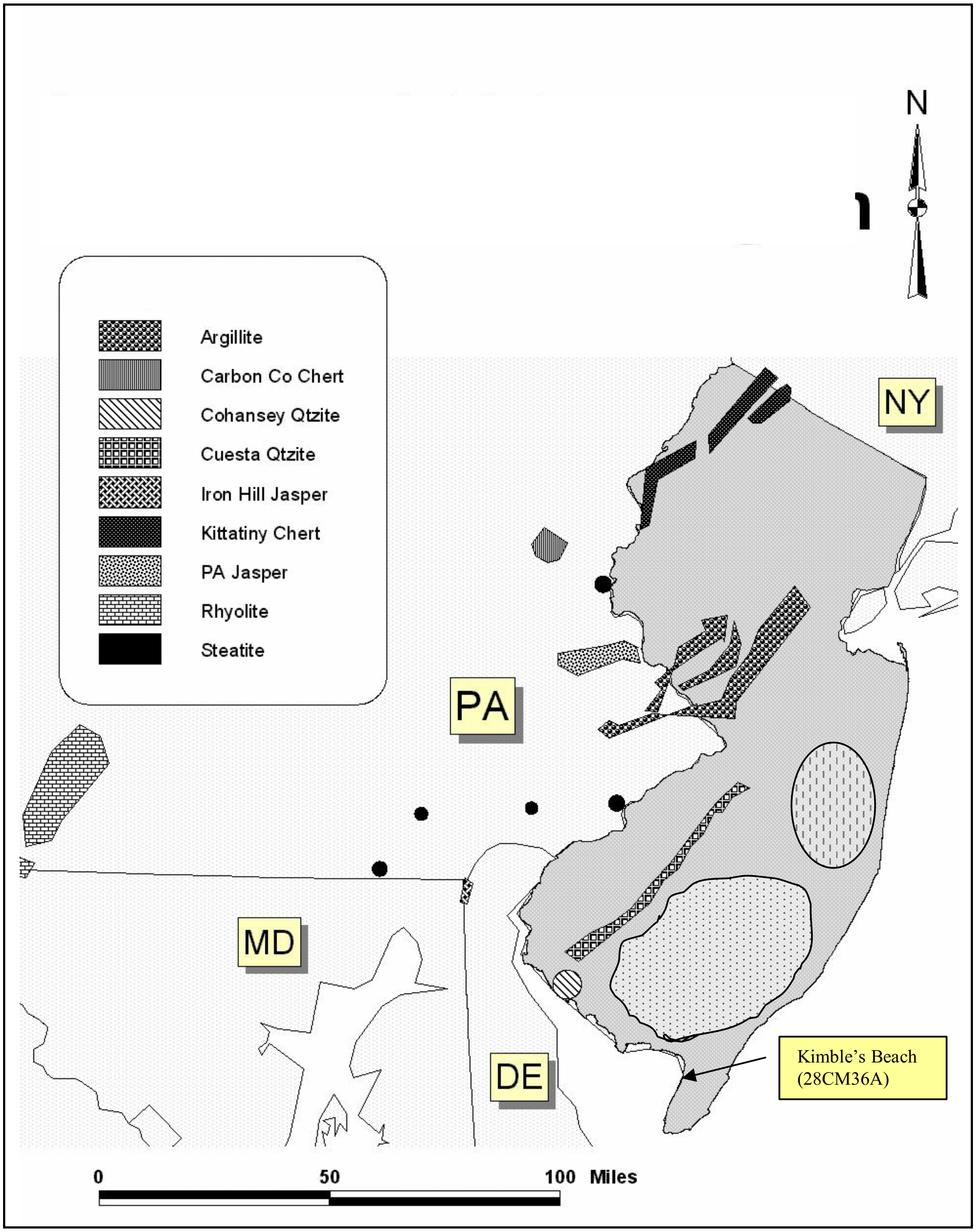


Figure 2.4. Lithic resources. Primary sources shown in legend. Secondary sources of chert gravels: Bridgeton Formation Beacon Hill Gravel
Modified from Grossman-Bailey (2001:Figure 2.8) and Marshall (1982:Map 6).

the Walkill River Valley in the northeastern portion of New Jersey alone, but there are few quarries in the southern portion of the state (Kraft 2001:40).

Although deficient in primary lithic outcrops, the Coastal Plains are “lithic rich” in gravel sources on both margins and from the surface deposits of the Pensauken and Bridgeton Formations and Beacon Hill gravels, which are found north of the Cape May Peninsula and south of the Raritan River (Cross 1941; Custer et al. 1983; Grossman-Bailey 2001; Kraft 2001; Lavin and Prothero 1981; Lavin and Prothero 1992; Marshall 1982). These fluvial deposits of cherts, jaspers, quartz, and quartzite provided a valuable supply of lithic materials for the prehistoric peoples of the OCP, especially in the Late Woodland cultural period (Cross 1941:21-22; Lavin and Prothero 1992:103-110). The cherts and jaspers in the surface deposits of the Pennsauken and Bridgeton Formations and Beacon Hill gravels have their origin in the formations of northern New Jersey, northeastern Pennsylvania, and southern New York, while Delaware River deposits originated in formations as far as 80 km (50 mi) further to the north (Lavin and Prothero 1981:13-14; Lavin and Prothero 1992:104-105).

Chipped stone artifacts from the KBS are composed of 96 percent cherts or jaspers with quartz at less than two percent, the next largest group. These materials occur in relative abundance along the eastern margins of the Delaware Bay in the vicinity of the KBS (personal observation) as well as in the gravel deposits to the north (Custer et al. 1983; Lavin and Prothero 1981; Lavin and Prothero 1992). The raw material preferences would indicate that these people were not traveling to exploit the primary deposits (Figure 2.4), which are (measured in a straight line) 42 km (26 mi) to the Cohansey Quartzite in the vicinity of Fairton, and 75 km (48 mi) to the nearest Questa Quartzite deposits at the southwestern terminus of the cuesta in the vicinity of Mullica Hill (Newell et al. 2000) . The lack of these “exotic materials” doesn’t rule out trade links between the Late Woodland inhabitants of the KBS and their neighbors to the north, but if it occurred, there is no evidence from the beach face sample that the object of this interaction was lithic raw materials. The closest of the secondary sources, excluding the Delaware Bay margin, is the southern edge of the Bridgeton Formation gravel deposits. These gravels in the vicinity of the community of Woodbine are approximately 14 k (9 mi) to the north (Newell et al. 2000), which is beyond the 10 km site catchment area proposed for the KBS, but certainly within reason for lithic procurement forays. The secondary deposits along the eastern margin of the Delaware Bay were a few minutes walk from the KBS in Late Woodland times, and contained enough high-quality cryptocrystalline lithic materials in the form of waterworn gravels to meet the needs of these people (see Chapter 4, *Procurement of Gravels for the Knapping Experiments*).

Regional Prehistory

The prehistory of the Eastern United States and the Middle Atlantic Region is divided into four main cultural/temporal periods: the Paleo-Indian period (ca. 11,500-10,000 B.P.), the Archaic period (ca. 10,000-3,000 B.P.), the Woodland period (ca. 3,000-400 B.P.), and the Contact or Historic period (ca. 400-250 B.P.).[1] The foregoing are the generally accepted historical/cultural periods for the Middle Atlantic Region (Chesler 1982; Custer 1996a:Table 1; Dent Jr 1995; Griffin 1967:Figure 1; Grossman-Bailey 2001:Table 4.1; Kraft 2001:Figure 2.9), although there are other chronological systems in use by archaeologists, most notably Jay Custer of the University of Delaware (1984:Table 2; 1996b:Table 2). The Archaic and Woodland periods are usually further divided into Early, Middle, and Late stages. The last thousand years of the Late Archaic period is sometimes categorized (Kraft 2001:137) as the Transitional Archaic period, or the more preferred term, the Terminal Archaic period (ca. 4,000-3,000 B.P.). There are complications in the application of this system and its cultural generalizations for the times specified when applied to all areas of the region, particularly for the subdivisions of the Archaic and Woodland periods above (see critique in Custer 1996b:18-21).

The historical/cultural periods are largely based on diagnostic artifacts, such as projectile points and ceramics, in contexts which have been radiocarbon dated and can be compared across the region. These artifacts are considered to be indicative of certain technological and cultural changes among the indigenous inhabitants of the region, often in response to ongoing environmental changes. The following will discuss each period broadly in terms of the environment and the general lifeways attributed to it. Special emphasis will be placed on the OCP and the Cape May Peninsula of New Jersey.

Paleo-Indian Period

The Paleo-Indian period is the time when the region was first colonized by Native American hunter-gatherers. Although there is evidence for pre-Clovis settlement in the East, such as Meadowcroft Rockshelter in western Pennsylvania and Cactus Hill in Virginia, these and similar sites are rare in comparison to the somewhat abundant and distinctive post 11,500 BP Clovis sites. The relative abundance of these Clovis sites is viewed as representing populations capable of reproduction and expansion in comparison to the relatively unsuccessful pre-Clovis peoples (Anderson 2001:153-154).

The environment in this period is the direct result of the Wisconsian glaciation and the succeeding melting and retreat (18,000-6,000 B.P.) of the glacier (Sirkin 1977:215). This ice sheet covered approximately the northern 30 percent of New Jersey (see earlier in this chapter for a more thorough discussion) during the last glacial maximum (18,000 B.P.). In the midst of the general overall melting and warming trend of the period there were several climatic fluctuations which were geologically sudden in their onset (40 or less years) in both the Paleo-Indian and Early-Middle Archaic (11,500-5,000 B.P.) times (Anderson 2001:154-159).

At the onset of deglaciation, ca. 18,000 B.P., the areas directly to the south of the glacial front were covered by tundra (Sirkin 1977:215). This tundra, south of the terminal moraine in New Jersey and Delaware, was dominated by pine and spruce with either significant open areas of nonarboreal species, or open vegetation. No modern analog exists for this Pleistocene landscape in either boreal forests or tundra. It most resembles recently exposed land north of the terminal moraine of the Wisconsian glaciation (Gaudreau 1988:238; Russell and Stanford 2000). As deglaciation proceeded, the tundra was followed by spruce forest (ca. 18,000-12,000 B.P.), and then pine forest (ca. 11,000-7,000 B.P.) (Gaudreau 1988:238-239; Sirkin 1977:215-216).

Hartzog (1981) characterized southern New Jersey as cold and wet from ca. 18,000-12,000 B.P., with a dense spruce-fir, birch, alder forest similar to the Canadian taiga. Megafauna such as mammoth and mastodon were extant, and present in even larger numbers were herds of caribou. The volume in rivers and streams on the OCP were higher than today due to the glacial melting. The Atlantic coastline of New Jersey was approximately 80 miles (130 k) to the east of the present location (Wolfe 1977:162) during the last glacial maximum (ca. 18,000 B.P.). The ancestral Delaware River was confined to a relatively narrow bed under today's bay center, with a dendritic pattern of rivers draining both Delaware and New Jersey. Since the majority of the bay is less than 10 m in depth, this portion was subaerially exposed in this period and fringed with tidal marsh (Kneibel et al. 1988; J. Kraft 1977; Kraft and Chacko 1978). The exposed Continental Shelf was a relatively flat area covered by spruce-pine forests and grasslands, which would be hospitable for herds of large game animals (Sirkin 1977:215).

The Paleo-Indian period is primarily associated with distinctive lanceolate shaped fluted points manufactured from high quality cryptocrystalline materials, a nomadic lifestyle, and the hunting of megafauna. These fluted points exhibit some of the finest flintknapping in prehistoric North America. Regional variants of these early fluted points appeared at various times within the period in the eastern United States (see Justice 1995). The Paleo-Indian toolkit was comprised of unifacial tools, such as endscrapers and sidescrapers, along with utilized and non-utilized flakes, as well as gravers, drills, perforators, knives, and pièces esquillées. This toolkit is considered to be indicative of hide, wood, and bone working, which would be necessary in the inferred big game hunting lifestyle (Anderson 2001; H. Kraft 1977; Kraft 2001; Marshall 1982). Often over 100 miles from their source, the presence of exotic or nonlocal cherts, at Paleo-Indian sites in the east and the west are considered to be indicative of a highly mobile lifestyle. In long distance trade and exchange, the items traded usually consist of finished products, but these nonlocal raw materials often comprise entire assemblages. This would appear to preclude their being the result of trade or exchange (Goodyear 1989:6-7).

The hunting of mastodons and mammoths by Paleo-Indians is inferred from the association of their fluted points with butchered remains of these animals from western and plains sites. Remains of these megafauna have been found in association with more eastern Paleo-Indian sites in Wisconsin, Ohio, Missouri, and possibly New York, although the evidence for such hunting practices is not found in New Jersey, or to the north in the New England-Maritimes (Anderson 2001; Kraft 2001; Spiess et al. 1998). Mastadons and mammoths did exist contemporaneously with early human populations in New Jersey, and it is not an unwarranted inference that they were hunted by the Paleo-Indians at least opportunistically (Hartzog 1981; Kraft 2001). In addition to the possible hunting of these proboscideans, caribou, seal, bear, great beaver, peccary, elk, moose, and bison were available (Marshall 1982:18). Remains of many of these animals have been dredged from the now submerged continental shelf, indicating it is highly likely that this area was exploited by Paleo-Indians (Kraft 2001:79). The generally poor preservation in the wet acidic soils of the East make associated finds of physical traces of these megafauna and humans unlikely. Plant material was also likely utilized by Paleo-Indians, based on the carbonized materials recovered from the Shawnee-Minisink site, which is in proximity to the Delaware Water Gap (Dent Jr 1995:142; Kraft 2001:69). Paleo-Indians have been shown to be associated with seasonally water filled thermokarsts or pingoes (see page 24) on the OCP, suggesting a wider prey preference than megafauna (Bonifiglio and Cresson 1981).

Grossman-Bailey (2001:Table 8.1) reported 16 sites on the OCP in New Jersey that contained Paleo-Indian materials. Three of these sites are on the Maurice River drainage 40-65 km northeast of the KBS, and 12 of the sites are along the Atlantic coast, 40-135 km from KBS (Grossman-Bailey 2001:Figure 8.2). The sixteenth site with Paleo-Indian artifacts (n = 2) is Kimble's Beach on the Delaware Bay. During this period, the OCP was much larger than today, and undoubtedly many of these sites are under water or were destroyed by the sea.

Although the KBS artifact samples are primarily Late Woodland, Paleo-Indian components are evidenced by a finely flaked fluted point of high quality black chert, along with a late Paleo-Indian Dalton-like point (Justice 1995:35-36). Both of these projectile points (Figure 2.5) washed up on the beach at the Kimble's Beach site and were recovered by a local resident, Geoff Carr. Upon examination, the fluted point was still fresh looking with sharp edges, and not rounded by surf action as was the other point. This suggests that it may have recently eroded from the sediments beneath the bay before it was found.

Archaic Period

The Archaic period begins with the onset of the current glacial interstadial or the Holocene (Anderson 2001:156; McWeeny and Kellogg 2001:194). The Archaic is a lengthy period of time that spans 5,000 years. It is a time of change in both the climate patterns and in the cultural adaptations of early Native Americans. In the early phase it is a continuation of the Paleo-Indian pattern of hunting and foraging that culminates in large social groupings, intensive exploitation of native seeds and plant foods and with the development of stone containers and pottery. The Archaic is divided into three or sometimes four sub-periods: Early Archaic (ca. 10,000-8,000 B.P.), Middle Archaic (ca. 8,000-5,000 B.P.), Late Archaic (ca. 5,000-4,000/3,000 B.P.),

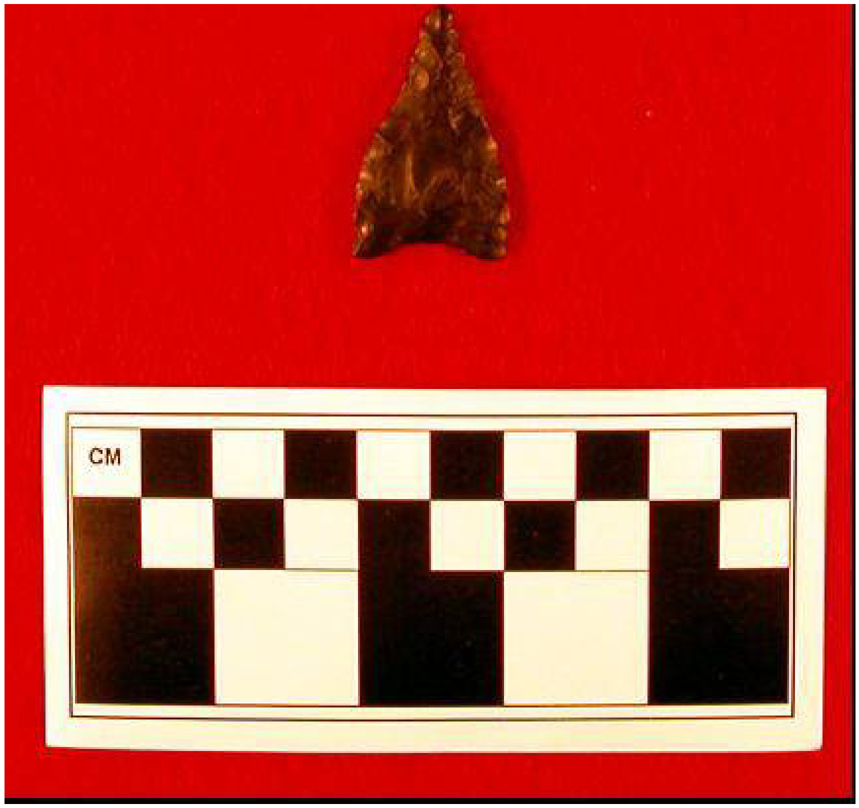


Figure 2.5. Fluted Paleo (upper) and Dalton-like (lower) points. Found at Kimble’s Beach after eroding out from the Delaware Bay sediments.

and Terminal Archaic (ca. 2,000-1,000 B.P.) (Anderson 2001; Grossman-Bailey 2001; Kraft 2001; McWeeny and Kellogg 2001).

Deglaciation continued with some interludes in the Archaic period, but by ca. 6,000 B.P. the glaciers in North America were approximately at their present state, with sea level stabilized at current levels between ca. 6,000-3,000 B.P. (Fairbridge 1977:91). The climate of today was established ca. 5,000 B.P., along with the essence of modern vegetation patterns (Joyce 1988:197). The deciduous forest began to establish a presence in the Middle Atlantic ca. 11,000-9,000 B.P. and eventually dominated the region, although the proportions of the various species changed in response to climatic fluctuations in temperature and moisture (Gaudreau 1988; Ogden 1977:30). Pine, spruce, hemlock, and birch were still important species especially in higher areas (Joyce 1988:200). The deciduous forest produced large amounts of mast that fed populations of elk, deer, bear, elk, turkey, and squirrel. These animals would in large part replace the extinct megafauna of the earlier period (Kraft 2001:92). The seasonality of the early Holocene (ca. 10,000- 8,000 B.P.) was more pronounced than today, with warmer summers and cooler winters along with a generally drier climate (McWeeny and Kellogg 2001:194-195). The thermokarsts continued to be filled with water, at least seasonally, and attracted Early Archaic peoples on the OCP of New Jersey (Bonifiglio and Cresson 1981).

In the Middle Holocene (ca. 8,000-5,000 B.P.) deglaciation continued until it reached present areas (ca. 6,000 B.P.) and the overall climate tended to be drier (McWeeny and Kellogg 2001:198). The oak-hickory forest continued to expand and dominate much of the region (Gaudreau 1988). The variation of seasonal temperatures noted above continued for this period. The drier climate led to decreased levels in lakes, or in some cases their disappearance, making those areas with permanent sources of water more amenable to habitation by humans (Anderson 2001:158). Hartzog (1981:9) inferred that a stable, unchanging forest of mixed pines, oaks, hickory, and chestnut had established itself on the OCP by ca. 10,000 B.P., which continued until the Contact period. She found this pattern to be different than the successional forests of northern New Jersey, New York, and New England in the same period.

In the latter part of the Holocene period (ca. 5,000-3,000 B.P.), trends in climate and vegetation of the previous period continued with some fluctuations. By the end of the period (ca. 3,000 B.P.), an essentially modern climate, sea level, and vegetation were established in the region (Anderson 2001:161). The outline of the coastline in southern New Jersey was similar to today, although tides tended to reach higher upstream, and a high water table was prevalent inland along with more swamps (Hartzog 1981:8).

The Early Archaic inhabitants of the Middle Atlantic Region and New Jersey continued the hunting-gathering lifestyle from the Paleo-Indian period (Kraft 2001). Custer (1984; 1996b) saw so little difference between the two periods he combined them together into one chronological period, Hunter-Gatherer I. The highly curated stone tool kit of the previous period was also maintained (Anderson 2001; Custer 1996b). The major cultural change from this period is in the style of projectile points. The fluted points were replaced by larger corner notched points of the Kirk, Palmer, and Charleston variety (Custer 2001:70-71; Kraft 2001:93). This change may be due to the adoption of the *atlatl* or spear thrower in this time period (Grossman-Bailey 2001:83). Another widespread change was greater utilization of local lower quality cryptocrystalline materials in place of non-local, high-quality cherts used almost exclusively in the Paleo-Indian period (Anderson 2001; Custer 1996b; Kraft 2001). This may be an indication of decreasing ranges for Early Archaic people (Anderson 2001:157).

The Middle Archaic is a period of change in the climate and of substantial cultural developments in the region. The change of projectile point types, and the increase in the number of types, serve to distinguish it from the Early Archaic. In the early segment of the period the development of stemmed and bifurcated varieties marks the demarcation between the two (Custer 1996b; Custer 2001; Kraft 2001). Stemmed varieties such as Stanly, Neville, and Kirk are widespread over the region, while bifurcate variants, St. Albans, Lecroy, and Kanawha, appear at approximately the same time period (ca. 6,500-6,000 B.P.). Some of the stemmed varieties were manufactured through the Late Archaic period well into the Woodland period. Points such as Otter Creek, the corner notched Vosberg, Piney Island types, and the relatively rare Morrow Island dominate in the later part of the period (ca. 6,000-4,000 B.P.). Custer (1996b:149) views this proliferation of points as stylistic changes, rather than an indication of technical changes. The Middle Archaic also marks the extensive use of argillite, rhyolite, and quartzite in place of high quality cherts and jaspers (Custer 1996b; Kraft 2001; Wall et al. 1996).

The Middle Archaic is also distinguished for its different types of tools and tool manufacturing techniques. In addition to tool types of the previous periods, stone tools such as atlatl weights or bannerstones, polished and grooved axes, adzes, hollow gouges, and grinding stones are associated with Middle Archaic sites. The technique of pecking and grinding is used to manufacture many of these tools. The inferred use of many of these tools was in woodworking or to process plant foods, which was a departure from earlier periods (Anderson 2001; Custer 1996b; Kraft 2001).

Exploitation of shellfish intensified in the East at coastal and riverine sites. Ceremonial shell/earthen mounds were constructed in the Southeastern and Mid-Western United States by Middle Archaic peoples. These more complex societies also developed long distance exchange networks in raw materials and goods (Anderson 2001:158). Although these ceremonial mound structures are not found in New Jersey, shellfishing was a major enterprise of Native Americans in this period. Extensive shell middens were excavated and dated in the Lower Hudson River Valley to the Middle and Late Archaic periods (Brennan 1974). Shellfish middens are ubiquitous on the New Jersey coast from Keyport to Cape May and along the Delaware Bay (Cross 1941:39-42; Kraft 2001:130; Stanzeski 2001).

The Late Archaic period (ca. 5,000-3,000 B.P.) is a continuation of many of trends from the Middle Archaic period. However, the increase in mound building and long distance exchange of prestige goods found in the Southeast, had very little expression in the Middle Atlantic and New Jersey (Anderson 2001; Kraft 2001). Population continued to increase especially near riverine, estuarine, and coastal settings. Many of these resource rich areas may have contained year-round human populations (Custer 1996a; Kraft 2001).

Among the tools found on Late Archaic sites are mortars, manos, pestles, grinding and milling stones, knives, ulu or ground slate knives, three-quarter grooved axes, and nutting stones (Kraft 2001). The pecked and ground stone tools increased in number, if not variety. The grinding tools are seen as an increased reliance on plant foods and seeds to support expanding populations (Custer 1996:191). Stemmed projectile points, many from the Middle Archaic, are common on sites from this period. These stemmed projectile points are mainly long and narrow with weak shoulders. The stems are generally narrow, contracting, sometimes converging, and side or corner notched. Among the most common stemmed projectile points are Piney Island, Poplar Island, and Lackawaxen points. In addition to the stemmed points, the Brewerton series corner notched and side notched points are also distinctive of the period (Custer 2001; Kraft 2001). Triangular projectile points, long considered a hallmark of the spread of the bow and arrow and the Late Woodland period, have been documented for Middle and Late Archaic contexts in the Abbott Farm complex along the Delaware River near Trenton (Wall et al. 1996). These triangles are virtually indistinguishable from the Late Woodland points. A discriminant analysis of these Archaic projectile points utilizing metric attributes was unable to separate them from a sample of Late Woodland triangles (Kotcho 1998). Stewart's (1998a) work indicates that these points possibly could be differentiated from the Late Woodland points through an examination of flaking patterns in the basal area.

Two other major developments, the use of stone pots and the introduction of the broadspear tradition, occurred in the later portion of Late Archaic period, hence, it is referred to as the Terminal Archaic period (ca. 4,000-3,000 B.P.). The broadspear bifaces were a new and unique development in the Middle Atlantic Region. It is conjectured that this tradition came from the southern Piedmont (Savannah River types), and either indicates importation of the tradition through trade, or a migration into the region by these peoples (Kraft 2001:134). Broadspear bifaces were manufactured from high quality cherts, jaspers, and rhyolite. Variants found in New Jersey include Lehigh, Koens-Crispin, Snook Kill, Perkiomen, and Susquehanna (H. Kraft 1977; Wall et al. 1996). The term broadspear, implies its use as a projectile point but it is most likely they were all-purpose tools (Custer 1996a:185).

The Koens-Crispin complex in New Jersey, in addition to a broadspear type, is noted for its burial practices. Cremated human remains were interred with prestige grave goods such as broadspear bifaces, atlatl weights, celts, and various exotic items. Two of the more significant of these Late Archaic sites containing such burials are the Koens-Crispin site and the Savich Farm site, both in the vicinity of Medford, in Burlington County near the boundary between the ICP and OCP (Cross 1941:81-90; Kraft 2001:133-137).

The manufacture and use of flat bottomed soapstone and steatite vessels is another distinctive marker of the Late Archaic period. This material must have been procured from quarries in Pennsylvania and northwestern New Jersey, and required substantial effort to manufacture. They were too heavy to be easily transported so they most likely stayed at an occupation site. A cooking function is inferred and larger specimens are referred to as pots and kettles. Fishtail projectile points are often found in association with the stone vessels and are considered sure markers of the very end of the Late Archaic period (Custer 1996b:178-186; Kraft 2001:140-143). Early, thick, relatively crude pottery types such as Marcy Creek Plain, Seldon Island, and Ware Plain, and Vinette I occur contemporaneously with stone vessels. The first three types are flat bottomed with a likely Potomac origin and the Vinette I wide mouthed and conoidal shaped which most likely originated in the Northeast (Kraft 2001:144-146; Stewart 1998b:158-171).

Grossman-Bailey (2001:193) reported 276 sites with Archaic components in the OCP. These sites tend to cluster around riverine and coastal/estuarine settings.

Woodland Period

The Woodland period is a time of significant cultural developments in the Middle Atlantic Region and New Jersey. Populations grew more sedentary, the use of pottery became widespread, cultigens and village life developed in many locales, and the triangular projectile point, indicating the spread of the bow and arrow, dominated the later part of the period (Custer 1984; Custer 1996a; Custer 2001; Dent Jr 1995; Kraft 2001; Stewart 1995). The period is divided into three sub-periods whose actual time frames are subject to some disagreement, often based on which artifacts are considered diagnostic of the period and the radiocarbon dates associated with them (Custer 1984; Custer 1996b; Dent Jr 1995; Kraft 2001; Stewart 1995). The Early and Middle Woodland periods are often combined together, due to the view that they are virtually indistinguishable (Gardner 1982b; Williams and Thomas 1982), or combined with the Late Archaic into one period (Custer 1984; Custer 1996b). This study approaches this period with the traditional categorization that maintains the three subdivisions as being distinct and identifiable (Stewart 1995). The chronologies for these periods following Grossman-Bailey (2001:79) are: Early Woodland (ca. 3,000 B.P.-2,500/2,000 B.P.), Middle Woodland (ca. 2,500/2,000 B.P.-900/850 B.P.), and the Late Woodland (ca. 900/850 B.P.-350 B.P.).

As previously noted, the climate and environment was essentially modern by ca. 3,000 BP. In the Woodland period, temperatures were generally warm and drier with three periods of cooler temperatures several centuries in duration, which occurred at the beginning of the period, the transition between the Middle/Late Woodland, and the Little Ice Age, which encompassed the last three hundred years of the Late Woodland (Anderson 2001; Carbone 1982; Custer 1984; Hartzog 1981). Sea level continued to rise, although the rate of the rise declined ca. 2,000 B.P.-2,500 B.P. to present rates (Psuty 1986). A large portion of the OCP that was formerly open for exploitation in the Late Archaic period was now submerged and unavailable. This trend continues today with an average sea level rise of 3 mm per year recorded for the last century at Lewes, Delaware almost directly west across the bay from the lower end of the Cape May Peninsula (Pirazzoli 1996:Figure 106). As a result, many of the coastal sites of even the Late Woodland times have been either inundated or destroyed by the action of the water.

The Early Woodland period is a continuation of the hunting, fishing, and gathering trends of the Late Archaic period with the widespread adoption of pottery, and the decline in the use of soapstone and steatite vessels (Custer 1996b; Gardner 1982; Kraft 2001; Williams and Thomas 1982). It has been postulated that a population decline occurred in the Early Woodland period due to environmental stresses and upward population trends in the East. This decline (Fiedel 2001) is inferred from the relatively small number of Early Woodland sites compared to Late Archaic sites, and the much greater number of diagnostic projectile points from the Late Archaic relative to the Early Woodland types in some regional collections (for a contrary view see Custer 1996b:260).

Fiedel (2001:130) acknowledges that this population decline may not have occurred in all areas of the East and probably varies regionally.

The Orient Culture (ca. 1250-500 B.C.) continues from the Late Archaic period to the Early Woodland period, which Kraft (2001:152) views as primarily a phenomenon of the later rather than former period. Fishing and shellfish gathering assume greater importance to these people. The distinctive fishtail projectile point, steatite and soapstone vessels for cooking and ceremonial use, and cremation burial with mortuary offerings are diagnostic of this culture (Custer 1996b; Dent Jr 1995; Kraft 2001).

Two cultural manifestations of this period, the Meadowood Culture and the Middlesex Burial Complex, both with rather elaborate mortuary practices, are found in northeastern New Jersey, in the vicinity of the Delaware Water Gap, and throughout parts of New York and the Northeast into southeastern Canada. Both groups are contemporaneous with the Orient Culture. The Middlesex appears to be influenced by the Adena in the Ohio River Valley and related to the Delmarva Adena (Kraft 1998). Extensive mortuary offerings of exotic goods, such as copper and clay smoking pipes, gorgets, pendants, food, and various tools are found with the cremated burials, although the extensive burial mounds associated with Adena are not present. Major waterways such as the Delaware and Hudson Rivers appear to have been the avenues for the spread of these cultures (Custer 1984; Custer 1996b; Kraft 2001; Williams and Thomas 1982).

The Meadowood Culture is marked by the use of conoidal bottom Vinette I ceramics and distinctive, finely crafted Meadowood points and blades. These points and blades, or preforms, are often found in burial caches. The serrated edged Hellgramite points also appear to be associated with Meadowood (Custer 1996a; Kraft 2001). Rather large lobate, stemmed, side notched projectile points made of exotic materials are diagnostic of Middlesex sites. Tobacco and smoking pipes in a tubular shape are characteristic of both groups, and indicate the earliest use of tobacco in the state (Kraft 2001: 165, 170). Middlesex sites on the Coastal Plains of New Jersey were discovered at the Scott site at Beesely’s Point in north Cape May, the Port Elizabeth site in Cumberland county, as well as Delmarva Adena at the Fredrica and St. Jones sites in Delaware (Custer 1984; Kraft 2001).

In southern New Jersey, the Cadwalader Complex, identified by Mounier (1972; 1974), and found on the Maurice River contains flat bottomed ceramics that indicate a coalescence of Marcy Creek, Ware Plain, and Vinette I types. Indications of southern and northern ceramic styles may tell us more about the location of southern New Jersey in relation to the two influences, than suggest a propensity for trade and travel. The location of the Cadwalader site and the faunal remains excavated by Mounier (1972; 1974) suggests an exploitation of estuary, marine, and riverine resources. McCann (1950) excavated portions of the Ware site on the Salem Creek approximately six and half miles from the Delaware Bay, Salem County in southwestern New Jersey, which produced flat-bottomed ceramic styles indicative of an Early Woodland presence at the site. Recent studies (Morris et al. 1996) of the ceramics from the Ware site indicate a prehistoric presence throughout the Woodland period.

The use of the relatively widely distributed, convex base, Teardrop biface in the Middle Atlantic Region (Custer 2001:96) in this period suggests that the Early Woodland people made extensive use of softer wood and reeds, probably to make baskets and other containers. Mounier and Martin (1992) analyzed the breakage and rejuvenation patterns of 407 of these bifaces from the Woodbury Annex site (28Gl5) in Gloucester County, NJ. They concluded Teardrops were tools, most probably hafted and often broken in use, to process relatively soft woods such as willow and viburnum for use in the manufacture of basketry. The biface analysis indicated that they were continually rejuvenated until they could no longer be used for their original purpose.

The diversity and richness of the biological resources available to Early Woodland people led to a variety of settlement and community patterns. These people exploited the same food resources as the Late Archaic peoples but they may have more intensely focused on fewer resources such as anadromous fish, nuts, tubers, seeds, large mammals, and shellfish. How these pursuits influenced community and organization for work is unknown (Gardner 1982a; Stewart 1995).

The Middle Woodland period continues the trend toward a more sedentary way of life, with increased focus on fish and shellfish in marine and estuarian environments of the Coastal Plain. Social complexity found in parts of Maryland, Virginia, and West Virginia may have been echoed in the Adena-Middlesex in New Jersey. An east to west trade network with redistribution to the north and south along the coast developed in this period (Gardner 1982a; Stewart 1995; Williams and Thomas 1982). In addition to the trends noted above, two possible migrations of Algonkian speakers and the displacement of populations may have occurred in the later Early Woodland to the mid Middle Woodland periods along the Coastal Plains of the Middle Atlantic region. These migrations are inferred from linguistic evidence, and the appearance of net impressed pottery styles in this area at the time of the proposed migrations, as well as inferences drawn from the fall line as a cultural boundary in Late Woodland times (Custer

1996b:243; Dent Jr 1995:278-279; Fiedel 1987; for a contrary view see Gardner 1982b:67; Lopez 1961:32-33; Stewart 1995:192).

The development of incised and decorated ceramics, especially from the Abbott Farm complex near Trenton north along the Delaware River, continued into the Late Woodland period until contact (Kraft 2001; Stewart 1995; Stewart 1998b). While the development of increased decoration proceeded to their north, southern New Jersey peoples remained relatively conservative in their ceramic patterns. The pottery is collarless, bag shaped, round bottomed, and sub-conoidal, but with some increased decoration (Kraft 2001; Mounier 1982).

The Fox Creek Culture is found throughout the Middle Atlantic and parts of New England. In New Jersey the most visible manifestation occurred at the Abbott Farm complex. Most of the Fox Creek sites are in riverine, and coastal areas where the exploitation of fish was a major economic endeavor (Dent Jr 1995; Kraft 2001; Stewart 1995). Fox Creek stemmed and lanceolate points are representative of this culture. They are large and broad, most often manufactured from argillite and rhyolite, and probably served as knives rather than spear points (Custer 2001:32). The large petalas blades, fish processing tools, netsinkers, and large fields of fire cracked rock indicate an exploitation of anadromous and other fish for their flesh and oil (Kraft 2001). Zoned ornamentation on ceramics such as Abbott Farm dentate, incised, and net impressed were dominant (Stewart 1998b).

Some manifestations of the Adena/Middlesex were evident in the Kipp Island and Webb phase complexes in the Middle Woodland. The Kipp Island culture was discovered originally in Seneca county, New York (Ritchie 1965:233), and the Webb phase culture "type site" is the Island Field site in Delaware (Custer 1984:138; Custer et al. 1990). These cultures are represented diagnostically by the small, thin, well made Jack's Reef Corner-Notched and Pentagonal varieties, which Kraft (2001:194) maintains could have served as arrow heads when the bow arrived in the region at the end of Middle Woodland. Custer (1990:203) believes that there are so many similarities in artifact design and composition of assemblages, that there is a connection between the Webb phase and the late Point Peninsula culture in New York, as represented by Kipp Island. In addition to projectile points, ceramics such as Hell Island, platform pipes of steatite, burials (flexed and extended), cremations, and grave goods in approximately one quarter of the burials mark the Webb phase (Custer et al. 1990). The Kipp Island culture is similar to the Webb phase, but with more extensive use of lithics and decorative items as grave goods in the recovered burials (Ritchie 1965:232-234). A cremated burial with classic Kipp Island grave goods was excavated in New Jersey on Minisink Island in the upper Delaware River (Ritchie 1965:234). Diagnostic lithic artifacts of both these cultures are found on sites throughout New Jersey (Kraft 2001:193).

The Late Woodland is a period of increasing sedentism, the development of village and hamlet life, decreasing territorial size and distinctive cultural territories, the introduction and adoption of maize, increasing social complexity, the break down of trade networks, and the adoption of the bow and arrow (Custer 1984; Custer 1996b; Dent Jr 1995; Stewart 2000; Stewart 1995). Although maize does not appear in the archaeological record for southern New Jersey and northern Delaware, the trend of increasing sedentism continued in these areas. The groups occupying these areas

Figure 2.6. Map of the divisions of the Lenape by dialect (Goddard 1978a:Figure 1).

exploited the rich, productive, and reliable riverine and estuarine resources available (Stewart 1995:194). There is also scant evidence from these areas for any village life (Custer 1984; Mounier 1982; Stewart 1998c).

New Jersey in Late Woodland times was occupied by two major cultural and linguistic groups of the Delaware, or Lenape; the Munsee in the north, and the Unami in the central and south (Figure 2.6). The Unami speakers were further subdivided into a Northern Unami and Southern Unami (Goddard 1978b:73). The Munsee occupied New Jersey north of the Raritan River Valley/Delaware Water Gap, northeastern Pennsylvania, southeastern New York state, Manhattan and Staten Island, as well as western Long Island (Kraft 1982:143). The Northern Unami or Unalachtigo occupied the central portion of the state below the Raritan River Valley/Delaware Water Gap boundary, to the falls at Trenton, then easterly to the Atlantic coast at the northern end of the Barnegat Bay, and parts of eastern Pennsylvania in the Lehigh River drainage. The Southern Unami occupied New Jersey from south of the Trenton-Atlantic coast boundary to Cape May, the northeastern area of Delaware along the Delaware Bay and Atlantic coast, and southeastern Pennsylvania in the Schuylkill and Brandywine drainages (Goddard 1978a; Kraft 2001; Weslager 1972). Weslager (1972:45) defines the term Unalachtigo "as the people who live by sea," however Goddard (1978a:214) attaches the same term to the Northern Unami speakers. In reality, this difference has little significance for the present study.

The inhabitants of northern New Jersey are more culturally akin to the inhabitants of the Mohawk and Hudson River valley, especially in ceramic traditions. Kraft (1982) divides the Late Woodland in the north into a Pahaquarra phase (ca. A.D. 1000-1300) and the Minisink phase (ca. A.D. 1300-1600). He later interpreted an Intermediate phase (ca. A.D. 1300-1400), which appears to be a transition from the earlier to the later phase (Kraft 2001:207-208). The evidence for these occupations derives almost exclusively from excavations in the vicinity of the Delaware Water Gap (Kraft 1982:153). Fishing, hunting and gathering, and the eventual adoption of cultigens mark the significant economic activities. Longhouses with storage pits and hamlets of one to a few dwellings are distinctive residential features found on the later Minisink phase sites. These hamlets were unfortified (Kraft 1982), as opposed to the palisaded villages to the north in New York (Ritchie 1965), and west in the Susquehanna River valley (Stewart 1993). Tobacco use is inferred from the presence of smoking pipes. The growth of cultigens in the later phase is also strongly in evidence (Kraft 1982:154; Kraft 2001:280-281).

The transition area of the ICP to the Piedmont in New Jersey occurs in the vicinity of Trenton. The Abbott Farm complex of sites provides the best information on the Late Woodland period in this section of the state. Some of the changes from the Middle Woodland period in this area are the decline of fishing, an increase in broader based exploitation of resources and the planting of cultigens, a decline in the use of argillite and an increase in the use of local cryptocrystalline cobbles, and the disappearance of staged biface sequences (Stewart 2000; Stewart 1998d; Stewart et al. 1986). Small triangular projectile points are the dominant biface found in the area[2]. Bipolar technology, as well as freehand knapping, are used to process the cobbles with an extensive use of a core and flake technology (Stewart 1987; Wall et al. 1996). Ceramic tradition, such as the Abbott zone-decorated pottery, continues with an increase in other varieties such as Riggins fabric impressed and Overpeck incised, as well as other regionally known types (Stewart 1998b). Riverine and wetlands sites indicate exploitation of these resource rich areas (Stewart et al. 1986:70) and use of flood plain sites indicates a possible shift in emphasis to agricultural pursuits (Stewart 1998d). Semisedentary hamlet life may have been the norm, but these soils are notoriously poor in preservation quality and evidence is ephemeral at best (Stewart 1998d).

In the OCP of southern New Jersey, some of the trends seen in other parts of the area are also in evidence. Populations appear to increase, as indicated by larger sites with food storage pits, and a semisedentary lifestyle based on the exploitation of coastal and wetland resources is established (Mounier 1982; Stewart 1998d). The use of local cryptocrystalline materials in the form of cobbles to manufacture flake tools, small scrapers, and expedient tools is widespread. Triangular bifaces completely dominate this category in assemblages suggesting the adoption of the bow and arrow as the hunting weapon of choice (Blitz 1988:130-131; Mounier 1982; Stewart 1998d).

The resource base for these people was rich and diverse especially in the coastal areas and various fresh and salt water wetlands. Shellfish such as clams and oysters, in addition to deer, birds, and other small animals and various nuts from upland settings, were readily exploited (Mounier 1982). Robert Evelyn's letter of 1634, quoted in Weslager (1954:1-2), catalogs a menagerie of wild game birds and animals and edible plant foods along the Delaware Bay coast of New Jersey that were available to support the native inhabitants. No evidence of agriculture has been found on the OCP in southern New Jersey (Kraft 2001:283-284; Stewart 1998d), although Becker (1999; 1988:80) maintains that for a limited time frame (A.D. 1640-1660) in the Contact period the Lenape cash-cropped maize to sell to Swedish settlers, but it did not alter their traditional social structure or foraging lifestyle. The OCP soils are generally considered poor for agriculture without fertilizer, due to their droughty and acidic nature (Markley 1977), and also preserve little evidence of dwelling patterns for the area.

Ceramic traditions are fairly conservative in the region, with collarless ovoid or conoidal pots with fabric, net, or cordage impressions on the body, and little decoration is common. In the later stages of the period, decoration increased, and styles such as Overpeck Incised, Bowman's Brook Incised, and Riggins Fabric Impressed were common (Cross 1941; Mounier 1982; Stewart 1998b).

Areas that were favored for settlements in the south were riverine locations, the littoral of the Delaware Bay, and coastal bays on the Atlantic behind the barrier islands. Sites on the OCP are generally unstratified. Many of these bay and coastal sites have been lost to submergence and erosion (Mounier 1982:164). Indeed, it is highly likely that a substantial portion of the BF locus of the KBS has been lost to bay transgression.

Contact Period

The Contact period refers to the interactions of the Native Americans with the English, French, Dutch, Spanish, and Swedish explorers and settlers (Williams and Kardas 1982:185). The Contact period begins on the east coast in the sixteenth and seventeenth centuries but varies for different regions of North America. Most of the ethnographic accounts of the various Lenape bands during this period are derived from accounts written by early explorers, settlers, and missionaries in the state (Weslager 1972). In the period 1600-1663, Dutch and Swedish explorers visited the Delaware Bay and established trade outposts on the Delaware, Pennsylvania, and New Jersey shores. In

1655, the Dutch were able to wrest control of the bay from the Swedes. However, their control was short lived, as the English seized control of New Amsterdam (New York City) in 1664, and eventually gained control of the entire Delaware Bay by 1674 (Weslager 1961). Many of the early English settlers came to Cape May to establish whaling stations, such as the now submerged Town Bank community in 1687 (Beesley 1857). During the period 1685-1705, the majority of the Cape May Peninsula was settled, although sparsely, by the English (Wacker 1982:Map 1).

There are few Contact period sites in New Jersey, especially in the OCP, in comparison to the large number of Late Woodland sites in this area. Mounier (1982:163) believes this dearth of sites is due to two possible reasons: one, a population collapse of Native American inhabitants due to European diseases early in the interaction; two, Native Americans may have moved to yet undiscovered interior refuge areas after they were pushed from the desirable Delaware Bay and coastal areas. The warfare between the Susquehannocks and the southern Delaware in the early seventeenth century may have contributed to this second scenario (Williams and Kardas 1982). The Contact period sites that are known in New Jersey, are marked by the presence of European goods resulting from the fur trade, often found in burials, and tend to occur from the upper Delaware Bay to the Delaware Water Gap, and in the northwestern portion of the state (Kraft 2001:Figure 9.31) . Of course this lack of Contact period sites may simply be an artifact of where surveys are conducted, or an earlier unregulated period of development in the state in which sites were overlooked and destroyed.

The Treaty of Easton in 1758, which ended the bloodshed between the Delawares and the English colonists during the French and Indian War, also marked the end of the

Lenape land claims in New Jersey. Most of them had been forced to move west to the Susquehanna Valley of Pennsylvania, Ohio, lower Canada, and those remaining east of the Mississippi were removed by the U.S. government to Oklahoma in the nineteenth century (Weslager 1972). The Lenape did maintain a presence in the state at the Brotherton Reservation in Burlington county's portion of the Pine Barrens on land purchased by Quaker and Presbyterian religious leaders (Figure 2.6). This reservation was occupied from 1758-1801 (Kraft 2001:468-474; Williams and Kardas 1982:194). The Unami Lenape are still present in the OCP. They are incorporated within the Nanticoke-Lenni Lenape, who are culturally centered in Salem and Cumberland counties (Kraft 2001:544).

Late Woodland Sites on the OCP and the Delaware Bay in Southern New Jersey

The NJSM is the official organization that assigns Smithsonian site numbers to reported sites, and serves as a repository for site forms for the state. Grossman-Bailey (2001:Appendix C), in her study of the OCP, reported a total of 42 prehistoric sites for Cape May County. She listed another 43 prehistoric sites from various sources including the Pinelands Survey, the SHPO, and other sources. The latest review (May, 2008) of the NJSM site files indicated an additional nine sites had been added to the list of prehistoric sites. Three of the nine sites were originally reported by Skinner and Schrabisch (1913) in their archaeological survey of New Jersey. This is the least number of recorded sites for any county in the OCP. Many of the site reports for Cape May were based on eroded artifacts which washed up on the beach from the Atlantic Ocean and the Delaware Bay, such as the Cape May Point site (28CM1), Cook's Beach site (28CM35), Pomerantz site

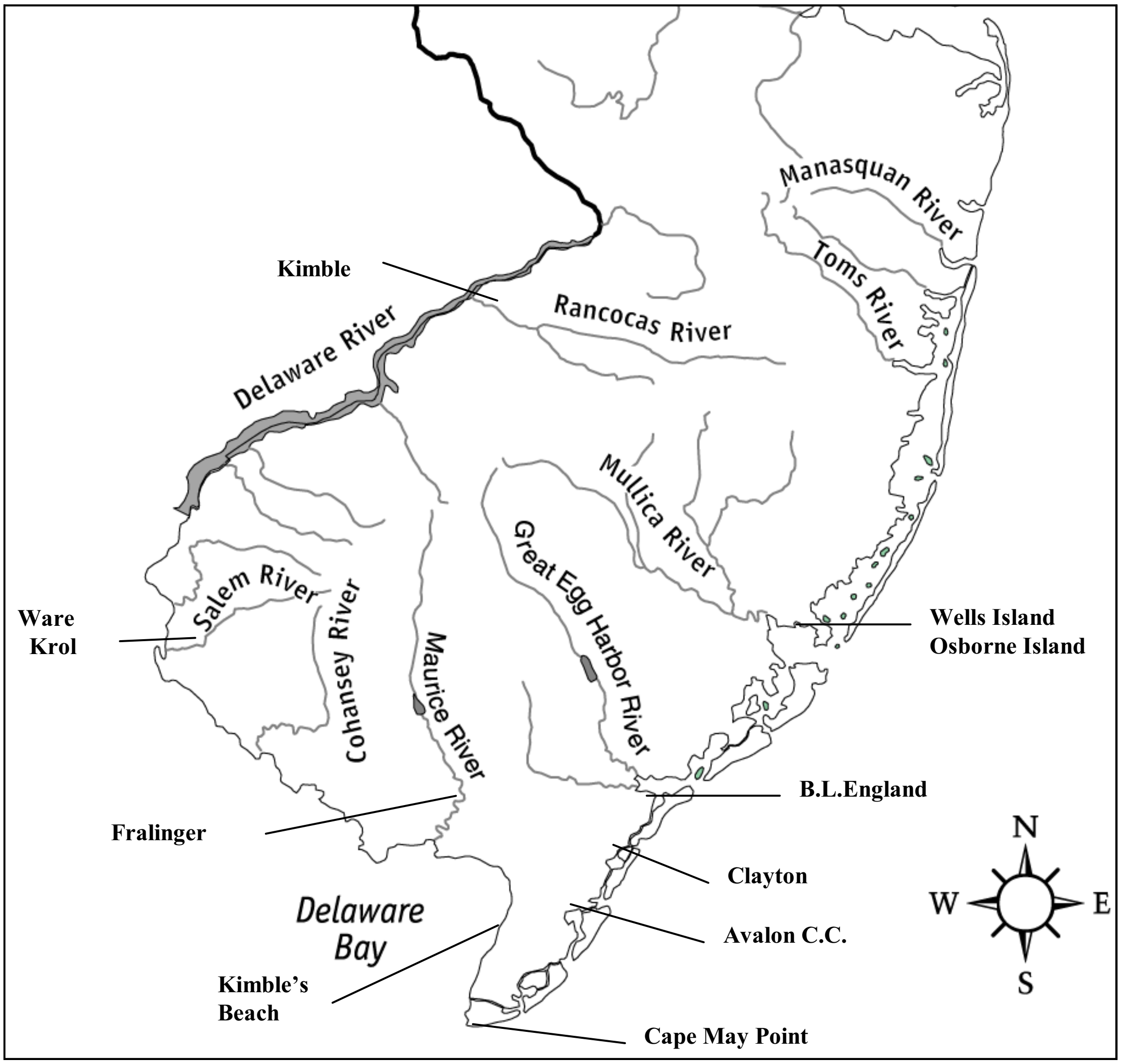


Figure 2.7. Late Woodland sites located on the Coastal Plain and the Delaware Bay in southern New Jersey. Selected sites discussed in text**.**

(28CM49). Although Cape May has been occupied by Native Americans for 10,000 years, it is obvious that it has not been an archaeologically well documented area of the state.

In the following I discuss some of the more prominent Late Woodland sites in Cape May county and those in relative proximity on the OCP (Figure 2.8).

Avalon Country Club Site (28CM28). This site contains Middle and Late Woodland components. The following description is derived from Mounier's (1997a; 1997b) report of the excavations. It is located along a stream at the head of Deep Creek, which flows through tidal meadows between Great Sound to the South, and Stites Sound to the north, on the Atlantic side of Cape May in the vicinity of Swainton (U.S.G.S. 1972b). It is located approximately 9 km almost directly east from Kimble's Beach. It was an easy walk (.6-1 km) to both the fresh springs that fed the stream and to the sounds and tidal marshes.

A total of 227 artifacts were excavated, in addition to a large quantity of shell and some faunal remains. Among these were bifaces (n = 3), cobble tools (n = 5), flakes (n = 18), unmodified pebble (n = 1), thermally altered stone (n = 8), and shell artifacts (n = 25). Two of the bifaces were triangles attributed to the Late Woodland period, which were manufactured from chert and Cohansey Quartzite and an argillite biface fragment more indicative of Middle Woodland times. Seventeen of the flakes are of chert and jasper, and one was argillite. The shell artifacts were of broken conch, and the columns removed from conch shells. None of the columns were drilled but it suggests that a stage of shell bead manufacture may have occurred at this location (Mounier 1997a:14). The faunal remains included deer, turtle, fish, and birds. These faunal remains most likely represent opportunistic hunting behavior, rather that a concerted effort to procure these prey targets.

Ceramic sherds (*n* = 167) are the most numerous form of artifacts found at the site. Eighty percent of the sherds contain some shell as tempering, and 20 percent are grit tempered. Stewart (1998b:215-216) views shell tempering as typical for coastal sites in New Jersey. The exterior surface treatment of the bodies of the vessels was 50 percent fabric impressed, 37 percent unidentified, and the remainder corded and cross corded. The fabric impressed sherds typical of the Late Woodland on the OCP while the corded varieties are considered more Middle Woodland in origin.

The site contained four features, an oval cooking pit, a sheet midden of shells, and two shellfish cooking pits. Feature 2, the oval cooking pit was radiocarbon dated to 710 ± 70 years (A.D. 1240). Feature 3, a shellfish preparation pit, was dated by charcoal at the base, below any shell deposits, to 1,600 ±70 years (A.D. 350). In the later feature, the dated level is almost exclusively oyster shell while the upper levels associated with Late Woodland cross corded and fabric impressed ceramic sherds are overwhelmingly clam shell. Mounier (Mounier 1997a:3-4) interprets this dichotomy as the result of sea level rise and increasing salinity in coastal sounds and ponds, which oysters cannot tolerate. The resulting assemblage may not be that of a food preference, but simply that gathering oysters became too costly and dangerous. The site is interpreted as a transient location with intermittent occupations to gather shellfish.

The Avalon Country Club site is representative of undoubtedly numerous small sites scattered along the bays and estuaries of the coastal regions of New Jersey (Mounier 1982:164). The exploitation of shellfish, coupled with opportunistic taking of prey species, is an indicator of the resources available to exploit and the changing pattern of shellfish exploitation over time. Although the lithic materials are few, the presence of cortex on 11 of the 18 pieces of jasper and chert debitage indicate a use of local pebble sources.

B.L. England Prehistoric Site, Locus 1 (28CM32). This is a mixed component site with two episodes of occupation, a Late or Terminal Archaic occupation (ca. 4,000-3,000 B.P.), and a Middle to Late Woodland occupation (ca. 2,000-350 B.P.). This site is included because the majority of deposits were Middle to Late Woodland in age, and it gives indications of the natural resources available to exploit and lithic raw material procurement patterns. The description of this site and artifacts is taken from Pagoulatos (1992).

The site encompasses 2.5 acres of land, separated by an access road, on the grounds of the B.L. England Generating Station. It is situated on a low terrace near tidal marshland, on the south shore of the Great Egg Harbor Bay, on the Atlantic slope of the Cape May Peninsula, just south of the political boundary of Cape May and Atlantic counties. It is approximately 30 km to the northeast of the Kimble's Beach site (U.S.G.S. 1984b). The site was divided into Areas 1, 2, and 3. It was suggested that the site extended beyond Areas 1, 2, and 3, but only the portions of the site threatened by construction were excavated. Area 1 contained mostly Late Woodland lithic diagnostic artifacts (triangular projectile points and a Fox Creek point), Area 2 contained mostly Late/Terminal Archaic lithic materials (broadspears types and Orient Fishtail), and Area 3 was a shell midden. Chert comprised 78 percent of core reduction and tools in Area 1 and quartzite 74 percent in Area 2.

A total of 44 prehistoric features were excavated. These features were interpreted as trash pits, hearths, storage facilities, possible post molds, shell middens, and activity areas. Radiocarbon dates of ca. 1670+/-50 B.P., ca. 780+/-70 B.P., and ca. 860+/-60 B.P. were derived from organic materials found in three features. Artifacts were generally found in the plowzone (Ap) which extended four to twelve inches beneath the surface but some artifacts were found in the intact B horizon usually in the initial six to nine inches. The interface between the Ap and B horizon was approximately three inches. The B horizon was 15-40 inches below the surface. The artifacts were concentrated in clusters around dense accumulations of quahog and oyster shell.

A total of 6,083 lithic artifacts were recovered. Of this number, 39.4 percent (n = 2399) were fire cracked rock (FCR). The remainder were cores, hammerstones, chunks, shatter, amorphous flakes, biface reduction flakes, retouched tools and a spokeshave. Analysis indicated that two percent (n = 55) of the lithics, excluding FCR, had some form of use-wear evident. Fifty percent of the usewear was in the form of stepped chipping, and crushing, both indications of use on medium to hard materials. Quartz, quartzite, and chert make up 99 percent of the raw materials recovered. Fire cracked rock (n = 2,399) made up 90 percent of the quartz component. Cores, debitage, and tools (n = 3,684) were composed of 57 percent chert, 37 percent quartzite, and the remainder spread among various raw material types. Twenty five percent of the total tool/core reduction artifacts are determined to be imported. The largest segment of this population consisted of Cohansey Quartzite from Area 2. Cohansey Quartzite deposits are located approximately 40 miles to the east in Cumberland county (see previous discussion pages 29-30). Argillite, steatite, and some non-local cherts and jaspers also were represented, all from great distances. The remainder of the lithic raw materials are interpreted as local, and derived from secondary sources along the Tuckahoe and Great Egg Harbor rivers.

Ceramic artifacts were the next largest class (*n* = 3,678) of materials found on the site. Uncollared rim sherds accounted for only a small portion (*n* = 25) of the total number and body sherds comprised the remainder. Fabric impressed, cord marked, incised, dentate, and punctate types comprised only eight percent of the sherds, and plain bodies accounted for remainder. All sherds recovered were grit tempered with some shell, quartz, and steatite combinations. These ceramic types are indicative of the Middle and Late Woodland periods. Only two sherds which contained steatite could be assigned to the Late/Terminal Archaic period. In addition, 12 bowl and tube fragments of tobacco pipes were recovered. They were grit tempered with half undecorated and the other six contained incised (*n* = 3), net impressed (*n* = 1), punctate (*n* = 1), net impressed (*n* = 1), and incised/punctate (*n* = 1). These types were interpreted as spanning the entire Middle-Late Woodland period.

Shellfish comprised the largest artifact class recovered at the site with a total weight of 188 kg. Quahog accounted for 168 kg (89.4 percent) and oyster 20 kg (10.6 percent), with other types accounting for .021 kg of the total weight. The relative amounts of shell remains of quahog and oyster derived from the three dated features were not sufficient to evaluate Mounier's (1997a; 1997b) hypothesis regarding the increased use of quahog in Late Woodland times. Faunal material (*n* = 1251) found at the site also indicated an exploitation of resources of area with fish (68 percent), the largest segment, mammal next (26%), reptiles and amphibians (5.6 percent), and last birds (less than 1 percent). No figures were published that indicated an assessment of the Minimum Number of Individuals (MNI) represented by these faunal remains. A few floral remains (*n* = 30), mostly hickory nut shells and various seeds, were also recovered.

This site was interpreted as a transient camp which was re-used by small groups as a processing station for natural resources found in the surrounding wetlands and coastal environments before transport back to a larger base camp.

This site demonstrates a broad resource base of food sources that were easily exploited by Late Woodland inhabitants that could support a semisedentary lifestyle. It also reinforces the use of cryptocrystalline lithic materials from local pebble sources on the margins of the rivers and bays.

<u>Wells Island (28Oc101) and Osborne Island (28Oc76)</u>. These sites are on two islands, in reality high areas 3 m above sea level in a salt marsh, located near the mouth of the Mullica River and the Little Egg Harbor (Grossman-Bailey 2001:325). These sites are located on the Atlantic coast behind the barrier islands and the present Intercoastal Waterway. The sites are located approximately 65 km northeast of Kimble's Beach. The "shell heaps and scattered implements" on the islands were noted by Skinner and Schrabisch (1913:51), and are located near the better known Tuckerton Shell Mound (Cross 1941:39-40). Surveys were conducted in this area in anticipation of construction of a seaside residential community at Mystic Island. As a result, several shell mounds and human burials were discovered in the 1970's and 1980's. The major occupation is considered to be of the Late Woodland period (Grossman-Bailey 2001:325-326).

Stanzeski (1996:43) obtained one radiocarbon date of ca. 650±75 B.P from oyster shell removed from a midden on Wells Island. A date of ca. 400±70 B. P. was derived from carbonized wood associated with a burial on Osburne Island, and a second date of ca. 720±70 B.P. was obtained from oyster shell fill from the same burial. All three of these dates fall well within the Late Woodland period.

The following material on Wells and Osborne Islands is derived from Stanzeski's (1996) review of the unpublished reports of the excavations relating to the contexts from which the radiocarbon dates were obtained. Artifacts discovered at Wells Island include ceramics, a triangular projectile point, and a drill of jasper, in addition to assorted jasper and chert flake tools along with possible clam shell tools. The lithic artifacts were determined to be derived from local pebble sources. The pottery sherds were sand tempered and fabric impressed. The midden on the site had a thin layer of oyster shell along with little in the way of flaked lithic materials or FCR. Osborne Island artifacts included Late Woodland fabric impressed pottery with shell, quartz, and crushed argillite temper, jasper and chert tool fragments and flakes, and possible shell tools. Relatively large numbers (n = 300) of faunal remains were found which included deer, river otter, turtle, reptile, turkey, Canadian goose, fish, and various small mammals. Remains of nuts, seeds, and fish scales were also found.

These sites give an indication of the diverse resources that were available to exploit in the Late Woodland period in coastal/estuarine environments occupants. They also demonstrate a pattern of use of locally derived chert and jasper pebbles from the margins of the river or bay. The density of sites and burials suggest this may have been a core area of a permanent community at some time in the Late Woodland period.

Clayton Site (28CM16). This is one of three sites (28CM17 and 28CM18) discovered during a site survey conducted by Ranere and Hansell (1985:20-21,56-66) for the Office of New Jersey Heritage. The site also received the designation of Clayton South/Temple 3-1. The Clayton site is located on the Atlantic slope in the northern Cape May Peninsula on a high flat adjacent to Corson Sound approximately 75 m from a fresh water stream (U.S.G.S. 1984b). It is located approximately 23 km northwest of the Kimble's Beach site. The site is not intact, as the southern portion was truncated by the construction of the Garden State Parkway, and a large borrow pit, now permanently filled with water from a spring, was dug in the center of the remaining site area. A total of 63 shovel test pits and four (1x2 m) units were excavated on the site. The site is stratified with deposits found as deep as 89 cm.

The lithic artifacts consisted of 16 tools and 185 flakes. The flakes, which were largely thinning flakes, showed little signs of utilization. Two triangular projectile points of quartz and Cohansey Quartzite, and the tips of two other projectile points of chert were recovered. Three cores as well as five whole and cracked pebbles, and decortication flakes suggest that local materials were reduced on the site. All but seven of the flakes are of chert or jasper. There is one flake of Cohansey Quartzite, the other six are local quartz and quartzite. A basal fragment of a large stemmed point suggests a possible small Late Archaic presence on the site.

Ceramic artifacts consisted of 26 badly eroded sherds, either plain or fabric impressed, fabric impressed with incisions, incised, or cord-wrapped lip impressed. Ranere and Hansell (1985:21) interpreted these sherds as Riggins type pottery.

Two shell middens of quahog and oyster shell were discovered in the process of completing the excavation units. The two triangular points, a few thinning flakes, and worn sherds were found in association with the shell. No bone was found although the shell middens preserve organic materials well. Features were not found in the course of the excavations

A quahog shell from one of these middens was radiocarbon dated. The corrected date was A.D. 820$\pm$60 and the uncorrected date A.D. 1220. This date and artifacts indicate that this was a predominantly Late Woodland occupation. The lack of features and preserved bone lead to an interpretation of this site as a short term shellfishing station. The cores, decortication, and thinning flakes all reinforce the argument for the use of local cryptocrystalline pebble sources. The importance of shellfish as source of food to be exploited is also made more apparent.

Cape May Point Site (28CM1). This site is unlike the others in this review, in that it was not excavated scientifically, but rather it is the product of artifacts eroded out of Atlantic Ocean and Delaware Bay. The site was reported by Dr. Richard C. Cook (1960; 1969), who, along with his family, scoured the beach at Cape May Point for Native American artifacts. By 1960 he had collected 3,026 stone artifacts. There are no excavations, no provenience or archaeological context, and the artifacts are not rigorously analyzed. In addition, the natural bias inherent in the nature of collecting leads to finding "good stuff," hence the preponderance of projectile points (n = 2,221) in his lithic collection. This is not characteristic of excavated archaeological sites on the OCP where projectile points are a small fraction of the lithic materials recovered. However, the site is included for two reasons: first, certain projectile points are diagnostic of time periods and can indicate the span of occupation, and perhaps the intensity of occupation in certain periods in the Cape May Peninsula; second, triangular projectile points, which are generally attributed to the Late Woodland period, are relatively abundant and easy to recognize.

The Cape May Point site extends for four miles east to west on a section of beach at the very southernmost tip of the Cape May. The Atlantic Ocean and the mouth of the Delaware Bay lie east and west, respectively, of the point (U.S.G.S. 1972a). The area is located 20 km south-southwest of the Kimble's Beach site.

Stemmed points account for 783 items in this collection. This is not surprising since stemmed points of different varieties are found in Middle Archaic through Middle Woodland times. This period spans almost 7,500 years of Native American history. The bifurcated points (n = 39) are diagnostic of Middle Archaic times (Custer 2001). The convex base points appear to be Teardrop points from the Early Woodland (Mounier and Martin 1994). The triangular points (n = 269) are all overwhelmingly of what Cook (1960:3) refers to as "flinty materials" (n = 261). Some of these triangular points could be from the early Archaic period (see Stewart 1998a) but not all, given the complete dominance of Late Woodland period Riggins style ceramic sherds in Cook's (1969:19) collection from the same beach. The flinty materials consisted of chert, jasper, flint (mostly likely black chert), and chalcedony which are found in reasonable abundance in cobbles on both the Atlantic and Delaware Bay shores of the peninsula (Tom Radlov, personal communication 2004) .

This site provides substantiation for several points. The Native American presence on the Cape May Peninsula dates to Early Archaic, actually Paleo-Indian times considering the Kimble's Beach fluted point as evidence of this time period, and it was occupied consistently through the Late Woodland period. The use of local cryptocrystalline sources for Late Woodland times is reinforced. This utilization of these local sources may well be part of the technological strategies for most of the span of Native American occupation of this area. It also provides further evidence for bay transgression and the occupation of coastal areas over time on the Cape May Peninsula.

Fralinger Site (28Cu8a). The Fralinger site is located on the east bank of the Maurice River, slightly north of the confluence of the Manumuskin Creek, and eight miles (13 km) north of the Delaware Bay. The river is tidal at this point and bordered by extensive salt marshes. The site is situated on knoll of predominately oak and hickory, which rises 15 feet (4.6 m) above flood tide. Two Maurice River sites, Indian Head and East Point, were initially explored by Cross (1941:41-47) in the late 1930's. The Fralinger site was tested and excavated by Alan Mounier (1972; 1974) in December, 1971 through January, 1972. Ten squares (5x5 ft) were excavated during this time. The site was disturbed in the 1930's when a Works Progress Administration crew dug a drainage ditch through the site, and later erosion removed more material. Mounier (1974:32) estimated that little less than half of the site was undisturbed.

The Fralinger site is unique on the OCP, in that it was stratified. There was a modern O horizon (3-6 in) and a wedge-shaped layer of fill from the drainage ditch. Stratum 1 (6-18 in) is the A horizon that contained two sub-strata, which both contained similar artifacts of Late Woodland derivation. Stratum 2 was of yellow sand, which at the interface with the A horizon produced diagnostic artifacts of the Susquehanna broadspear culture of the Late Archaic period. This stratum contained the only feature on the site. Charcoal, radiocarbon dated to 1880±100 B.C., was derived from this feature.

This reinforced the interpretation from the diagnostic bifaces recovered from Stratum 2. There was no apparent mixing of artifacts from the two strata.

Artifacts from Stratum 1 included small triangular projectile points (*n* = 3), small endscrapers (*n* = 4), utilized flakes (*n* = 7), large heavy ovoid scrapers (*n* = 2), and a variety of shell, grit, and ochre tempered ceramic sherds including two varieties of ceramic smoking pipes. Limonite nodules, many of which were calcined, one graphite paintstone, and whetstones (*n* = 2) of finegrained sandstone were recovered. No bone or shell artifacts were recovered. All of the flaked lithic artifacts were of pebble jasper and the ovoid scrapers of local jasper and quartz. Historic artifacts, which included a pewter button and copper and iron items were found in the upper level of Stratum 1 in association with Riggins type ceramic sherds and triangular projectile points both of Late Woodland derivation (Mounier 1972:34-45). Inferred root disturbance was deemed responsible for an intrusive Rossville and corner-notched projectile point (Mounier 1974:34).

Mounier (1974:34-36) described two new Late Woodland ceramic types, Union Lake Corded and Fralinger Corded. Both types were undecorated, collarless with everted rims, ovate/conoidal in shape with conoidal bases, and malleated with a cord-wrapped paddle. The former was tempered with grit, crushed quartz, and some muscovite while the later contained temper of crushed oysters and mussels along with grit, sand, and crushed quartz. They also differed in body treatment with the Fralinger Corded haphazardly applied, compared to the more careful and slightly oblique impressions on the Union Lake Corded. The two ceramic types are considered a continuation of an Early to Middle Woodland ceramic tradition in southern New Jersey. Mounier (1982:160) has noted that the ceramic traditions of southern New Jersey are conservative. It is common for types found in earlier periods to be carried over into the Late Woodland period.

The relatively ubiquitous Late Woodland period Riggins Fabric-Impressed and Plain ceramics types are well represented on the site. They were found in the upper portions of Stratum 1 in association with the historic artifacts and triangular points. This led Mounier (1972:30) to conclude that a portion of the occupation was in the early Contact period.

Remains of fauna and flora were limited to some bones, most likely deer, oyster and clam shell, and hickory nuts. There was no evidence of housing although a clayey area (Stratum 1a), was conjectured to be deliberately constructed as a living floor (Mounier 1974:32).

The location of this site placed its inhabitants in excellent position to exploit the resources of the bay, river, forest, and tidal marshes. Grossman-Bailey(2001:323) found 18 sites with Late Woodland components within two miles of Fralinger and 35 sites with Late Woodland components within five miles. This area appeared to be heavily occupied in Late Woodland times. Although the organic material recovered is limited due to the poor soil preservation what was found offered indications of a variety of resources. It does not require much imagination to believe that the Native American inhabitants were taking advantage of the full range of resources available. The lithic artifacts exhibit the characteristics of derivation from the locally derived cryptocrystalline cobbles from river or bay margins. It is informative to note that the lithic raw materials from which the Late Archaic bifaces were manufactured primarily from non-local argillite, Cohansey Quartzite, shale, and fine quartzite (Mounier 1972:49-54).

Discussion. In the preceding section some of the excavated coastal/bay Late Woodland sites on the OCP were discussed. The list was not comprehensive but was intended to illustrate some major trends in the area that could be applicable to the KBS (for a more extensive discussion see Grossman-Bailey 2001). There are no excavated sites on the Delaware Bay side of the peninsula other than the KBS. The nearest excavated sites are in the Maurice River drainage to the north, such as the Fralinger site. It appears reasonable that Late Woodland sites further north along tributaries of the Delaware River, such as the Ware and Krol sites on the Salem Creek, Gloucester County and the Kimble site on the Rancocas Creek, Burlington County followed similar patterns of food and lithic resource exploitation (McCann 1950;1957). Lithic materials recovered from components on these sites, attributed to the Late Woodland period, indicated their inhabitants exploited local gravel sources of cryptocrystalline materials or the nearby Cohansey Quartzite outcrops to manufacture their tools and triangular projectile points.

Two trends in the patterns of resource exploitation are apparent. The first is that Native American groups on the OCP and Delaware Bay situated their encampments near wetland areas that were rich in food resources readily available for exploitation. Shellfish, fish, turtle, other reptiles and amphibians, deer, bear, small mammals, birds, nuts, plants, and tubers were available at times in great abundance. Robert Evelyn's observations of the New Jersey side of the Delaware Bay in 1634, previously noted, chronicled an impressive listing of waterfowl, shellfish, animals and plants available to the native inhabitants (Weslager 1954:2). In the mid-nineteenth century Dr. Maurice Beesley (1857:135-154) compiled a list of the wildlife of Cape May county. This list is comprehensive in scope, including black bear, deer, smaller mammals, gamebirds, waterfowl, and a great variety of freshwater and saltwater fishes, and shellfish. These preceding observations suggest that the ubiquitous layers of clams and oysters found on coastal sites and at Kimble's Beach may be partially an artifact of the notoriously poor preservation qualities of the droughty and acidic soils of the OCP, and a biased representation of the food sources that were actually exploited. It is reasonably inferred that a semisedentary lifestyle could be supported by this rich and diverse resource base.

The second trend is the almost exclusive use of cryptocrystalline alluvial gravels, easily found along the margins of the bay and river mouths, to manufacture tools including triangular projectile points. All of the sites discussed above indicate that pebbles from river and bay were the source of the overwhelming majority of flaked lithic artifacts recovered from Late Woodland components. Gravels are readily available along the Atlantic coast, the bayshore, and along rivers especially at the mouth. Growing populations in the Late Woodland period may be linked to increased territoriality with a dramatic decrease in evidence of long distance procurement or trade (Stewart 2000), and hence reliance on local lithic materials. The complete dominance of triangular projectile points in the Late Woodland assemblages is usually viewed as an indication of the adoption of the bow and arrow in the region (Blitz 1988; Custer 1996b; Dent Jr 1995; Kraft 2001; Stewart 1995). The range of the length of triangular points from Late Woodland contexts at the Abbott's Farm site complex was 15-73 mm (Wall et al. 1996:60). Ritchie (1989:31-34) reported ranges of three-quarters to three inches (19-76 mm) for Levanna and Madison[2] points from New York State, which is almost identical to the Abbott Farm assemblage. The demise of the large biface, with a staged reduction sequence, and its replacement by small triangular points allowed native inhabitants of the

OCP to utilize local gravels of relatively high quality cryptocrystalline materials to manufacture these small bifaces. It would appear that the pebbles of ocean, bay, and river margins were a good fit for their needs.

1. Uncalibrated radiocarbon dates are indicated as ca. B.P. unless otherwise specified. Calibrated dates will be identified as cal B.C./A.D. The radiocarbon present is considered A.D. 1950.

2. Ritchie (1989) proposed two types of Late Woodland triangular projectile points, Levanna (ca. A.D. 900-A.D. 1350) and Madison (ca. A.D.1300-A.D.1800). Custer (2001) and Wall et al (1996) placed both types into a general category of Late Woodland triangular points since triangular projectile points with the distinguishing characteristics of size and shape of each type are often found in the same radiocarbon dated contexts.

CHAPTER 3

SITE BACKGROUND

Project History

In March, 1994, Dr. Sandra Bierbrauer, professor of ecology at Richard Stockton State College, was notified by Dick Regensberg, a New Jersey archaeologist, that prehistoric artifacts were eroding from the Delaware Bay, Middle Township, Cape May County, New Jersey. Two local residents, Geoffrey Carr and Kurt Himstedt, who collected numerous prehistoric artifacts that washed up on the beach, alerted Regensberg of their discoveries. Bierbrauer investigated the report and then contacted Dr. John Cavallo, director of the Rutgers University Center for Public Archaeology (RUCPA). After further investigation by Bierbrauer and Cavallo, it was concluded that the site contained extensive deposits of prehistoric artifacts. Dr. Bierbrauer reported the site to the NJSM who then assigned Smithsonian site number designations (Cavallo, et al. 1996). The BF locus was undergoing severe shoreline erosion due to the constant action of the waves and the effects of storms. Permission was granted by the U.S. Fish and Wildlife Service to conduct a scientific excavation to prevent the loss of valuable archaeological information.

The registered sites (NJSM site files) along this portion of the Delaware Bay were the Kimble's Beach site (28CM36) and the Cook's Beach site (28CM35). The BF locus of the Kimble's Beach site was designated 36A, and the upland loci on private property and the Cape May National Wildlife Refuge and Nature Conservancy properties 36B (Figure 3.1). The locus 36B, which is on private property, was further sub-divided into

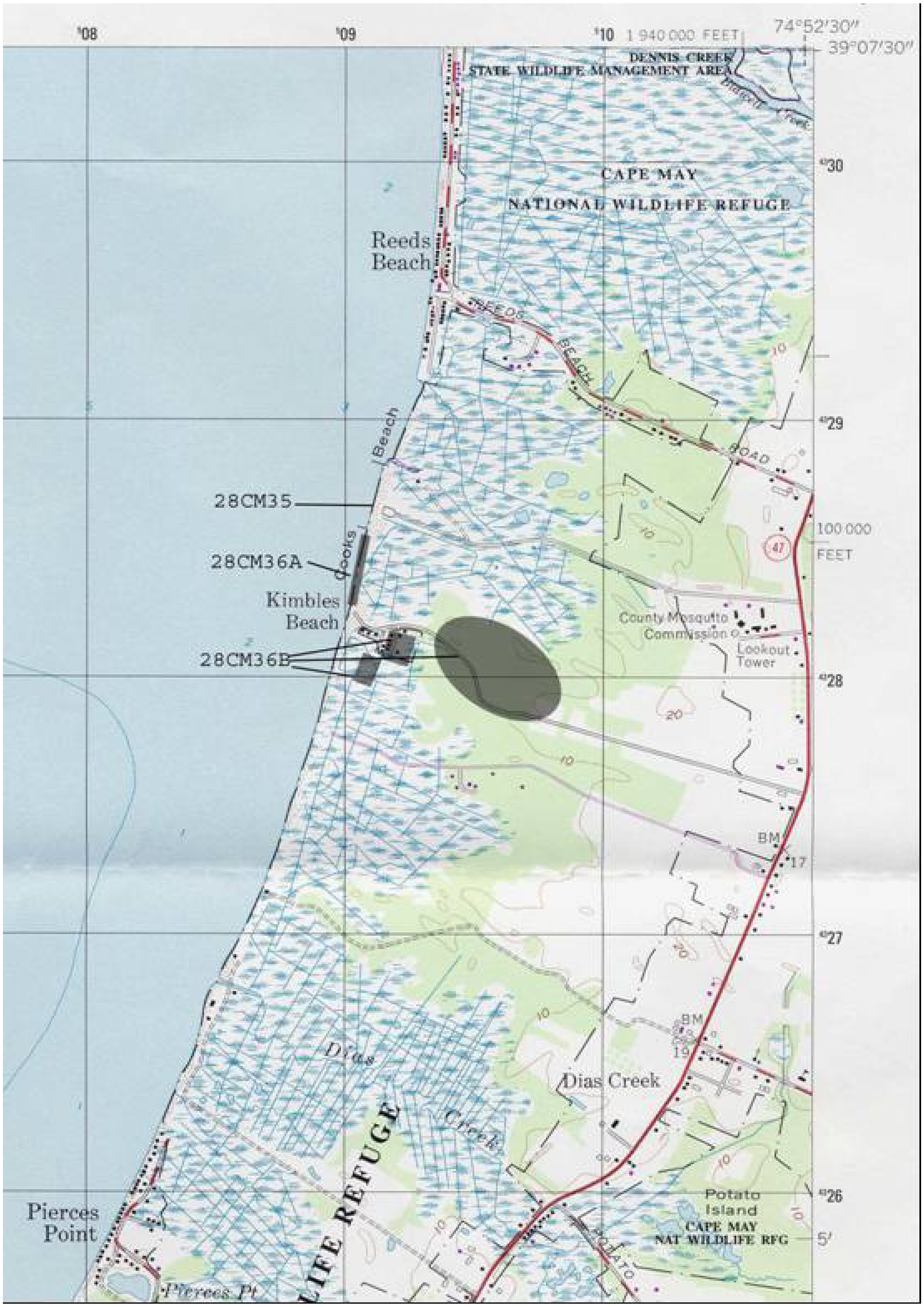


Figure 3.1. Location of Kimble's Beach site (28CM36A and 36B) and Cook's Beach Site (28CM35). USGS 7.5 ', Rio Grande Quadrangle, Cape May County, NJ. Excavated areas of the Kimble's Beach site are shaded.

the Carr, Lomax, and Willow Tree areas. The Cook's Beach site is a section of beach face approximately 500 m north of the Kimble's Beach site along the bay.

A joint interdisciplinary study of the site was conducted by the Rutgers Department of Anthropology and Richard Stockton State College in four six-week field schools spanning the period 1995-1998. The principal investigator was Dr. John Cavallo of Rutgers University, with ecologist Dr. Sandra Bierbrauer, and geoarchaeologist Dr. Raymond Mueller, both of Richard Stockton State College. Carolyn Hartwick, a PhD candidate at Rutgers University, served as archaeological field supervisor for all four field seasons. I participated for limited periods in the 1996 and 1997 excavations, and served as a crew chief for the entire 1998 field school. Supervised excavations and data gathering were accomplished by students of Rutgers University and Richard Stockton State College.

The great majority of diagnostic artifacts recovered from all loci were of the Late Woodland period, although artifacts spanning the entire Woodland period were present in small numbers. The Late Woodland artifacts, which have been associated with well dated contexts (Custer 2001; Ritchie 1989; Stewart 1998b), consisted of small triangular bifaces (classified as projectile points) and ceramic sherds dominated by the southern New Jersey Riggins Fabric Impressed type. The chipped stone assemblage consisted of pebbles, cores, debitage, scrapers, and various stages of triangular biface reduction, which were assumed to be derived from local gravels and overwhelmingly (more than 95 percent) of chert and jasper. Fire cracked rock (FCR), hammerstones, anvils, and pitted pebbles dominated the non-flaked lithic assemblage. Shell middens, mainly of oyster and clam (95 percent), were found in all loci. Additionally, a diversity of faunal remains associated with wetlands and upland environments were recovered. Among those identified were white-tailed deer, muskrat, black bear, river otter, raccoon, fish, bird, and seven species of turtle (Bierbrauer, et al. 2002). Two burials of Native American adult males, one flexed and the other extended, were discovered on private property in the upland loci (36B).[1] No typical grave objects (Kraft 2001:343-350) were recovered (for an alternative view of grave objects see Clark and Custer 2003). Bierbrauer (2001) obtained a radiocarbon date of 530 $\pm$40 B.P. from the extended burial. Relatively few features were uncovered, and no evidence for housing such as post molds or evidence of pit houses were found. Cavallo (1997) considered the amount of FCR to be "...unexpectedly low." This was the case for the entire four seasons of excavation.

The recovered artifacts were analyzed and entered into a Paradox database by Rutgers students under the supervision of Cavallo and Hartwick in a fall lab class following each field school session. Faunal and botanical analyses were accomplished by Sandra Bierbrauer with the assistance of John Rebar and Bruce Mohn, graduates in biology from Richard Stockton (Bierbrauer, et al. 2002; Cavallo, et al. 1996; Cavallo, et al. 1997; Mueller 1997).

Beach Face Excavations (28CM36A)

The fieldwork at the BF locus was conducted through a combination of surface collection, shovel tests, 1x1 m test units, and soil auguring along the length of the beach face comprising Kimble's Beach (Figure 3.2). Excavation results from the BF locus (36A) are the focus of this thesis. All analyzed artifacts were recovered from the BF locus, and all data presentations and interpretations apply only to the BF locus of the

Figure 3.2. Beach face at Kimble’s Beach: (Top) excavation area viewed from datum point looking north; (Bottom) salt marsh viewed from water line at low tide with clay cap in center of beach.

greater Kimble's Beach site. The majority of the excavation was accomplished by a series (*n* = 22) of 1x4 m trenches and 1x2 m units perpendicular to the shoreline both north and south of the intersection of Kimble's Beach Road and the beach (Figures 3.3 and 3.4). Three (1x2 m) units were excavated south of Kimble's Beach Road, but they produced no artifacts, and no further excavation was conducted in this area. The units and trenches were subdivided into 1 m quads. Additional quads were added to three trenches to explore features or heavy concentrations of artifacts. Because the BF locus was covered by the waters of the bay during the high tide period, excavation was limited to the one week per month when low tide occurred during daylight hours early enough to allow for four to five hours of work. The incoming high tides deposited enough sediment in the form of beach sand to fill in the trenches. The following day this natural fill would be removed by the students and excavation continued. This method of excavation has been styled as "sandpiper archaeology" (Johnson and Hayes 2004). The clayey/silty nature of the soils, beneath the sand and the relatively low energy of the waves, generally prevented erosion by the incoming tide and maintained wall stability. Notwithstanding this overnight stability, this site surely would have been lost to coastal erosion unless it was excavated (see Hoyt, et al. 1990:149-150).

Excavation was accomplished primarily with shovels in arbitrary 10 cm levels within a soil horizon with features removed by trowel. All materials were screened through quarter-inch hardware mesh, with buckets of water from the bay to aid in breaking up clumps of clayey and organic rich soil that often clogged the screens. A catalog number was assigned for each level in each quad within the trench. Catalog sheets containing information on provenience, soil categorization, Munsell colors, note

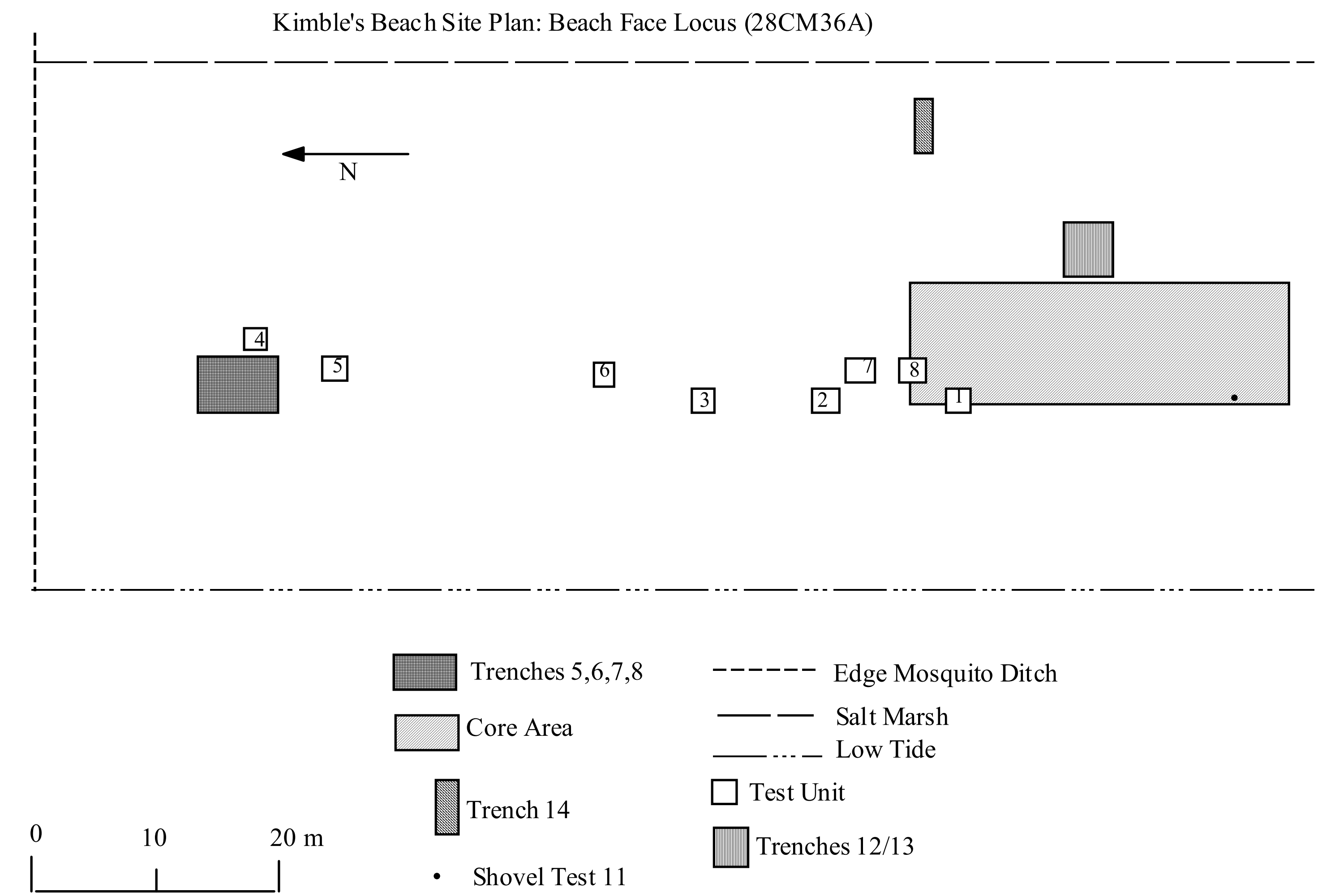


Figure 3.3. Site map of excavated areas, Beach Face locus, Kimble's Beach site (28CM36A). The lithic assemblage in this study was recovered from these units.

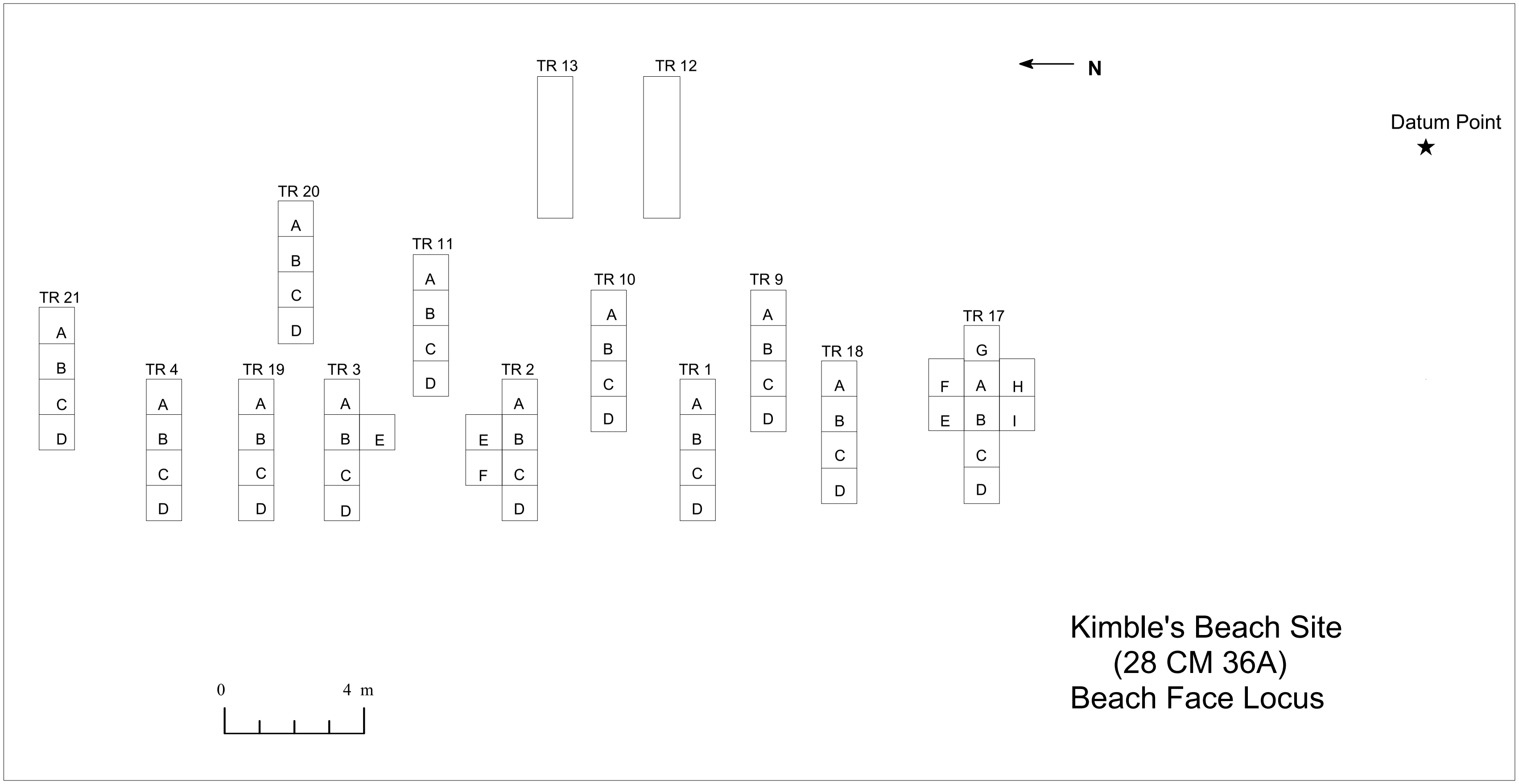


Figure 3.4. Plan map of excavation units in core area.

on the excavation, drawings, and a list/description of artifacts recovered were completed. Soil was brushed off artifacts, and the artifacts were categorized into CSA and debitage, ceramics, non- flaked lithic artifacts, and faunal/organic remains. All artifacts were bagged by catalog number. Profiles of each trench, and plan views of features were drawn. Artifacts were cleaned with fresh water both at the field school and the lab class in the following fall semester.

Rise of the Delaware Bay

The key to understanding the stratigraphy of the BF locus at Kimble's Beach is in the sea level rise during the Holocene (ca. 10,000 B.P.) (Berger, et al. 1994; Kraft 1977; Kraft and Chacko 1978). The three factors responsible for relative sea level rise are eustatic effect, or actual increase in the amount of water in the oceans, tectonic effect or coastal zone subsidence, and sediment compaction (Psuty, et al. 1996). Coastal zone subsidence has been estimated to account for approximately one meter of relative sea level rise in the post-Wisconsian period, and sediment compaction and coastal subsidence are negligible in the Delaware Bay (Kneibel, et al. 1988:124). The continued effects of deglaciation and the ensuing meltwater runoff are largely responsible for this rise. Sea level rose at 2.11 mm per year in the period 8,000-2,500 B.P., and .8 mm per year from 2,500 B.P. to the present (Psuty 1986:165). The rate of sea level rise, as derived from tidal gauge stations, has increased in the last 150 years with averages of 3.85 mm per year at Atlantic City and 3 mm at Lewes, Delaware (Pirazzoli 1996:Figure 106). Relatively shallow and gently sloping areas of the bay in the vicinity of Kimble's Beach

(Figure 3.1) resulted in a greater bay transgression landward, than in more steeply sloped coastal areas of New Jersey (Kneibel, et al. 1988).

Measurements of aerial photographs of the Kimble's Beach area from 1940 and 1995 were undertaken to quantitatively determine shoreline change in this 55 year period. This information was derived from aerial photographs stored at the Bureau of Tidelands Management, in Trenton, New Jersey. Elevation in the study area varies from 0-3 m, hence there is little relief distortion in the photographs and measurements can be made accurately. The procedures followed Philips (1985:43-70), except the western edge of the salt marsh, which is indicative of the Mean High Tide level at this section of shoreline, was utilized in all four measurements. The salt marsh is a good indicator of shore line movement, because it advances and retreats in response to bay transgression and retreat (Kraft and Chacko 1978:55). The eastern terminus of the measurements were cultural features present in both sets of photographs that were determined to have not been moved or altered. A more exact scale for each photo was derived by taking measurements from a 7.5 minute U.S.G.S. quad map (U.S.G.S. 1977b) between two cultural features present on both photos (road intersections) and relatively near the principal point of both photographs. The formula is

$$RF = \frac{1}{(MD)(MS)/PD}$$

where MD equals map distance, MS equals map scale, and PD equals photo distance between the two points (Avery and Berlin 1992:73). All measurements were taken by the same procedures and in the same units (metric).

Measurements were taken from a 1940 (date: April 10, 1940; roll/frame: 19-14) aerial photo of Kimble's Beach area taken by Texas Air Aero Service held at the Bureau of Tidelands Management and a 1995 NAPP photo (date: March 25, 1995; roll/frame:8645-008) purchased from the U.S.G.S. The 1940 photo had a nominal scale of 1:20,000, and the 1995 photo a nominal scale of 1:40,000.. The 1940 photo scale was revised by the above method to 1:19,636, and the 1995 photo to 1: 38,857.

Two measurements were taken from stable cultural features (road and road intersections) west to the salt marsh (SM) edge at the intersection of Kimble's Beach Road KBR) and the beach face and two measurements, 127.6 m north and 206.6 m south

Table 3.1. Beach Erosion/Bay Transgression at Kimble's Beach, 1940-1995.

Measurement Points	1940 (m)	1995 (m)	Erosion/ Transgression (m)	Per Year (m)
1-KBR/SM	1865.4	1787.4	-78	-1.42
2-KBR/SM	1708.3	1632	-76.3	-1.39
3-North	1678.8	1593.1	-85.7	-1.56
4-South	1826.2	1748.6	-77.6	-1.41
Mean	1769.7	1690.3	-79.4	-1.45

of this of this point, for a total of four (Table 3.1). The mean erosion/transgression of the four readings is 79.4 m, with a mean erosion/transgression rate of 1.45 m per year. These results are similar to the mean transgression rate of 1.62 m per year for four points in the vicinity of West Creek (the northern political boundary of Cape May, 9.5 km north of Kimble's Beach) in the period 1940-1978 (Phillips 1985:119). Phillips (1985:127) found that erosion/transgression rates varied widely in his study areas, even at 3 km intervals. Erosion/transgression rates in one section of the bay cannot, with any confidence, be assumed to be applicable to another section.

Physical evidence of this erosion/transgression at Kimble's Beach occurred in 1994, when a concrete U.S. National Oceanic and Atmospheric Administration Tidal Bench Mark (KB No 1), set 31 ft (9.45 m) inland of the high tide mark in 1975, fell on its side and was submerged at high tide (Hartwick 2001). Vandemark (1997) compared maps of the Kimble's Beach area from 1856 and 1956, and estimated beach loss at 500 ft (152.4 m) for this 100 year interval. Hartwick (1998) estimates that the shoreline at Kimble's Beach may have been 450 m west of its present location during the Late Woodland occupation. The erosion is significant enough that the state of New Jersey currently plans to conduct a beach replenishment program in a 7.5 km section of bayside that includes Kimble's Beach (William Liebeknecht, personnel communication 2005). This evidence of erosion/transgression, along with stratigraphic evidence, indicates that Kimble's Beach was in an upland position in relation to the Delaware Bay in the Late Woodland period.

Salt Marsh Formation

In the Delaware estuary, coastal environments similar to the present existed throughout the Holocene. Inundation of these coastal environments by the Delaware Bay since the onset of the latest deglaciation caused a continuous landward movement of estuarine and lagoon fringing marshes (Kraft, et al. 1992:234). The area at Kimble's Beach underwent this landward migration of the salt marsh that hedges most of the Delaware Bay in this section of the Cape May Peninsula.

Salt marshes develop in a regime in which the accretion rates in the estuary exceed the rate of coastal submergence resulting in a net accumulation of sediments. The process of salt marsh formation is threefold: first, fine grained sediments accumulate to form a tidal flat; second, vegetation colonizes the flats, if accumulation elevations are sufficient and the area sheltered; and third, marsh surface is built up through the trapping of inorganic sediments and the development of an organic substrate. If the rate of sedimentation cannot keep up with the rated of submergence, then marsh area will be converted into open water (Orson, et al. 1985; Phillips 1985).

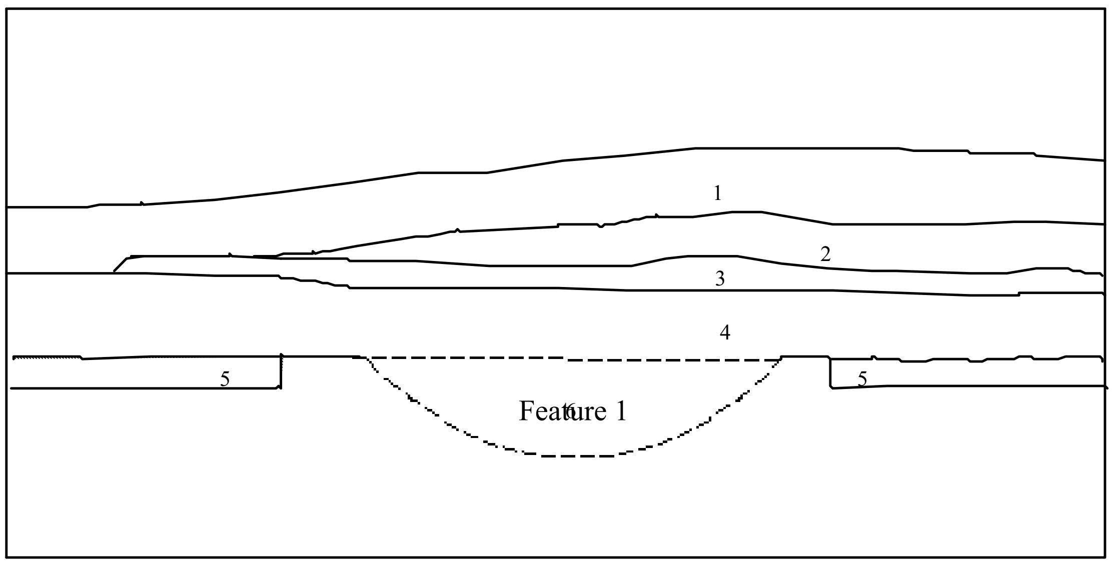
Mueller (1997) outlined a sequence of changes for the Kimble's Beach site complex as a result of coastal submergence. The current BF locus (36A) would have passed through a succession of changes in both geomorphic positions and depositional environments, as the bay transgressed the land and the salt marsh migrated landward. Originally, the site (36A) was in an upland position similar to the current uplands east of the shoreline. It would have passed through the stages of transitional wetlands, salt marsh, coastal dune, beach face, and ultimately submergence underneath the bay. On the beach, the buried A horizon is overlain by a muck soil that was deposited when the current beach face was in its salt marsh phase. Auguring, both parallel and perpendicular to the shoreline, demonstrated that the buried A horizon continued under the present salt marsh to the uplands, where it is the modern surface soil. Phillips (1985:86) found this is a common occurrence along the bayshore, as beaches are underlain by relict salt marshes, and layers of peat deposited by salt marshes, throughout the Cumberland county shoreline north of Kimble's Beach.

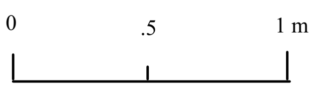
Site Stratigraphy

The program of augering at Kimble's Beach yielded a profile of the general site stratigraphy. Laterally buried, beneath the beach face were extensive organic-rich sands and histosols which in some areas were greater than 7 m in thickness. Roots (mat-like) recovered from these strata indicate they were deposited in a salt marsh environment. The uppermost buried histosol is the artifact bearing layer. The strata were closest to the surface where the uplands and salt marsh meet. The layers appear to be draped over a landscape similar to the present, but with greater relief. In the uplands there were no organic-rich strata within the 7-8 m range of the augur (Cavallo, et al. 1996; Mueller 1997).

The stratigraphy of the beach face generally consists of five layers, which may not be present in all excavation units (Figures 3.5-3.12). The uppermost layer is a light brownish-gray beach sand (2.5Y 6/2), which is reworked as a result of tidal action. This is underlain by a mottled grayish-brown (2.5Y 5/2) and dark gray (10YR 4/1) sandy loam (interpreted as a historic fill) in which most of the coal slag and historic artifacts were found. This fill layer is not present in all units. Underlying either the beach sand or fill is a dark gray (2.5Y 3/1) thin clay/silt cap containing decayed roots, which is interpreted as a tidal flat deposit and where present is approximately 5 cm in thickness. Underlying the three upper layers is a black (10YR 2/1) sandy loam that is approximately 25 cm in depth which tapers somewhat in the western units of the trenches. This layer is interpreted as a buried A horizon and is found in all units. The majority of the prehistoric artifacts were recovered from this stratum. Underlying this layer is a silty sand subsoil

Trench 2: North Profile





Context Descriptions
1-2.5Y 6/2 sand
2-2.5Y 5/2 and 10YR 4/1 mottled sandy fill
3-2.5Y 3/1 silt loam w/decayed vegetation
4-10YR 2/1 sandy loam/buried A horizon
5-10Yr 5/3 silty sand subsoil B horizon
Feature 1- 10YR 2/1 sandy loam fill w/flecks of charcoal

Figure 3.5. Trench 2, north profile, Beach Face locus, Kimble's Beach site (28CM36A).

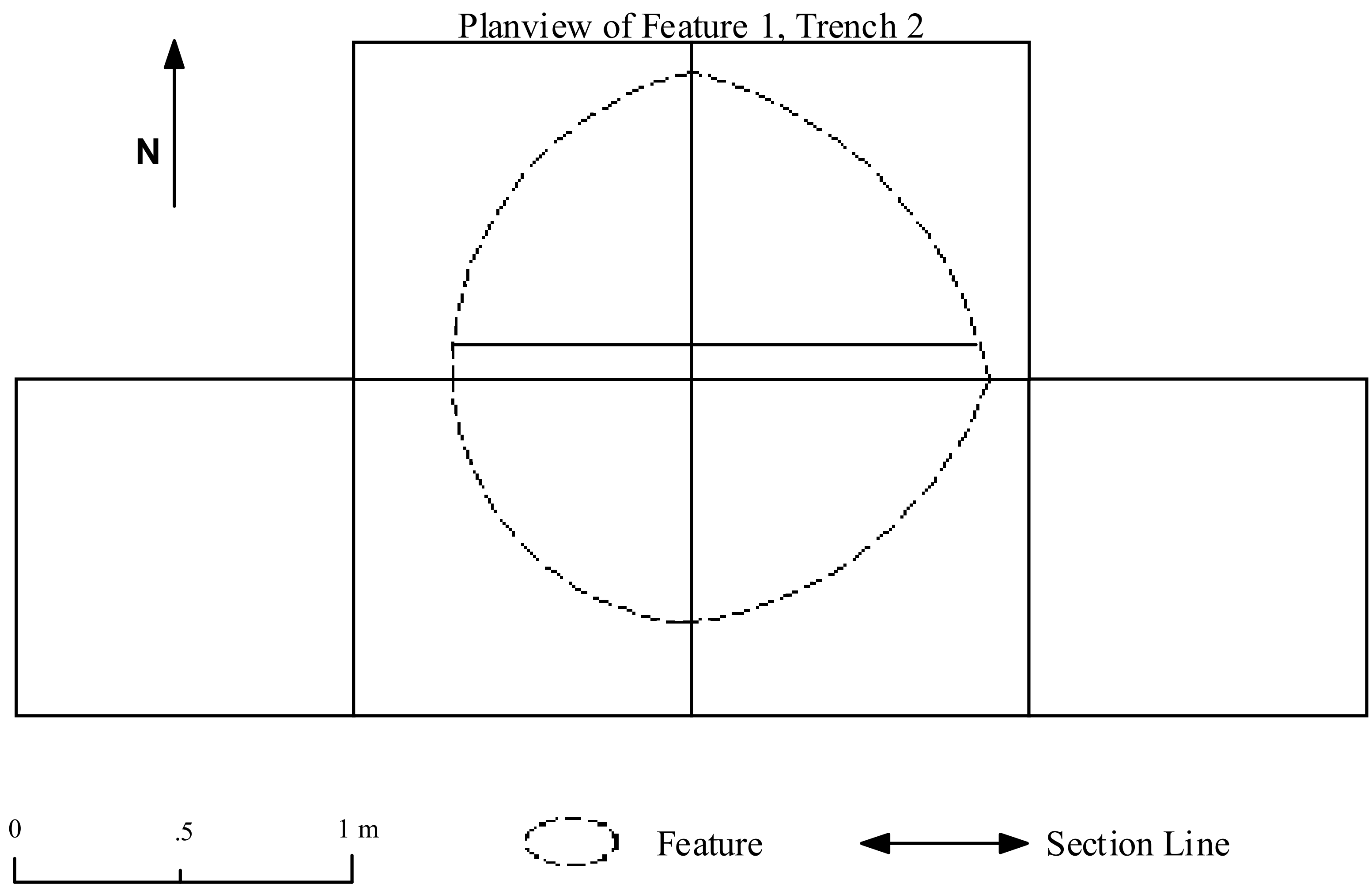


Figure 3.6. Trench 2, Feature 1, Beach Face locus Kimble's Beach (28CM36A).

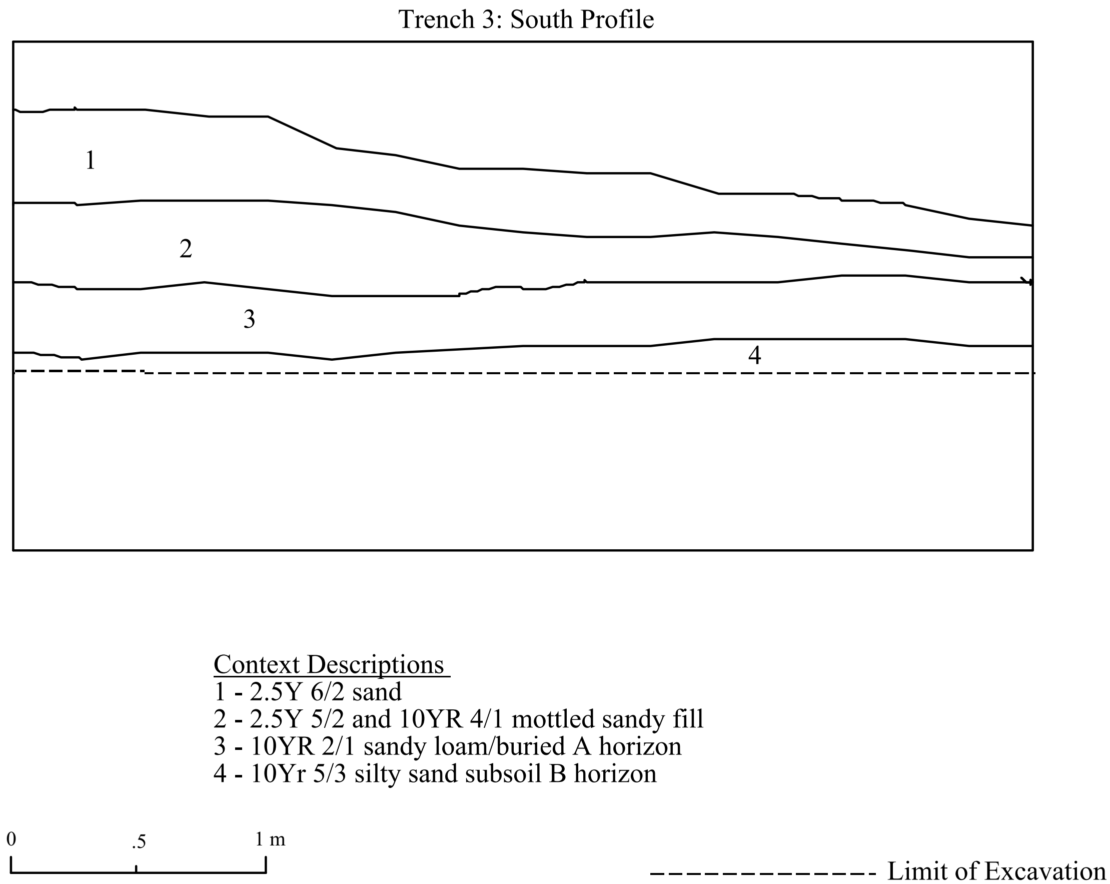
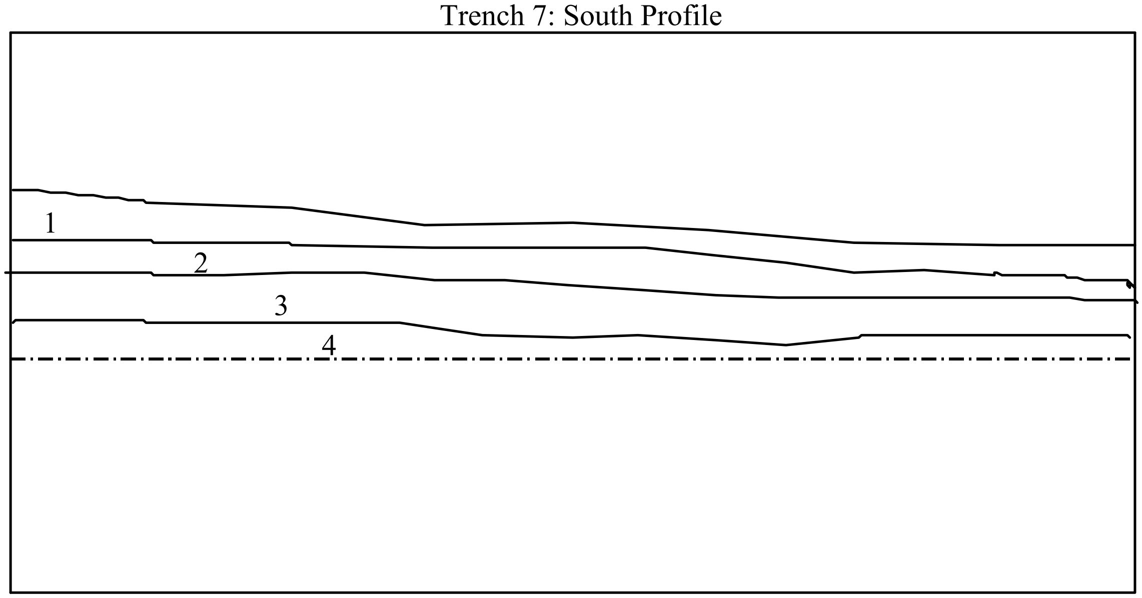
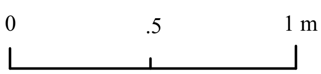


Figure 3.7. Trench 3, south profile, Beach Face locus, Kimble's Beach site (28CM36A).

Trench 7: South Profile

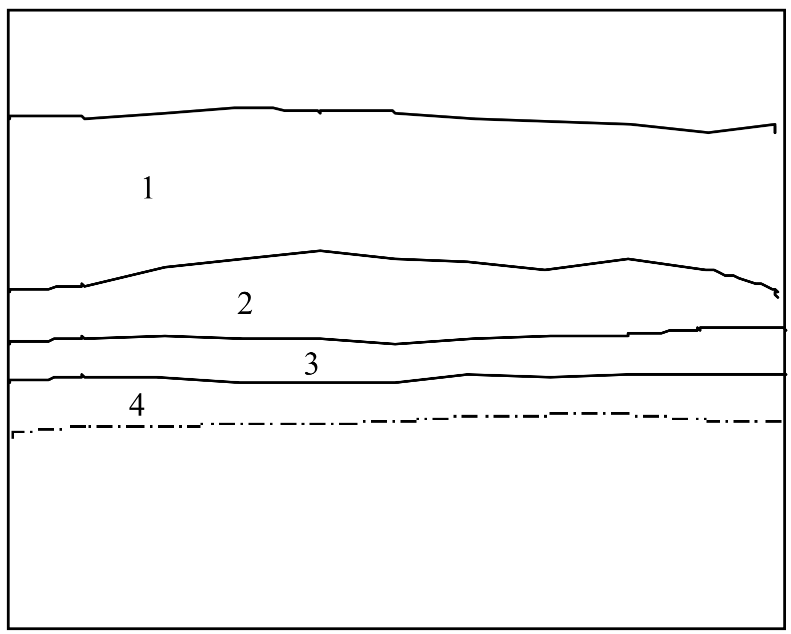


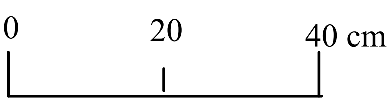


Context Descriptions
1 - 2.5Y 6/2 sand
2 - 2.5Y 3/1 silt loam w/decayed vegetation
3 - 10YR 2/1 sandy loam/buried A horizon
4 - 10Yr 5/3 silty sand subsoil B horizon
-·-·-·-·- Limit of excavation

Figure 3.8. Trench 7, south profile, Beach Face locus, Kimble's Beach site (28CM36A).

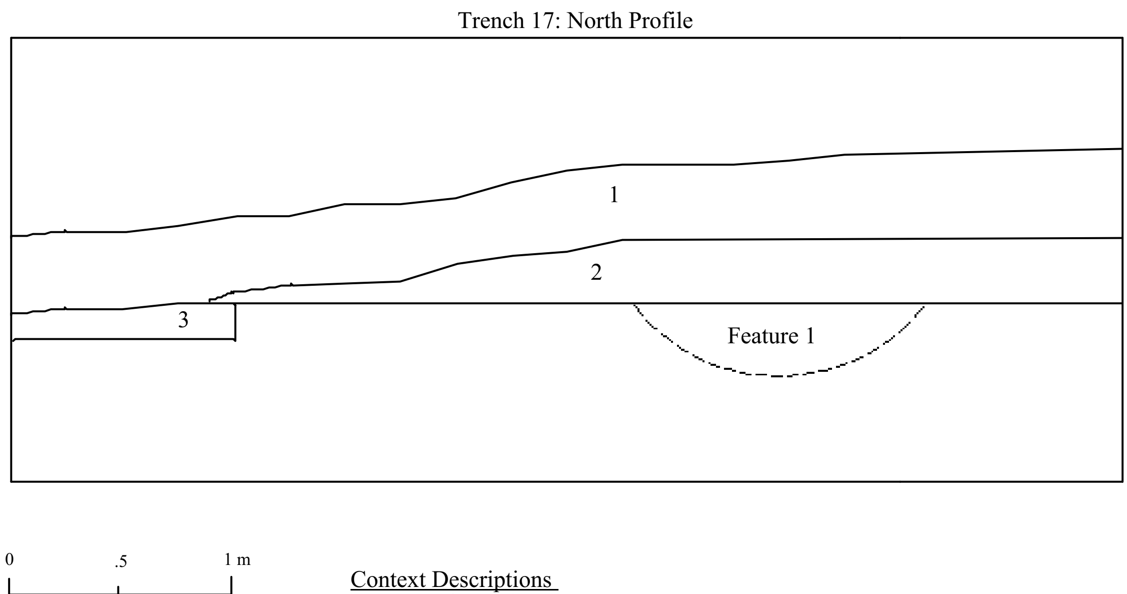
Trench 14: East Profile





<u>Context Descriptions</u>
1 - 2.5Y 6/2 sand
2 - 2.5Y 3/2 marsh muck
3 - 2.5Y 3/1 silt loam w/decayed vegetation
4 - 10YR 2/1 sandy loam/buried A horizon
–·–·–·–·–·–·– limit of excavation

Figure 3.9. Trench 14, east profile, Beach Face locus, Kimble's Beach site (28CM36A).



Context Descriptions
1 - 2.5Y 6/2 sand
2 - 2.5Y 3/1 silt loam w/decayed vegetation, thin veneer (5 cm) overlaying 10YR 2/1 sandy loam buried A horizon
3 - 10YR 5/3 silty sand subsoil, B horizon
Feature 1- 10YR 2/1 sandy loam

Figure 3.10. Trench 17, north profile, Beach Face locus, Kimble's Beach site (28CM36A).

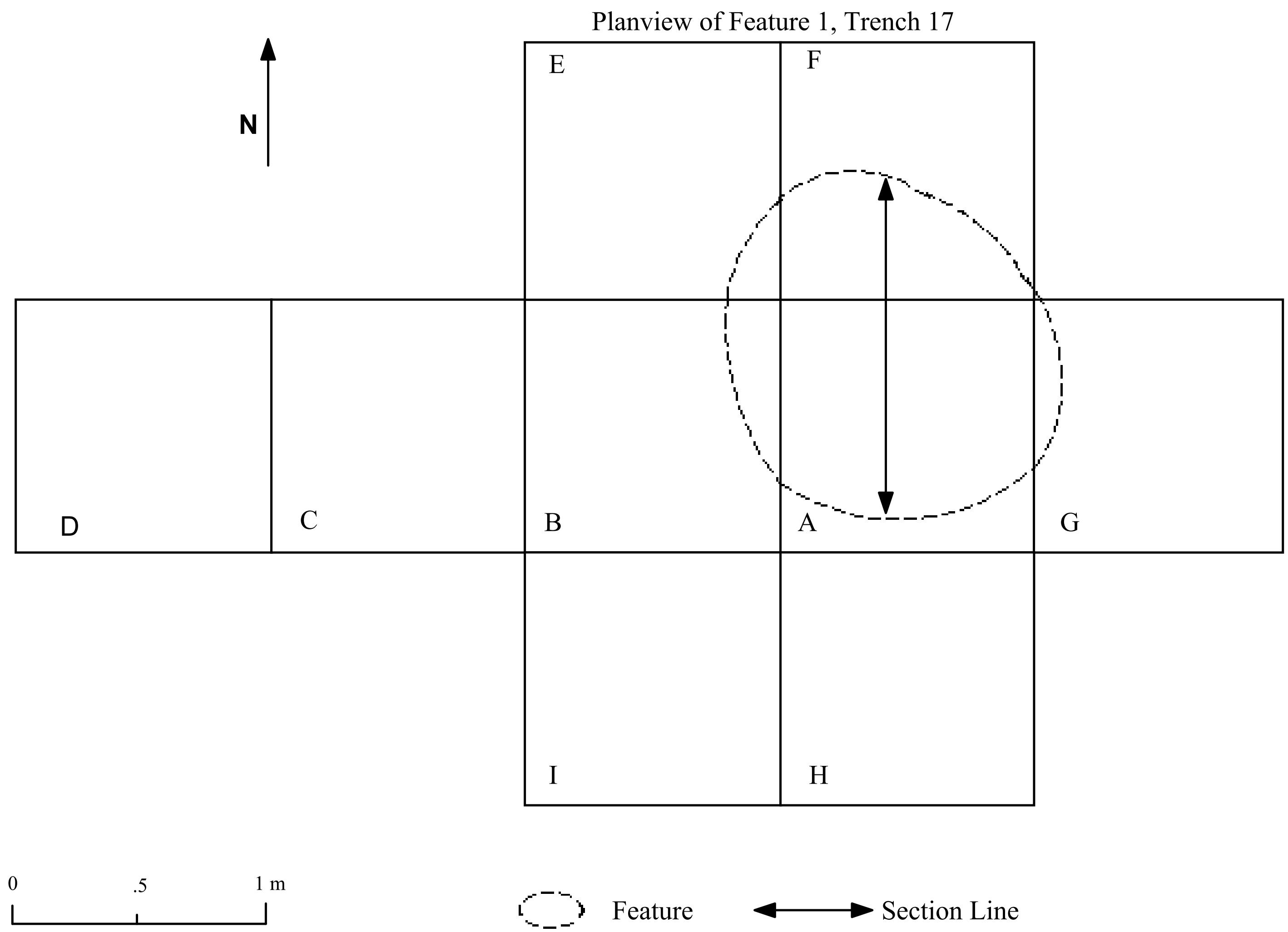


Figure 3.11. Trench 17, Feature 1, Beach Face locus, Kimble’s Beach site (28CM36A).

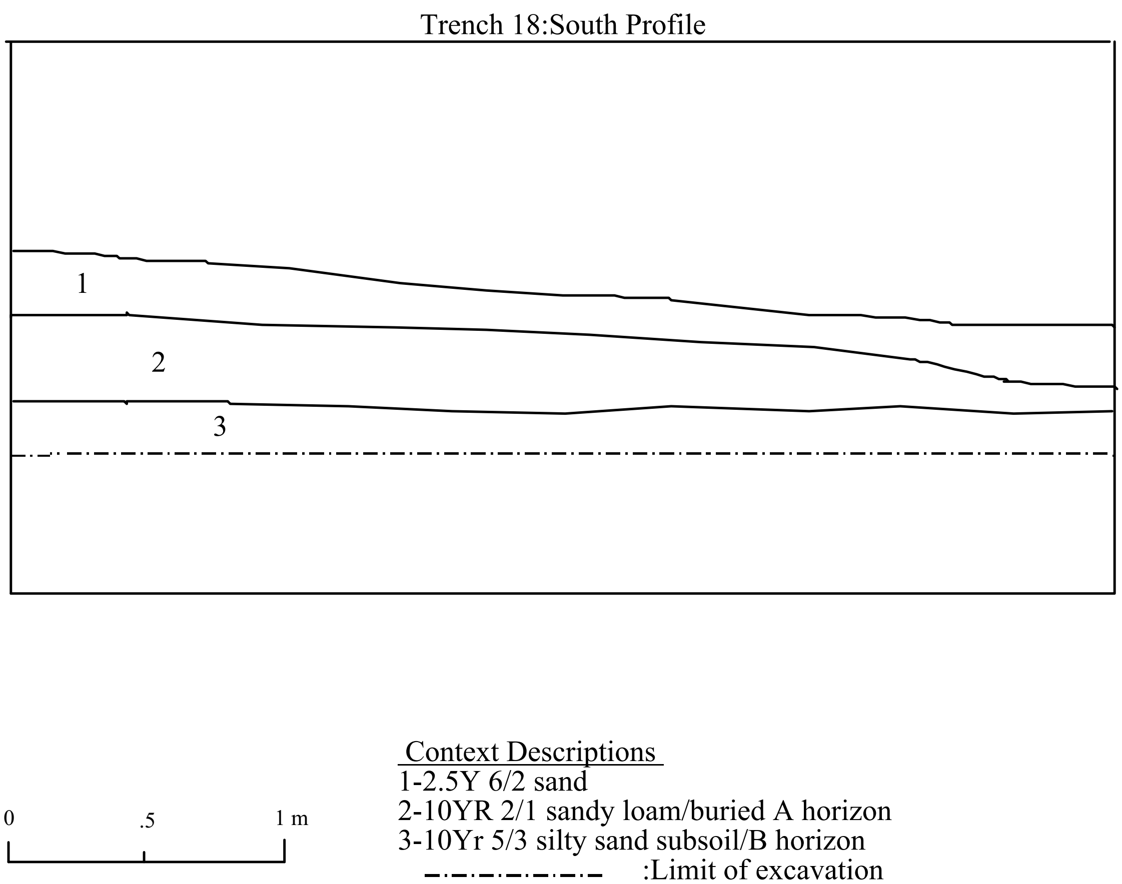


Figure 3.12. Trench 18, south profile, Beach Face locus, Kimble's Beach site (28CM36A).

10YR 5/3) or B horizon. This stratum did not contain artifacts except in the uppermost portions at the interface with the A horizon. As a result of the high water table present, excavation beyond 10 cm in depth in this stratum had to be discontinued due to water seepage which filled the lowest levels of the units.

This stratigraphic analysis indicates the Late Woodland occupation(s) of the BF locus took place on a well-drained, sandy loam soil that stood high and dry, well east of high tide level during the Late Woodland period. Subsequently, as the sea level rose and the beach face and salt marsh migrated eastward, the BF locus assumed its present location.

Paleoecology

The Late Woodland occupation(s) of the Kimble's Beach site were located on a peninsula of upland approximately 1.5-3 m above sea level. It was bounded on the west by salt marsh, with small fresh to brackish streams to the north and south. The total site area encompasses 800+ hectares. Current habitats included within this area are the intertidal zone on the Delaware Bay, dune line, salt marsh, upland fields, freshwater lowland forest, and second growth upland forest. This upland peninsula is on generally more fertile soils than the surrounding OCP with a resulting increased species diversity (Bierbrauer, et al. 2002; Cavallo, et al. 1996). Both Bierbrauer (2002) and Mueller (1997) maintain that the same habitats and their attendant floral and faunal communities would have existed in Late Woodland times, but eastward of their present location.

The area would have been rich in plant and animal resources to support the needs of the Native American population. Shellfish and fish from the Delaware Bay were a valuable and certain resource. Salt and freshwater marshes provided an abundance of mammals, birds, and reptiles. Reptiles comprised 65 percent of the faunal remains from the beach face (Bierbrauer, et al. 2002), which was overwhelmingly comprised of turtle remains (Morris 1997). Although very few remains of birds or fish were identified in the faunal analysis (Bierbrauer, et al. 2002), their relative paucity is most likely due to the small size of the bones and the poor preservation qualities of the soil. The CMNWR is on a major bird migration flyway and spring nesting ground, and it is hard to imagine that the Late Woodland inhabitants of Kimble's Beach would not have taken advantage of this bounty. Cedar swamps located 15-20 km to the north of Kimble's Beach were so thick and extensive in the early eighteenth century that all communication with the northern counties had to be carried by water (Beesley 1857:170). These cedar swamps provide browse for white-tailed deer as well as serving as yards during the winter (Cavallo et al. 1996).

Sandra Bierbrauer (Cavallo et al. 1996) identified 217 plant species in the area of Kimble's Beach. These species inhabited the sand dunes, salt marshes, brackish phragmites stands, freshwater ponds with emergent plants, some fresh water forested vernal ponds, and upland forest communities. Upland forests adjacent to Kimble's Beach Road consist largely of hickory, sweetgum, tulip poplar, white and chestnut oak, and some red maple, with the principal understory of holly, persimmon, sassafras, and dogwood, while the forest in the vicinity of Dias Creek contains less hickory with willow oak and lobolly pine as codominants, and a similar understory. Many of the 217 plants are sources of edible nuts, fruits, seeds, tubers, and greens or provided mast that attracted game animals, and 45 percent of these plant species have some known medicinal uses

(Cavallo et al. 1996). The range and seasonal availability of food resources to support a sedentary or semisedentary population year round were available, although other factors such as insect pests, winter shelter, and social networks must certainly be considered.

Beach Face Locus: A Late Woodland Occupation

The assessment of the Native American occupation of the BF locus (28CM36A) to the Late Woodland period (A.D. 900-A.D. 1600) is based on the recovery of well dated diagnostic artifacts, exclusive use of local cryptocrystalline materials, and radiocarbon dating. Seventeen bifaces that were either Preform I and II (see proposed biface reduction sequence, Chapter 4, *Biface Reduction Sequence*) or complete bifaces were recovered from the beach face. Of this number, 16 can be identified with reasonable certainty as either completed triangles (n = 4), or early and late stage (n = 12) triangles (Figure 3.13). Small triangular bifaces or triangular projectile points (isosceles and equilateral) are well dated to (Custer 2001:48; Justice 1995:224-227, 228; Ritchie 1989:31-34) the Late Woodland period in the Middle Atlantic, and they are almost exclusively predominant among projectile points in this period. Because Stewart (1998a) documented the use of “Archaic triangles” in the Middle Archaic at Abbott Farm, and the difficulty in distinguishing them from Late Woodland types, they cannot serve alone as a marker for this time period.

A second diagnostic element is the presence of Riggins Fabric Impressed and Plain ceramic sherds at the BF locus. This ceramic type is ubiquitous in southern New Jersey and has been reliably dated (Mounier 1982:161; Mounier 1991; Stewart 1998b:213-216) to A.D. 900-1600 A.D. Ceramics in various concentrations were found spread throughout the majority of trenches (14 of 19) and test units (5 of 8) on the beach face.

The most consistent and accurate analysis of the ceramics was conducted by Hartwick (2001) for trenches 2 and 17 (Figures 3.4, 3.9). She counted a total of 587 prehistoric ceramic sherds, but she did not attempt to calculate the minimum number of vessels represented by these sherds. These were tempered predominantly of crushed quartz (80%), with some of sand (11%), shell (1%), and indeterminate (7%). Body sherds accounted for 98 percent (n = 575) of the ceramic assemblage, and rim sherds accounted (Figure 3.14) for two percent (n = 11). Decorative treatments included fabric impressed, cord-wrapped stick impressed, smooth, cord impressed, and incised. The mouths of some vessels were determined to be in excess of 11 in (28 cm), and Cavallo (1996) hypothesized that some may have served as storage vessels rather than cooking pots. The entire ceramic assemblage was examined by Alan Mounier and Jack Cresson, long experienced archaeologists in southern New Jersey, who agreed that none of the sherds would be inconsistent with the Riggins ceramic tradition as they know it, and would be indistinguishable from the ceramics at the Fralinger site (see previous discussion Chapter 2). They viewed these materials as dating to the later half of the Late Woodland period (R. Alan Mounier and Jack Cresson, personal communications 2003). Riggins ware ceramics are similar to Townsend, Minguanan, and Potomac Creeks wares found in Delaware, Maryland, and Virginia on Late Woodland sites (Griffith and Custer 1985:15-16; Lopez 1961:17-21).

Figure 3.13. Examples of Preform I (top row) and Preform II (bottom row) bifaces. All specimens recovered from the BF locus at Kimble's Beach.

Figure 3.14. Ceramic sherds recovered from BF locus. Catalog 144,Trench 2, decorated, incised, one rim sherd with mend hole and one body sherd; Catalog 376, Feature 1, Trench 17, two decorated rim sherds with incised decorations; and Catalog 190, Trench 2, five rim sherds mended with cord impressed decorations. All specimens quartz tempered.discussion Chapter 2).

The use of high quality local cryptocrystalline lithic materials, mostly from cobble and pebble sources, is considered a hallmark of the Late Woodland period in the Middle Atlantic Region (Custer 1996:247; Dent Jr 1995:247; Stewart 2000; Stewart 1995:196). The Gropp's Lake site (28Me100G), part of the Abbot Farm complex in the Trenton area, produced 122 Type 1 (triangles) projectile points from dated Late Woodland contexts. They are overwhelmingly (*n* = 114) manufactured from cobble cryptocristaline sources of chert, jasper, quartz, and quartzite, with argillite accounting for only eight, although bedded sources of argillite are found nearby (Stewart 1987a:Appendix A). This is in marked contrast to the Early Woodland/Late Archaic deposits at the site in which argillite represented 96 percent (*n* = 47) and chert and jasper 4 percent (*n* = 2) of the biface assemblage.

The 20 percent sample of debitage from all units on the beach face (see page 143) indicated that 96 percent of debitage was chert (*n* = 450) or jasper (*n* = 76), with the other four percent comprised of quartz (n = 10), quartzite (*n* = 9), and sandstone (*n* = 4). Twenty-five biface specimens representing all stages of manufacture from blank to finished triangle are in the assemblage, and all are of chert (*n* = 18), jasper (*n* = 6), and Cohansey quartzite (*n* = 1) (Table 6.3). It is worthwhile to note that the one biface (broken specimen) in this assemblage that is obviously not a triangle is of argillite (Trench 5). All the non-debitage chipped stone (*n* = 105) consists of 89 percent (*n* = 93) chert and jasper, and 11 percent (*n* = 9) consists of quartzite, quartz, sandstone, Cohansey quartzite, and argillite, in order of abundance. This trend by itself is not diagnostic of the Late Woodland period, because these local cryptocrystalline cobble sources are well represented in earlier periods throughout the region, however, in combination with the ceramic and biface assemblages, it bolsters the argument for assigning the BF excavated artifact sample to the Late Woodland period.

The final evidence for a Late Woodland occupation of the BF locus is two radiocarbon dates obtained from samples of charcoal. Charcoal was relatively rare at the beach face, and most of the collected samples were found in contexts that made it difficult to associate their presence with the artifacts found at the site. The two samples submitted for dating came from the most reliable contexts of all the charcoal recovered. Hartwick (2001) obtained a conventional radiocarbon date of 620$\pm$50 B.P. with a two sigma cal A.D. 1285-1420 date range, from a single piece of charcoal recovered from the second arbitrary level of the south half of Feature 1, Trench 2 (Figure 3.6). The second sample, which consisted of four pieces of charcoal (.5 g) recovered from level 7, quad A, Trench 4, at the interface of the A and B horizons (Figure 3.4), was submitted to Beta Analytical for Accelerated Mass Spectrometry dating[2]. This sample yielded a conventional radiocarbon age of 390$\pm$40 B.P. and two sigma date ranges of cal A.D. 1430-1530 and cal A.D. 1550-1630 (Beta-193957; wood charcoal; $\delta C^{13}/C^{12}$= -23.8). The intercept of the radiocarbon age with the calibration curve is cal A.D. 1470 (cal B.P. 480). The first dated sample, is from a sealed context in a feature from a single piece of charcoal, while the second is from four pieces of charcoal from a living floor, with the possibility of disturbance. The two radiocarbon dates do place the BF locus in the mid to later Late Woodland period, although they do not exactly evince contemporaneity. These radiocarbon dates, the diagnostic lithics, and the ceramics securely place the beach face occupation in the Late Woodland period.

Restriction of the Lithic Study to the Beach Face Locus

The BF locus was chosen for this study by virtue of its intact vertical stratigraphy, secure dating, and the sealed context of the deposits. The upland portions (36B) of the site were disturbed in historic times as a result of farming. The A horizon in these loci has been plowed, and historic period artifacts are often mixed with Late Woodland and earlier artifacts, although the later are predominant (Cavallo, et al. 1997). As a result of the eastward salt marsh migration, the A horizon at the beach face is undisturbed. The buried A soil horizon in the beach face, with its combination of diagnostic artifacts and radiocarbon dates, is dated securely in the Late Woodland period. The historic artifacts are above the A horizon, with only one artifact (previously discussed argillite biface) seemingly from an earlier period. The clay/silt cap of approximately 5 cm in thickness, formed as a result of deposition during its salt marsh phase, effectively sealed the site from contamination and disturbance. The beach face was most likely in its salt marsh phase when European settlers began farming activities in the area of Kimble's Beach. These factors coupled with the density of lithic artifacts and debitage made this locus the most amenable to the goals of this study.

Site and Lithic Assemblage Constraints

There are several limitations on research concerning the site and the lithic technology that must be considered. The site is truncated by processes of bay transgression and beach erosion. Bierbrauer (2002) noted that a shell midden and exposed artifacts visible in 1994 had been eroded away by wave action by the time of the first field season, in 1995. This process of erosion is apparent in quad D, Trench 17

(Figure 3.10), and Quad D, Trench 18 (Figure 3.11). The beach sand in quad D of Trench 17 was directly underlain by the sterile B horizon with the A horizon completely eroded away. The A horizon in Quad D, Trench 18 was eroded to a scant few centimeters and contained no artifacts. The artifact bearing A horizon, to the west of these two excavations on the beach face, is no longer in evidence. All of the units excavated, with the exception of Quad D, in both Trench 17 and 18, are intact and did not undergo erosion. The full extent of the Late Woodland deposits at the BF locus is unknown. There is nothing that can be done to reconstruct the portion of the BF locus truncated by bay transgression and beach erosion. While it is unfortunate that a portion of this locus is lost to examination, it has no appreciable effect on this study.

The remaining artifact bearing A horizon is intact, but not stratified. It is impossible to make temporal distinctions in lithic technology within vertical units with this stratigraphy. The simplest solution to the unstratified nature of the deposits, is to consider the recovered artifacts as the result of one occupation for each unit. Interpretation is further complicated, since it is likely that the site was formed as a result of multiple occupations (see previous discussion of radiocarbon dates). The relative simplicity and conservatism of lithic technology in the Late Woodland period in southern New Jersey, combined with the Kimble's Beach inhabitants apparent reliance on the reduction of local gravels, the few tool types recovered from the beach face, and evidence for the manufacture of only one biface type (triangular projectile point), allow for the aggregate consideration of the debitage assemblage for each unit and trench and finally the site assemblage as a whole. Although, it is likely that individual units or clusters of units were the result of a single occupation, the site considered as a whole was most likely the result of multiple occupations. Inferences about potential differences in intrasite activities from total lithic artifact distribution are still possible.

The nature of excavation on the beach face at low tide imposed a relatively short work period (four hours generally), and the refilling of the units with sand each succeeding high tide until the next day's excavation posed additional difficulties. As a result, control of the excavations was not as precise as would be desired. The possibility of erosion and wall collapse, thereby transposing artifacts from upper levels to lower levels, is a concern.

Although the erosion of walls was always possible, experience in over three seasons of excavation at the beach face, showed that the walls remained relatively intact and historic artifacts were rarely found in the A horizon, if they were, it was readily apparent that they were transported from the upper levels. The highly organic nature of the overlying salt marsh deposits and the A horizon made these layers relatively impervious to overnight erosion.

The density of debitage in the excavated trenches is relatively light ($32/m^2$) for specimens recovered by quarter-inch screen. Statistical analysis of individual units was limited to those containing 30 or more specimens for multivariate analysis and 100 or more for the remainder of the statistical analysis as appropriate. However, in the majority of instances the various analyses treated the debitage as a composite assemblage encompassing all units. As previously noted, the limited number of tool types, small sized river gravels (<86 mm), and the relatively limited technological choices available indicate this procedure can be effective.

Unfortunately, the excavated material was screened through quarter-inch (6.35 mm) hardware cloth in the field. Pressure flaking, which was employed in the final tasks of sharpening edges and preparation of the basal section for hafting on the triangular bifaces, produced debitage too small to be recovered by quarter-inch mesh. Kalin (1981:164) found in his experimental production of pressure flaked small stemmed chert points that less than one percent of all debitage by quantity and weight was recovered with a quarter- inch screen. In the same experiment, percussion flakes recovered with a quarter-inch screen were 41 percent of the weight and three percent of the quantity (Table 19). It was anticipated that only relatively few of the pressure flakes were recovered from the archaeological assemblage at the beach face (see Chapter 6, *Classification of Hard Hammer and Pressure Flakes*).

Shott (1994) observed that the lithic reduction experiments he reviewed approximated standard archaeological recovery, by considering only flakes equal to greater than 6.4 mm without loss of discrimination between core reduction types, or in biface reduction sequences. Experimentally derived debitage less than 6.4 mm was removed from the statistical analysis in this study. It is not anticipated that the absence of pressure flakes and other debitage less than 6.4 mm will effect the outcome of the above analysis. The debitage experiment and analysis were designed, in consideration of the relatively low recovery rates of the total archaeological debitage, to differentiate between core reduction types and biface manufacturing stages in the absence of this small sized debitage.

Post-depositional breakage of the debitage at the beach face through human actions (trampling) or natural actions may effect the results of this analysis. Shott

(1994:100) reported on experimental studies of trampling that indicated that a breakage rate of 15-50 percent of all flakes was possible. However, he noted that breakage was more common among larger flakes (greater than 2.54 cm) and less likely in smaller sizes.

The 20 percent sample indicated that 96 percent of the flakes in the archaeological assemblage were less than 2.5 cm in size, hence, they were the least likely to suffer breakage. There were differences in the proportions of whole and broken flakes among various trenches and units (see discussion of 20 percent sample in Chapter 4). This could either be the result of post-depositional breakage, or differences in lithic reduction activities. If the proportions of whole and broken flakes from the reduction experiments in comparison to the archaeological assemblages shows the proportion of flake fragments and reduction fragments (see Figure 4.4) in any of the trenches or units is significantly greater that any of the reduction experiments, post-depostional breakage would have to be considered as one of the causes. The multiple flake attributes measured and recorded should offset any skewing of results from breakage than if only the size and proportions of whole and broken flakes were considered. With these facts in mind the decision was made not to conduct a trampling experiment with any of the experimental assemblages and note, as Shott (1994:100) advises, that post-depositional breakage could be a minor source of bias.

1. Both burials were in imminent danger of destruction due to impending construction activities. The excavation, study, and dispositon of the remains were in accordance with the policy of the Society for American Archaeology (SAA 1986).

2. The AMS radiocarbon date was funded by a grant from the Archaeological Society of New Jersey.

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CHAPTER 4

METHODOLOGY

The goal of this thesis is to elicit behavior patterns pertaining to Late Woodland life on the OCP of New Jersey through the analysis of chipped stone tools and flaking debris (debitage) from the BF locus of the Kimble's Beach site (28CM36A), an upland site along the Delaware Bay. This study combines lithic analysis of stone tools, experimentation in thermal alteration and tool manufacture, and an attribute analysis of the debitage recovered from the excavations. The project was designed to provide information to answer questions in the following general areas of inquiry.

Technological Organization

The Cape May Peninsula is devoid of primary lithic outcrops but is rich in secondary deposits of cryptocrystalline gravels, especially along the margin of the Delaware Bay and the Atlantic coast. Initial examination of the lithic artifacts indicated a high proportion of waterworn cortex with percussion marks on the tools and debitage indicating beach gravel origins of the raw materials from which the artifacts were made. It was important to determine if the KBS environs (10 km radius site catchment area) contained sufficient secondary deposits of high quality lithic raw materials to sustain the needs of the indigenous population. As part of the research, gravels were collected along the Delaware Bay, and other likely areas for secondary deposits were scouted to provide a comparative collection of raw materials available to the Late Woodland residents of the Kimble's Beach locality. The gravels collected from the beach face were categorized as oblate, prolate, bladed and equant shapes (Shelley 1993; Zingg 1935). The classification of the raw materials used to manufacture lithic artifacts derived from the excavations, coupled with a comparison of the remnant cortex to the collected sample, provided an indication of the source of the raw materials. This part of the study was used to determine if the behavior of the Native American residents of Kimble's Beach incorporated the procurement of lithic raw materials into daily foraging activities (Binford 1979, 1980), and fit the pattern of a preference for local cryptocrystalline materials during the Late Woodland period in the Mid-Atlantic region rather than exotic non-local stones (Stewart 1995, 2000).

The cortex of gravels from the Delaware Bay margins may indicate that they contain suitable cryptocrystalline materials for the manufacture of tools and bifaces. However, cortex alone as an indicator can be deceiving, and may result in the selection of poor quality materials or those with internal flaws. To preclude this circumstance, prehistoric knappers could either test pebbles by removing a flake, usually at one end, or split them by the bipolar method to determine the quality of material beneath the cortex before carrying them back to their camp or residence. The knappers could trust their judgment and experience and transport whole pebbles to the site, or they could test or initially process the materials at the beach face. The analysis of the BF locus lithic materials for the presence or absence of split pebbles and bipolar flakes was conducted to provide an indication of behavior in this phase of the production system.

Parry and Kelly (1987) determined that the use of unpatterned or expedient tools and unstandardized or expedient cores increased as groups became less mobile and more sedentary. Expedient tools for this study were considered to be unmodified flakes with use-wear apparent under 10X magnification, and flakes with minimal marginal retouch. Formal tools were considered to be bifaces and unifaces that require facial retouch, and hence, more effort. The diversity of the chipped stone tool assemblage should provide a further indication of the degree of mobility and sedentism. Shott (1986) found that the diversity of tool types generally increased as societies became more sedentary. He also discovered a link between the increase in artifact diversity and the increased length of site occupation. The CSA analysis provided data on the variety of tool types present on the site and the relative numbers of expedient and more formal tools. If inferences concerning site function/type cannot be made from this data, it is hoped that its addition to the generally scanty body of knowledge in southern New Jersey may be of value in future research.

The 20 percent sample of the debitage from the excavation units on the beach face indicated relatively large differences in the percentages of thermally altered pieces, and the number of complete flakes and flake fragments between some trenches. These differences may be indicative of differing lithic reduction activities, or a difference in the strategies involved in the procurement, testing and initial preparation of pebbles. The attribute analysis of the site debitage assemblage relative to the experimental data is designed to provide insight into these potential differences.

Core Technology

Lithic raw materials derived from pebble (<64 mm) sources (Waters 1996:20) provided a test of ingenuity for prehistoric knappers (Stewart 1988). Initial entry into small stones is extremely difficult to accomplish by freehand knapping due to their generally rounded surfaces. The other option is bipolar reduction, or splitting of a pebble to produce a split half or a flake blank, which provides an exterior platform angle (<90˚) suitable (Whittaker 1994) for knapping. These detached pieces may then be reduced into a bifacial and unifacial tool forms. Analysis of the CSA and debitage compared to the experimentally derived assemblage provides data that will be used to attempt to determine if one option was favored, or if both were utilized to take advantage of available lithic resources. See Figures 5.17 and 5.18 for starting forms.

In manufacturing selected tool forms from pebble raw materials, the goal of the knapper initially is to produce either a split pebble or a flake blank with proper striking surfaces for freehand reduction. Can the archaeological assemblage be differentiated on the basis of flake blank or split half initial starting form? The experimentally derived assemblage of debitage, which contained both starting forms, was compared to the debitage from the site to provide an indication of which strategy was used/preferred.

The Sullivan and Rozen typology (Sullivan III 1987; Sullivan III and Rozen 1985) differentiates between generalized core reduction and biface manufacture using data from collected chipped stone flaking debris or debitage (see discussion of use on pages 163-165). Their free-standing typology has been evaluated in several experimental studies of bifacial reduction (Bradbury and Carr 1995; Ingbar, et al. 1989; Prentiss 1989; Prentiss 1998), scraper production (Baumler and Downum 1989), bipolar core reduction (Kuijt, et al. 1995), and several other types of core reduction (Bradbury and Carr 1995; Prentiss 1989; Prentiss 1998; Tomka 1989). Although these experimenters disagree with the technical interpretations (relative proportions of complete and broken flakes as representative of different types of reductions) made by Sullivan and Rozen (Sullivan III

1987; Sullivan III and Rozen 1985), the typology (sometimes modified) itself has demonstrated some usefulness when applied in specific contexts coupled with an experimental assemblage (Andrefsky Jr. 1998:123-24). A multivariate classification of the experimental assemblages of triangular biface and uniface production, and bipolar core reduction data in Mohney (2004) provides a meaningful standard to evaluate the beach face debitage for patterned tool manufacture and bipolar core reduction.

Biface/Tool Production Technology

Preliminary examination of the beach face artifacts indicates that triangular biface manufacture was a major lithic endeavor at this site. A four stage triangular biface classification scheme (Johnson 1989; Stewart 1987a) was developed to categorize these incomplete specimens along a reduction sequence (see Figure 4.2). To assess their place in the reduction sequence a detailed analysis of all incomplete and complete bifaces was conducted.

Statistical analysis of experimental assemblages has often been used to determine the signature of reduction strategies for application to archaeological assemblages (see Studies of Lithic Technology following). The signatures from these lithic experiments require confidence and probability tests to justify their use (Andrefsky Jr. 1998: 188). The statistical analysis of the experimentally derived assemblage of biface and uniface tool manufacture, and the SRT data from the experimental bipolar and freehand core reduction of Mohney (2004) provided signatures that were used to identify the type of reduction represented by the debitage from the beach face assemblage. Further statistical analysis of the experimentally produced debitage was conducted to test the ability of the flake attributes, to discriminate between the known stages of the biface production experiments. An additional goal is to determine if the flake attributes selected for the experimental debitage can discriminate between hard hammer and pressure flaking.

The preliminary examination of artifacts indicated that thermal alteration was practiced by the Late Woodland inhabitants of Kimble's Beach. A complete analysis of the archaeological debitage for indications of thermal alteration (gloss and reddening), compared to the experimentally derived reduction sequence of heat treated pebbles, was used to indicate the stage at which this treatment took place. It also provided an indication of the proportion of heat treatment within the overall lithic reduction sequence as well as intrasite differences.

Attribute Analysis

The debitage produced in the reduction experiments was analyzed to isolate those flake attributes that will best provide information to answer questions regarding trajectory length, type of reduction, application load discrimination, and available flintknapping choices (flake or split half). This information was then applied in an analysis of the excavated debitage from the beach face units, which utilized the isolated variables from the experimental assemblage. It was utilized to explore intrasite differences, and to determine if attribute analysis can effectively provide information on relatively low densities of debitage (≥30 and ≤165 pieces) from the excavation units, in addition to the more densely clustered debitage from Trenches 2 and 17 (>450 pieces).

Studies of Lithic Technology

The study of lithic technology through experimentation can be traced back to the mid-nineteenth century. Among the early pioneers in lithic analysis and experimentation were Frank Cushing, Sir John Evans, William Henry Holmes, Joseph McGuire, and Sven Nelson (Johnson 1978:337-343). Of this group, Holmes is considered " ...one of the earliest and most comprehensively accurate" (Flenniken 1984:188). William Henry Holmes (1894), in a seminal article entitled "The Natural History of Flaked Stone Implements," established the basic outline of the process of stone tool manufacture. Holmes (1894:122) developed the concept of the "natural history" of an individual flaked stone tool from raw material acquisition to the final form. In this scheme of analysis, he differentiated between the manufacturing techniques of percussion (direct and indirect) and pressure. Holmes (1894: 128) also detailed the essentials of the lithic reduction sequence and manufacturing stages. Flenniken (1984:188-189) maintained that some archaeologists unfamiliar with the works of Holmes actually claimed credit for innovations and insights in refitting and bipolar technology that he had developed eight decades prior. A comprehensive account of knapping experimentation from 1838-1976 can be found in Johnson (1978), and a more personal perspective on this topic in Flenniken (1984). An annotated bibliography of works in lithic technology, 1725-1980, is found in Honea (1983).

In the first six decades of the twentieth century after Holmes, the Classificatory-Historical period (Willey and Sabloff 1993), American archaeologists were chiefly concerned with issues of typology and chronology in artifact analysis (see as examples, Fowler 1963; Ritchie 1989; Rouse 1960). The arrival of the New Archaeology, with its emphasis on hypothesis testing and experimentation, ushered in an age of experimental lithic studies (Crabtree 1975). A new literature focused on the various elements of stone tool manufacture, use, rejuvenation and remanufacture and discard soon developed (see as examples, Collins 1975; Crabtree 1972; Crabtree and Butler 1964; Frison 1968; Schiffer 1976). In 1965 the Les Eyzies Conference in France brought together three of the foremost experts on flintknapping, the American Don Crabtree, and the French scholars Francois Bordes and Jacques Tixier and 14 nonknapping archaeologists (Jelinek 1965). A series of demonstrations of manufacturing techniques, and technological analysis of artifacts brought by the participants to the conference, left the archaeologists with a sense of the new possibilities that lithic technological analysis and experimentation could bring to their studies (Jelinek 1965; Johnson 1978:278). Beginning in 1969, Crabtree, at his annual workshops, trained a whole generation of archaeologists as flintknappers (Whittaker 1994:60). As the interest in knapping and experimentation expanded, publications by Crabtree (1972), Callahan (1979) and Flenniken (1981) were directed to those who wished to replicate prehistoric flaked stone technology, and archaeologists interested in the technological analysis of stone tool production. Bradley (1975) and Collins (1975) expanded upon the concept of the reduction stage in tool manufacturing as an analytical device, if not the actual template in the mind of the prehistoric knapper (see this chapter, Biface Reduction Sequence, for further discussion). The idea that the debitage by-product from this process, could provide meaningful information to archaeologists, began to take hold.

Debitage is among the most ubiquitous artifacts in an archaeological assemblage and considered to be an important component of lithic analysis that can aid in the understanding of prehistoric technology, economy, and organization (Andrefsky Jr. 2001a:2). Debitage is valuable, because it is relatively abundant, rarely curated, and exhibits evidence of the reduction stage from which it was removed (Collins 1975). This waste material from knapping was not always so highly valued, and as recently as the 1960's and 70's debitage was discarded by archaeologists (Scott 1991:172; Shott 1994:70). As the pace of debitage studies (see as examples, Ahler 1989a, 1989b; Amick, et al. 1988; Andrefsky 1983; Andrefsky Jr. 1986a; Magne and Pokotylo 1981; Odell 1989; Patterson 1990; Rozen and Sullivan III 1989; Sullivan III and Rozen 1985) accelerated, variables by which useful information could be derived from these "waste flakes" were proposed and tested (for a more complete review see Shott 1994). These variables allowed archaeologists to summarize debitage attributes for an entire assemblage, rather than the typological classification[1] of individual flakes into groups (Andrefsky Jr. 1998:110). Variables derived from experimental studies were often used to discriminate the reduction stages represented in an archaeological assemblage (Ahler 1989a, 1989b; Andrefsky 1983; Gilreath 1984; Henry, et al. 1975; Johnson 1987; Magne 2001; Patterson and Sollberger 1978; Pecora 2001; Shott 1997; Stahle and Dunn 1982; Verrey 1986). Coinciding with the expanding interest in debitage analysis, research by Cotteral and Kaminga (1979; 1987) and Moffat (1981) in fracture mechanics associated with the production of flakes, gave archaeologists a greater understanding of the mechanical aspects of this activity (see this chapter, *Debitage Variables*, for a fuller treatment of variables and fracture mechanics).

The works of Lewis Binford (1980; 1977; 1979; 1982) emphasized how a prehistoric group's technology, particularly its stone tools, played a dynamic role within their cultural systems. A group's settlement organization, procurement of resources, and the manufacture, use, and eventual discard of stone tools may be related to their organization of technology. Nelson (1991) and Kelly (1992) made explicit the basic tenets and assumptions of technological organization in lithic studies.

Two volumes, *Time, Energy, and Stone Tools* (Torrence 1989) and *The Organization of North American Prehistoric Chipped Stone Tool Technologies* (Carr 1994a), resulted from the 1982 and 1992 Society of American Archaeology symposiums on the topic. These works contained a cross-section of lithic technological organization studies from the symposiums that represented the state of research at the time. The goal of these studies was to develop inferences on mobility and settlement systems of prehistoric groups. In other studies, the issues of tool design (Bleed 1986) and use (Kelly 1988), expedient and curated technologies (Bamforth 1986; Bamforth 1991; Parry and Kelly 1987), raw material procurement (Andrefsky Jr. 1994a; Andrefsky Jr. 1994b; Ingbar 1994; Wenzel and Shelley 2001), and overall prehistoric settlement behavior (Andrefsky Jr. 1991) were examined in relation to the technological organization of various groups. A combination of debitage analysis and experimental knapping was employed in other organization of technology studies to infer collector or forager residence types (Carr 1994c) and percent of core reduction and tool manufacture in relation to settlement systems (Carr and Bradbury 2001).

Experimentation through replication is viewed as having great potential in explaining the archaeological record (Amick, et al. 1989; Andrefsky Jr. 2001a; Crabtree 1975; Magne 2001; Shott 1994). It is not, however, without its critics. Thomas (1986b:621) maintains that replication produces one possible way that a particular task could be accomplished, but not how it was actually accomplished. Andrefsky (1998:8), while acknowledging this criticism, argues that replicative studies, the parameters of which are controlled and understood, can produce a wide variability in lithic artifacts. Variability derived from such replicative experiments can be compared with archaeological assemblages to gain an understanding of the parameters associated with the assemblage.

This study employs an organization of technology orientation to infer behavior from the lithic assemblage derived from the BF locus of the KBS. The total manufacturing process, from raw material procurement to discard, is examined. The individual CSA specimens were analyzed, and the debitage was studied as a population. The results of an experimental knapping study provided the variables to conduct the analysis of the beach face debitage assemblage.

Stone Tool Analysis

This study employs stone tool analysis to draw inferences concerning the behavior exhibited in the technological organization of the Late Woodland occupants of the BF locus, as it relates to site function and the degree of mobility. The purpose of the stone tool analysis from the beach face assemblage was to identify the various tool types present, the raw material type and the source of this material (river pebbles, bedded nodules, bedded/tabular), and to develop a biface reduction sequence that reflects the process of production of small triangular projectile points from cryptocrystalline gravels. Indication of thermal alteration was noted to assist in determining at which point in the sequence heat treatment may have been accomplished. In addition, working edges of tools and flakes were examined under 10X magnification for indications of use-wear (tiny step fractures, polish, and striations/scratches), modification, and rejuvenation. Flakes with signs of use-wear and little or no modification were considered expedient tools. Tools that required facial retouch (bifaces, projectile points, unifaces) were considered formal tools (Parry and Kelly 1987:298-299).

Goals

Technological Strategies. Were the lithic raw materials utilized by the indigenous population local waterworn gravels from the Delaware Bay, nonlocal materials, or a combination of both? A comparison of the lithic materials and any remnant cortex on artifacts from the site assemblage to the collected samples will assist in a determination of the raw material source. The relative proportions of raw materials, especially exotic imported stone, represented in the assemblage will provide further evidence. Special attention will be given to the partially reduced gravels or whole gravels found in the assemblage. Were the bifaces/tools completely manufactured on the site with pebbles brought from the beach face, or were the pebbles split utilizing bipolar technology at the beachface or both? The presence or absence of split pebbles and flake blanks will provide an indication of this behavior.

Manufacturing Technology. Were the pebbles split by the bipolar method to give the artisan a relatively flat surface to knap or to produce flake blanks to reduce by freehand, or could the pebbles be directly processed by freehand without splitting? Evidence of crushing on proximal and distal portions of gravel sections are considered indications of bipolar methodology. Analysis of the bifaces in the CSA assemblage, and comparison to the experimental set, should provide an indication. Did the prehistoric inhabitants of Kimble's Beach thermally alter lithic materials to improve their flaking characteristics? If so, at which stage in the biface reduction sequence was this accomplished? What proportion of the raw materials was heat treated? Were different raw materials treated differentially? Examination of the CSA, especially the bifaces, will produce information to answer these questions. The characteristics of gloss and color change (reddening) will be considered indications of thermally altered stone.

Technological Organization. Was this a residential site, a seasonal site, or a temporary processing or collecting site? The amount and variety of tool types will be an indicator. A large variety indicates a residential site, and a low variety or dominance by specialized tools indicates a processing or temporary site (Binford 1980, 1979; Custer 1984; Kelly 1992; Nelson 1991; Shott 1986). What was the mobility strategy employed by the Late Woodland inhabitants of Kimble's Beach? Were they mobile, sedentary, or semisedentary? The procurement of lithic raw material (local versus exotic material), as well as tool type (expedient versus curated tools) should provide an indication of the mobility strategy employed (Binford 1980; Binford 1979; Kelly 1992; Nelson 1991). Do the lithic deposits excavated indicate a generalized pattern in each excavation unit, or were there distinctly different activities taking place in the various parts of the site? The tool types, in concert with measures of the types of lithic reduction (core, biface, uniface), should provide evidence of activity differentiation (Stewart 1986).

Procedures

Lithic material was separated into three categories: chipped stone artifacts (CSA), debitage, and other lithics (OL). The CSA included projectile points, bifaces, scrapers, cores, and pebbles/cobbles (split, flaked). The OL consisted of abraders, FCR, hammerstones, anvils, pitted pebbles, and unmodified pebbles and cobbles. The CSA were assigned to various lithic artifact types based on their attributes or form and perceived function. Definitions of common lithic artifact types found at other Late Woodland sites on the OCP were examined for relevancy to this assemblage (Mounier 1991, 1992; Pagoulatos 1992; Wall 1996). Appendix A is a glossary of lithic types used in this analysis and Appendix B is the analysis protocol for each artifact type with the measurements to be taken or attributes noted. Abbreviations for the lithic artifacts types used in this study are contained in Appendix B.

Identification of raw materials utilized in the flaked lithic assemblage was accomplished mainly through comparison to a type collection of common lithic materials from central and southern New Jersey. In the few cases where there was any doubt as to raw material in question, Jack Cresson, of Moorestown, New Jersey, who has wide experience in lithic analysis and raw material identification, was of assistance. The remnant cortex on the flaked lithics was compared to samples of cortex found on the gravels gathered from the Delaware Bay margins at Kimble's Beach. The identification of raw materials and comparison of remnant cortex to collected gravels from the Delaware Bay margins allowed for the determination if the material was locally derived or nonlocal imported materials.

All flaked lithics were weighed within .1 g, and measured in the three dimensions of maximum length, width, and thickness to the nearest .1 mm. A digital scale was used to weigh all artifacts except for the heaviest objects (> 200 g), which were weighed on a digital scale at the local post office. A caliper was used to make linear measurements. Maximum circumference was measured with a length of nylon braided string wound around an artifact such as a core, unmodified pebble, or hammerstone, and measured along a metric ruler to the nearest millimeter. All bifaces, scrapers, and unifaces were measured for edge angle with a stainless steel goniometer. All edge angle measurements are given as a range or a mean of measurements for each margin and base in the instance of bifaces. Geometric shape was determined by dividing width (b axis) by length (a axis), and thickness (c axis) by width, to obtain two ratios whose intersection were plotted on a graph found in Waters (1996:27). Cortex amount was determined by visual inspection and recorded from 0-100 percent based on 10 percent increments. Photographs were taken of all artifacts. Notes were made as necessary and entered into a word processor document keyed to artifact number. Attributes were of nominal, ordinal, interval, and ratio scales. All attributes were entered into SPSS 6.1, a statistical computer program for the Apple Macintosh computer. A portion of the statistical analysis, especially of various assembly proportions, utilized MS Excel for Windows XP. All graphs and charts were constructed with these two programs.

Bipolar Reduction

Bipolar technology is practiced by groups throughout time in North America and the world (Ames and Smith 1999; Andrefsky Jr. 1994b; Boudreau 1981; Goodyear 1993;

Honea 1965; Kobayashi 1975; Leaf 1979; Ranere 1975; Shott 1989; Wenzel and Shelley 2001; White 1968). The use of bipolar technology is well documented in the Middle Atlantic region (Egghart and Shields 2000; Mounier 1997b; Neuman and Polgase 1982; Picadio 1999a; Picadio 1999b; Stewart 1987b; Stewart 1988; Wall, et al. 1996). This technique is viewed as a method of maximizing valuable lithic materials, often nonlocal, by reducing small-sized pieces to obtain flakes, fresh cutting edges, or other tool elements (Andrefsky Jr. 1994b; Binford and Quimby 1963; Hayden 1980). Another application of bipolar technology is when the available lithic raw materials occur in the form of small gravels (Knudson 1978:45), especially to prepare these gravels to manufacture bifaces (Ames and Smith 1999; Mounier 1997a; Stewart 1987a). It is this use in the manufacture of bifaces that appears to be a prominent activity at the KBS.

The bipolar technique is rather simple and requires little in the way of flintknapping skills (Stewart 1988:48). It is described and illustrated in most general works on flintknapping (Callahan 1979; Crabtree 1972; Whittaker 1994). The technique requires the use of an anvil and a hammerstone. The rounded gravel is held in one hand and placed on the anvil. Solid contact between the anvil and the ground, and the objective piece and the anvil, is essential (Figure 4.1). If the contact is not solid, then the force of the blow will be spent, fracture by wedging is not initiated, and incipient fracture cones are formed on the gravel, making succeeding attempts less likely to produce the desired results. The gravel is then struck with the hammerstone straight down on the proximal end. Wedging will be initiated, and the gravel will be split in half or occasionally into several pieces, some of which may take the form of a citrus section if the gravel is near round. A split half may be further struck in the same way to produce a

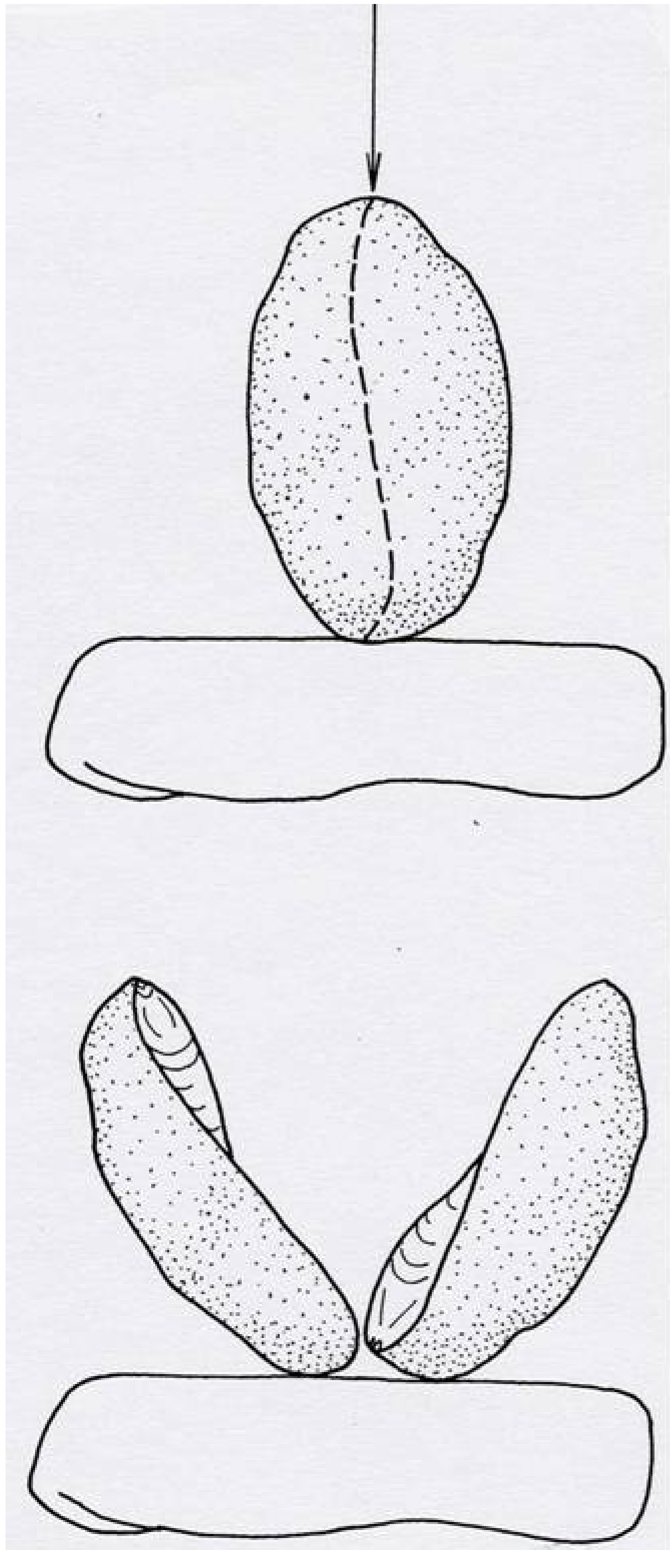

Figure 4.1. Idealized bipolar reduction. Adapted from Walker (1994:6.32).

flake blank suitable for production of a small biface, such as a Late Woodland triangle. The remaining gravel portions may be struck repeatedly in the same manner to produce general purpose cutting flakes until they are too small to hold. The gravel may be wrapped lightly with leather, or even a thick leaf, to prevent flakes from flying away. White (1968) provides an ethnographic account of bipolar techniques employed by the Duna in New Guinea similar to the preceding description.

Ames and Smith's (1999) analysis of the lithic artifacts of a late prehistoric site in the Northwest Coast of the United States, inferred a biface manufacturing technology identical to the one proposed for Kimble's Beach. Riverworn cobbles of cryptocrystalline materials were brought to the site and were split with the bipolar method. These cobbles were considered too small to use without initial bipolar processing. With a suitable platform of 90 degrees or less established, the biface manufacture proceeded with hard hammer reduction and finished by pressure flaking. This is the technological process that is anticipated in the proposed biface reduction sequence represented by the sample of CSA's and debitage from the BF locus of the KBS.

Biface Reduction Sequence

The production of a biface is often illustrated as a series of stages that result in the finished product that the artisan had in mind upon beginning the process (Callahan 1979; Johnson 1989; Morrow 1984; Rule and Evans 1981; Stewart 1987a; Whittaker and Kaldahl 2001). Although the manufacture of a biface is a continuum in which the knapper moves from the blank through to the finished product (Callahan 1979:33), all steps in this linear process, with the exception of the initial stage, depend on the previous steps having been accomplished (Collins 1975:17). The reduction sequence represents the technological stages that an objective piece must undergo to arrive at a completed biface. This requires the knapper to employ a strategy using tools and methods to produce the desired final features of the biface (Callahan 1979:34-35).

Staged reduction sequences generally begin with obtaining a blank. This may be a piece of tabular material, a river cobble, an outcrop of bedded material, or a suitably sized flake. The reduction stages that follow vary in the number of stages and the sequential tasks that are included in each stage, although the tasks are essentially identical and in the same sequence (Collins 1975). Biface reduction sequences in addition to procurement may be five stages (Callahan 1979:Table 2.a), four stages (Whittaker 1994:Figure 8.21), or three stages (Stewart 1987a:98-99). Collins (1975) outlined the sequential technical steps in the reductive process of tool manufacture that must be accomplished before arriving at a finished form.

Biface reduction stages, even if only used by the lithic analyst, are a potentially valuable tool. They can indicate where in the reduction sequence a biface was rejected due to mistakes in knapping, such as a lateral snap or flaws in the raw material (humps or inclusions) that could not be overcome. The presence or absence of earlier or later stages in an assemblage provides an indication of the length of the manufacturing trajectory at a site. This, along with raw material sources, can lead to inferences as to whether the sequence was partially accomplished at the raw material source and finished at a site, or completed in its entirety at the source, at a workshop site, at a residential site, or some combination. This in turn can lead to inferences concerning behavior in procurement of raw materials, or the effect of distance from the source of raw materials (Andrefsky Jr. 1994b; Andrefsky Jr. 1994a; Johnson 1989). In the case of the BF locus, it is the former that this study plans to elicit from the stages at which bifaces were discarded and entered into the archaeological record.

A biface reduction sequence (BRS) model for the production of Late Woodland triangular projectile points was developed to facilitate the analysis, and to provide a pattern for the knapping experiment. The sequence is the product of the examination of bifaces in the assemblage, general sources on lithic reduction sequences (Callahan 1979; Collins 1975; Whittaker 1994), and two “gravel-to-triangular-biface” reduction sequences previously described from the Middle Atlantic region (Rule and Evans 1981; Stewart 1987a). This study led to the conclusion that the production of triangular projectile points was a major lithic processing activity represented at the BF locus of the KBS. Of the 26 bifaces in the assemblage, 24 can be placed with confidence within the local reduction sequence (Table 6.3). The non-typed (possible Fox Creek) biface of argillite (Trench 5) certainly does not fit into this sequence, and the only relatively intact triangular projectile point in the assemblage is manufactured from Cohansey Quartzite (ST 11), a nonlocal material. It was unlikely to have been manufactured locally, although representative of a finished triangular projectile point.

This reduction sequence is very similar to the one proposed by Stewart (1987a) and restated in Wall et al. (1996) as a cobble reduction sequence to produce triangular projectile points for the Abbott Farm site complex in the Late Woodland period. The Kimble’s Beach BRS differs from the Abbott Farm sequence in two ways. The first is the starting form or blank. Stewart (1987a:96-100) proposed that the starting form was a bipolar split cobble while this study allows for a flake blank as well as split cobble or pebble. He saw little evidence in the lithic assemblage of continued bipolar reduction to flake blanks. A flake blank (Figure 5.18) is easily derived from a pebble with successive blows in a bipolar fashion after it has been initially split, which may have taken place at the beach face where it was procured, thus, leaving little evidence of this action, except for the debitage, in the assemblage. Evidence of bipolar reduction in the form of recovered bipolar flakes, core reduction fragments, bipolar citrus forms, and split pebbles suggest that the production of flake blanks may have been accomplished at the BF locus, but it may also represent the residue of generalized bipolar reduction to obtain usable flakes. The sample of recovered biface specimens (Preform I, Preform II, and Finished Triangle) do not appear to have been manufactured from a flake blank. The second difference is the use of the terms Preform I and Preform II in this study for the two middle stages where the Abbott Farm BRS uses the terms “Early Stage” and “Late Stage.” This is not an issue of personal preference, but rather conformity to the definition of preform by Bradley (1975:6) as “Any piece of lithic material that has been modified to an intended stage of a lithic reduction sequence in a specified assemblage.” These bifaces are not a finished product designed for another use, and it is apparent that further modification was intended. Morphologically, they can only be modified into one implement type in the assemblage, that is a triangular biface. It is for these reasons I concluded that the bifaces (n = 16) in these stages meet the criteria for categorization as a preform (see Figure 4.2).

The following BRS for the production of Late Woodland triangular projectile points at Kimble's Beach was developed to place recovered specimens within the manufacturing continuum for this study:

> **Blank**: Gravel split in half by bipolar method, relatively flat ventral cross-section, incomplete working of the lateral edges. Alternately, a flake blank derived from bipolar reduction of a large pebble or small cobble with a relatively straight longitudinal cross-section. Length, width, and thickness should be sufficient to enable the completion of a triangular biface.
>
> **Preform I**: Cortex removed but may contain small residual areas, lateral edges worked but remaining sinuous, thinning partially accomplished, large humps removed but small humps may still be present, flaked across one or both faces, and possesses a general triangular shape with intended distal and proximal ends apparent. The overall shape may be irregularly rectangular.
>
> **Preform II**: Lateral edges not completely straightened, thinning is accomplished, but small humps may be present capped by areas of cortex. It possesses a relatively flat cross-section and a defined triangular shape.
>
> **Finished Triangle**: In order to reach this stage the edges must be straightened and sharpened, final thinning is achieved, humps are removed, and thinning of the basal section to facilitate hafting is accomplished. It possesses a flat cross-section. There is evidence of pressure flaking to the obtain final form. It is a completed triangular projectile point.

In terms of the actual experimental biface manufacturing episodes, the BRS was considered a three step process marked by switching of knapping techniques. The initial bipolar reduction to obtain a split pebble or flake blank is considered the Blank stage. Preform I and II are accomplished by freehand with a hard hammer and are designated as Preform I, for statistical analysis. The final stage to obtain a finished biface is considered Preform II, and completed by pressure flaking with an occasional switch to the hard hammer to remove a particularly stubborn flake or hump. The manufacturing process is a continuum, with the stages representing differing amounts of reduction that must be

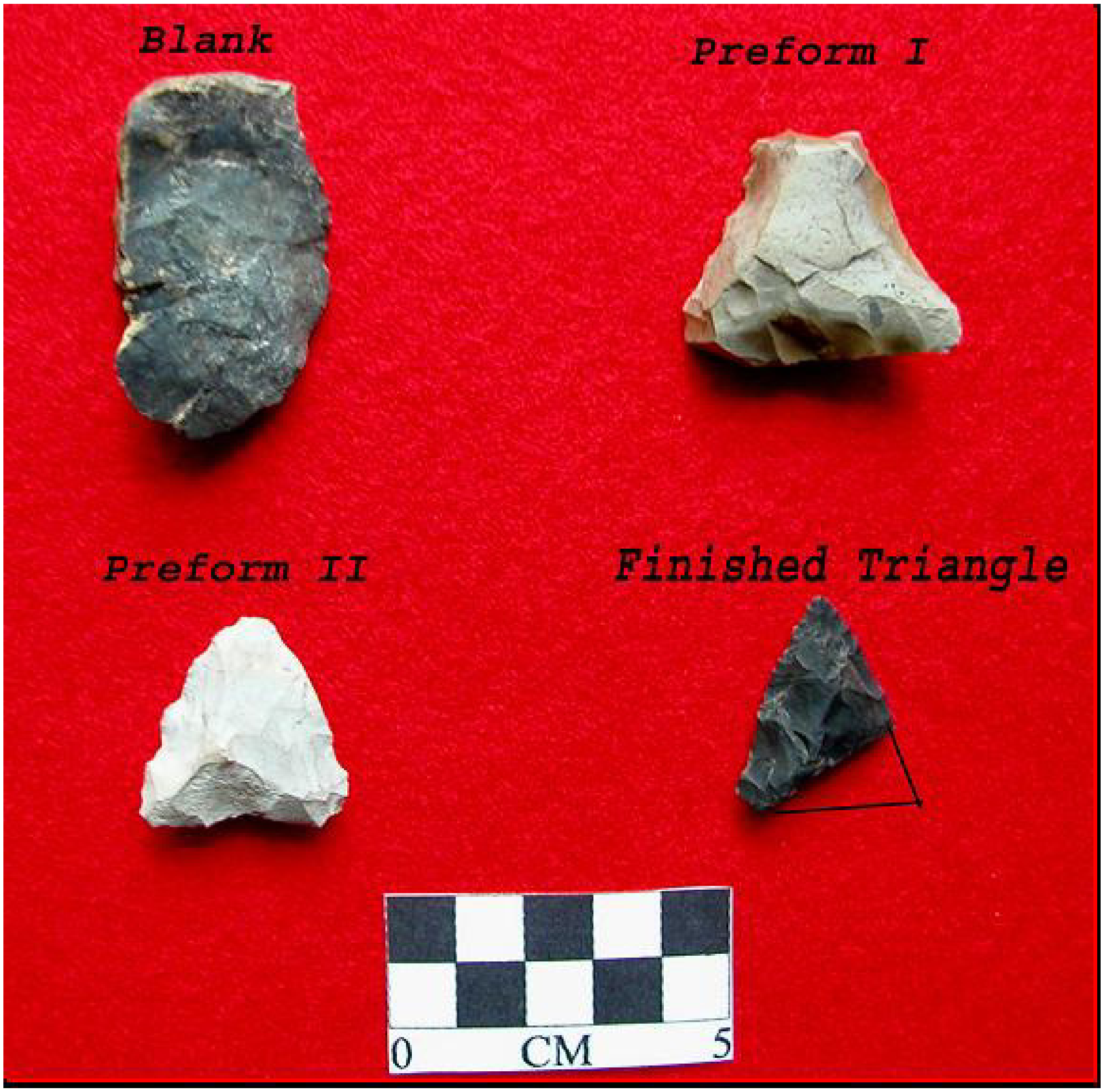

Figure 4.2. Proposed biface reduction sequence for the BF locus, KBS. Lines show Finished Triangle with reconstructed shoulder. Finished triangle appears to have been broken on impact in a prey animal (see Chapter 6, *Bifaces*).

accomplished in sequence on the path to the final form. The process is essentially accomplished by the use of three knapping techniques, bipolar reduction to obtain a split pebble or flake blank, freehand hard hammer percussion to shape and thin, and pressure flaking to accomplish some final thinning, straighten and sharpen edges and complete the hafting area to produce the finished biface. In the experiment these three processes are designated as Blank, Preform I, and Preform II.

20 Percent Sample of Debitage

The debitage was examined and counted prior to the development of the research problems that form the framework for this study. In the initial work it became apparent that a proportion of the debitage was struck from thermally altered stone based on perceived color change and increased luster on the ventral surfaces and on flake scars produced after the heat treatment (Luedtke 1992:95). It was also apparent that a large proportion of the debitage contained some amount of waterworn cortex, which is found on the gravels in the secondary deposits along the margin of the Delaware Bay, in the vicinity of Kimble's Beach. The relatively large number of split, flaked, reutilized material, and unmodified pebbles (n = 46) among the non-debitage lithic artifacts (n = 199) reinforces this observation. This coincides with several studies of lithic use on the OCP in New Jersey and Delaware, which concluded local secondary deposits of gravels were used extensively by the peoples who inhabited this area (See (Cross 1941; Custer and Galasso 1980; Grossman-Bailey 2001; Mounier 1972; Pagoulatos 1992; Petraglia, et al. 2002; Ranere and Ressler 1981, Stewart 1988).

Sampling Procedures

In order to determine if the knapping experiment should include stone that was thermally altered prior to being flaked, it was necessary to determine the actual percentage of thermally altered debitage, and the stage in the reduction sequence in which it was accomplished. Shennan (1990:299) observed that “Statistical sampling theory becomes relevant when the aim of the study is to use the sample selected to make estimates of characteristics of the population from which it is drawn.” It was determined that a suitable sample of the debitage would provide the information required to design the experimentation phase. This analysis was limited to a selected group of attributes that could quickly be determined and would provide the information required. In addition to provenience data, count, and raw material type, the following variables were recorded: flake size class, percentage of cortex, thermal alteration, indicators of thermal alteration, and whole and broken flakes. Inferences could be drawn from the individual variables or from their special relation to the other variables in the group.

Debitage was assigned to one of seven size classes which ranged from less than .75 cm to greater than 7.5 cm. Size classes have been utilized in several studies to differentiate between hard and soft hammer and pressure flaking (Henry, et al. 1975), projectile point manufacturing stages (Stahle and Dunn 1982), bipolar and freehand cobble reduction, as well as soft and hard hammer reduction (Ahler 1989), biface reduction activities (Patterson 1990) and core and tool production (Carr and Bradbury 2001; Prentiss 1998). These studies indicate that larger flake sizes occur earliest in the reduction sequences and smaller size classes in the later stages. These particular size classes were used in the original analysis by the Rutgers University Center for Public

Archaeology, and were kept intact for comparability to that data. Size classes used in the analysis were of different parameters.

Knapping in its essence is a reductive process, and the early stages of the process contain higher percentages of cortex than the later stages (Whittaker1994:17) when the stone raw material is in pebble or cobble form, although in some studies this assumption has been demonstrated to be inaccurate (Andrefsky 2001a:11). Considering the relatively small dimensions (statistics from collection) of the cortex encased pebble raw materials available, this assumption appears to be valid. Due to the inherent difficulty in accurate determination of the percentage of cortex on small pieces of debitage (95.8 percent of the sample was Classes 6 and 7 with a range of .75 cm-2.5 cm) found in this assemblage, a four rank ordinal scale of percentages was adopted. The categories of zero percent cortex and 100 percent cortex are simple to determine. The two mid-categories of >0% ≤50% and >50% <100% are in most cases relatively easy to distinguish. All four categories are easily determined and hence replicable. It was assumed for this sample that the percentage of cortex was related to stages of reduction.

Thermal alteration is one of two particular states; either a piece was thermally altered, or it was not. Studies of thermal alteration (Collins and Fenwick 1974; Crabtree and Butler 1964; Hatch and Miller 1985; Mandeville and Flenniken 1974; Moore 1999; Purdy and Brooks 1971; Schindler, et al. 1982) indicate that two characteristics are indicative of thermal alteration: color change, and the development of luster. Luedtke (1992:94-95) notes that some cherts do not change color, but all undergo a change to a glossy or waxy luster after sufficient heat treatment. Color change may differ from one type of chert to another. The most common change is to a red or pink when the iron compounds in the stone are oxidized to hematite. This change was observed in the initial survey of the debitage. The change in luster does not take place on the original surface of the stone but rather in its interior. It is best discerned on freshly flaked surfaces that contain a portion of the duller original exterior surface. In addition to the “Yes” and “No” categories of thermal alteration I included a nominal variable to indicate how the judgment was made. The four categories were no changes visible, color change, development of luster, and both color and luster. Although there is some utility for this variable it was primarily included as a check on myself as an analyst to quantify the criteria used to make a judgment as to whether a piece was thermally altered.

The last variable was that of a simplified SRT consisting only of two categories, broken and whole (Sullivan III and Rozen 1985). A flake was considered whole if it possessed both proximal and distal ends, as well as intact margins. If it did not possess any of these attributes, it was considered broken. Although many studies have disagreed with Sullivan and Rozen’s specific findings in regard to the relative proportions of whole and broken flakes in different reduction sequences, they have not disputed the value of this typology for lithic analysis, or that different reduction sequences (core, biface, tool) produced distinct proportions of whole and broken flakes (Andrefsky 1998:122-124). This variable is quick and easy to discern and I believed it would provide an indication of possible intrasite differences in lithic reduction activities.

In addition to these variables, it was necessary to determine an adequate sample size for this population of debitage. The standard deviation of a population of ones and zeroes which corresponds to the answers ‘Yes” and “No” to the attribute of thermal alteration is $[P(1-P)]^{1/2}$. In this instance P .is the proportion of interest. The standard error of the proportion is obtained by dividing by the square root of the sample size, thus the standard error of the proportion is $[P(1\text{-}P)/n]^{1/2}$. I used the largest and most conservative estimate of the needed sample size or P which is 1/2.

The formula to determine this sample size or n includes four values. The first is Z_α or the Z score which is the number of standard deviations associated with a probability level, in this case 95 percent. The second is d or tolerance which was set at 5 percent. The third is n or the number of samples. The fourth is P which is the proportion maximum for one's or zero's. This final value was set at 1/2, the maximum for a sample. A preliminary count of the total debitage from all units was 2,096. The necessary sample size becomes $n = \frac{Z_\alpha^2 [P(1-P)]}{d^2}$ or in this instance $\frac{Z_\alpha^2 \left(1/4\right)}{d^2} = \frac{Z_\alpha^2}{4d^2}$. By inserting the actual numbers into the formula it becomes $n = \frac{1.96^2}{4(0.05)^2} = 384.16 = 384$. To facilitate the actual selection of the sample I decided to use 20 percent or one in five which gave a sample size of $2{,}096 \times .2 = 419$. This resulted in a slightly lower tolerance level of 4.8%. Due to the reasonable size of this sample, a finite population correction to lower the sample size was not applied. The procedure discussed above was derived from Shennan (1990:301-313).

After calculating the confidence intervals and sample size, a sampling strategy was required. A simple random sample would not give enough information about individual units, so a stratified random sample was chosen. The advantage to this was twofold; each catalog number would be sampled so that all units across the site were included, and it would indicate any intrasite variability (Shennan 1990:315-316).

The process of stratifying the sample was straightforward. Each catalog number was sampled if the bag contained 3 or more pieces of debitage. A checkerboard arrangement of 64 numbered one-inch squares on a piece of graph paper was used to provide a selection number for each piece. All the debitage from the bag was placed on a square starting with number one. To randomize the start point for each catalog bag of debitage, one of five pennies marked with numbers one to five was drawn from a cup. After the number was selected, every fifth piece of debitage was analyzed beginning with that number until all pieces were analyzed and recorded with the designated attributes. If there were three or more pieces remaining at the end, the last piece was analyzed. This methodology added to the overall number of pieces analyzed (*n* = 554). As a result, although the actual count of the debitage was somewhat higher (*n* = 2,389), the sample was 23.2 percent. The results were entered in a database created with SPSS 6.1. The data were explored utilizing frequencies and cross-tabulations between variables and provenience data (Norusis 1994a).

Results of the 20 Percent Sample

The results of this analysis for the sample as a whole indicated that intentional heat treatment was indeed a part of the lithic technology of the inhabitants of Kimble's Beach. Taken as a whole, 25.3 percent of the debitage (*n* = 140) showed signs of thermal alteration with 77 percent of thermally altered pieces (*n* = 108) exhibiting both changes in color and luster or gloss, 21 percent discernible luster (*n* = 30) and less than 2 percent exhibited marked color change only (*n* = 2). Luedtke's (1992:95) survey of thermal alteration experiments indicates that the development of luster occurs at the same temperature as the improvement in the workability of the stone. Color change generally occurs at a lower temperature than the change in luster, but little improvement in workability was detected at this color only stage. Only one of the five studies that reported color change, development of luster, and improvement in workability indicated that all three occurred at the same temperature stage (Luedtke 1992:93).

When examined by dorsal cortex amount, the percentage of debitage thermally altered was 27 percent, 27 percent, and 23 percent respectively for the first three cortex classes. The last class, 100 percent cortical, was 12 percent of the total. This suggests that thermal alteration was applied early in the reduction sequence, most likely at the split pebble stage (interior visible) to avoid wasting the effort in treating a piece with internal flaws which would make it unsuitable for tool or biface production. A more exacting analysis, considering more variables, is discussed in Chapter 6, *Analysis of Beach Face Debitage*.

The 20 percent sample indicated that a quarter of the debitage was thermally altered. It also appeared that this treatment was accomplished early in the reduction sequence perhaps at the whole pebble stage but most likely at the split pebble stage. Based on this sample, it was decided to include thermally altered stone in the knapping experiment. The differences in the numbers of whole and broken flakes between units led to the inclusion of unifacial tools (endscrapers) in the knapping experiment and the testing of bipolar core reduction, along with the original biface production component. These two activities were also reinforced by the analysis of the flaked lithics minus debitage from the site which included both bipolar cores (n = 9) and finished unifacial scrapers (n = 7).

The analysis of the amount of dorsal cortex determined that 41 percent of the total debitage (*n* = 227) retained some cortex. This data cross-tabulated with size classes indicated the percentage of debitage with some cortex increased with the size of the pieces. In Class 6 (*n* = 343), 32.1 percent contained some cortex, which increased to 54.3 percent in Class 5 (*n* = 188) and 73.7 percent in Class 4 (*n* = 19). These two results taken together initially suggested that a complete reduction sequence, from the whole pebble or from the split pebble stage, took place on the site. See Appendix B for size class parameters.

The percentage of whole and broken flakes from the entire sample was 67.6 percent and 35.3 percent respectively. The number of whole flakes was greater than the broken flakes in most excavation units, with the exception of four trenches and one unit. In Trench 1, the proportion was almost reversed with 68 percent broken and 32 percent whole. Trenches 4, 20, 21 and Unit 1 contained approximately 50 percent whole and broken flakes. This was viewed as a potential indicator of differences in intrasite lithic activities or perhaps trampling.

The preponderance of the sample fell into two size classes with a range of .75 to 1.5 cm (*n* = 343) and 1.5 to 2.5 cm (*n* = 188). These two classes comprised 96 percent of the total sample. It was obvious that these size classes or classes based on standard screen sizes (.125, .25, .5, .75 and 1.0 inch), would not provide much differentiation in the determination of a reduction sequence utilizing alluvial gravels, so they were modified for the debitage analysis. It was concluded that discrete metric measurements would offer a greater likelihood of providing this differentiation within debitage of 2.54 cm (one inch) or less.

The analysis of raw material indicated that 99 percent were of cryptocrystalline materials, with cherts (*n* = 450) and jaspers (*n* = 76) combining for 95 percent of the total debitage. Although it was not included as a variable, waterworn cortex was the only type observed in those pieces that possessed remnant cortex. This reinforced the original hypothesis that chert and jasper pebbles from local sources, most likely the margins of the Delaware Bay, provided the lithic raw materials for Late the Woodland inhabitants of Kimble's Beach.

Lithic Experiments

Lithic Raw Material Availability

All the flaked lithic artifacts from the BF locus were examined to determine raw material type and observe characteristics of remnant cortex. This examination suggested it was highly probable that the source of the artifact raw material was local gravels, most likely from the margins of the Delaware Bay.

In the 20 percent sample of the beach face debitage, 95 percent were of chert (*n* = 450 or jasper (*n* = 76), and the remainder (*n* = 28) were of chalcedony, quartzite, quartz, and sandstone. All of these raw material types are commonly found among the gravels of the Delaware Bay, except chalcedony, which is somewhat rare. All of the cortex present on debitage in the sample was waterworn. Examination of the flaked lithic tools and unmodified pebbles in the sample produced similar observations. The same raw materials identified in the debitage sample comprise 98 percent of the total CSA, reutilized material, and unmodified pebbles (*n* = 128), and the remainder were two artifacts manufactured from nonlocal stones (Table 6.2). One biface fragment is made from argillite, and the most complete Late Woodland triangular projectile point is of Cohansey quartzite. Argillite deposits are found in central New Jersey, and Cohansey quartzite is common on sites in southern New Jersey near its source in Cumberland County. No debitage or other artifact of either material was found in the assemblage. One hundred percent of the remnant cortex found on these artifacts was consistent with the waterworn cortex of the Delaware Bay gravels. All of the artifacts were less than 100 mm in greatest dimension, and more than 90 percent were less than 64 mm. These dimensions are well within the size range of cryptocrystalline gravels found along the Delaware Bay. The raw materials, remnant cortex, and sizes represented in the assemblage are all consistent with gravels from the Delaware Bay.

A site catchment radius of 10 km was established for lithic procurement in this study. In hunter-gatherer studies reviewed by Kelly (1995:133), people walked a maximum daily round-trip of 20-30 km in a variety of habitats. He notes, however, the daily distances traveled are frequently less than the maximums. In consideration of the preceding, 10 km, which is a common distance used by archaeologists who study hunter-gatherer sites in North America (Roper 1979:121), was deemed to represent the most likely foraging radius for the Native American inhabitants of Kimble's Beach. The foraging distance is important because lithic procurement is generally embedded in daily foraging activities, and usually not a separate resource gathering activity (Binford 1979:259).

There are no primary sources of lithic raw materials within a 10 km radius of the KBS. See the discussion of primary lithic outcrops in the Chapter 2. Only secondary deposits of lithic materials are available within this foraging radius. The gravels of the Delaware Bay are not only the most easily accessible secondary deposits, but it is highly probable they are the only such deposits available within the foraging radius. In furtherance of this hypothesis, several other possible sources of secondary deposits were investigated. A trench cut into DsB soil, a variety of Downer sandy loam known to have gravels present at a depth of 60 cm (Markley 1977:30), was examined. This trench was located on the CMNWR approximately 1.2 km east of the BF locus. There were pea-sized gravels present, but none were observed to be larger than 10 mm in diameter. Gravel for construction purposes is commonly quarried on the Cape May Peninsula. However, these gravels are quarried from a depth more than 5 m below the present ground surface with power machinery. The salt marshes in the vicinity of Kimble’s Beach are crisscrossed by mosquito ditches, excavated to a depth of two meters by the Cape May County Mosquito Commission to keep water flowing, to reduce mosquito breeding habitat in these areas. No deposits of subsurface gravels were reported by the operators of the machinery used to cut these ditches (Kurt Himstedt, personal communication 2001). Traveling by kayak, the banks along the length of the Dias Creek south of the site where gravels were exposed or deposited were explored. No visible deposits were found. The banks of the streams on the bayshore side of the peninsula are generally lined with a Tidal Marsh soil or Muck (Markley 1977). Neither of these two soils is known to contain gravel deposits. There are secondary deposits of high quality cryptocrystalline gravels on the Atlantic coast of the peninsula, but these beaches are beyond 10 km and unlikely to be the source of raw materials used at Kimble’s Beach. It may be reasonably concluded that the gravels from the Delaware Bay were the source of most or all of the lithic materials found in the assemblage from Kimble's Beach.

Procurement of Gravels for the Knapping Experiment

High quality cryptocrystalline gravels are found along the margins of the Delaware Bay in the general vicinity of the KBS. The gravels used in the knapping experiment were collected from a 500 m stretch of shoreline extending north and south of site. The gravels were collected in a four day period during the daylight at low tide. The pebbles and cobbles of sufficient dimension (greater than 40 mm) to utilize in tool manufacture are normally 15-20 m out from the mean high tide line, and are only accessible for approximately 90 minutes before and after low tide. This shoreline is estimated to have been 400-500 m from the BF locus in Late Woodland times (see Chapter 3, *Salt Marsh Formation*).

The shoreline was searched for gravels of sufficient size that resembled the gravels in the archaeological assemblage (Figure 4.3). The classic ring cracks or peepholes that represent incipient cones of fracture from rolling around in a river are considered an indicator of knappable material (Whittaker 1994:71). The desirable gravels were difficult to identify, especially at the beginning, due to a film of water on the surface of the cortex which masked the peepholes and cortex appearance. Compounding the problem was the presence of attached sprats or immature oysters which further obscured the cortex.[2] Relatively inexperienced in this process, this analyst employed a regimen not unlike that followed by the prehistoric knappers, that is testing gravels by flaking off an end with a quartzite hammerstone or rock hammer

Figure 4.3. Gravel collection at beach face of Kimble's Beach: (Top) gravel field with chert pebble at tip of rock hammer; (Bottom) author collecting gravels for knapping experiment.

(Mounier 2003). In many cases gravels were split by the bipolar method to relate the material encased to its cortex. After several hours of this effort, it became easier to identify the desired gravels and eventually more than 400 pieces were collected for use in the experiment.

Table 4.1. Summary Data for Delaware Bay Gravels Selected for Knapping Experiment.

Attribute	N	Mean	S.D.	Range	
				Min	Max
A-Axis (mm)	80	57.22	9.51	33.8	85.9
B-Axis (mm)	80	36.46	6.58	23.6	56.0
C-Axis (mm)	80	26.68	6.59	11.7	39.8
Weight (g)	80	68.34	32.61	22.3	172.5
Wt*MLD	80	4122.53	2369.78	926	14,073

This was a biased sample of gravels, in that this analyst specifically searched for desirable cherts and jaspers. No attempt was made to quantify the number, shapes, and raw material types for a delimited quadrate of the beach (see Shelley 1993). The goal was to collect as many pieces of high quality knappable stone as possible. The collected gravels were dried, sprats removed, and cortex re-examined. Approximately 200 pieces were selected as candidates for the knapping experiment. The flintknapper, Jack Cresson, then assisted in selecting 80 pieces for the experiment.

Core Morphology

The 80 clasts chosen for the experiment were categorized into four shapes (prolate, oblate, equant, and bladed) following Zingg (1935). The shapes were determined by the ratios of three mutually perpendicular axes of measurement. The a-axis is the longest, the b-axis intermediate, and the c- axis the shortest dimension of the gravel. The ratios of measurements b/a and c/b were determined for each gravel, and the intersection of the results plotted on a graph in Waters (1996:Figure 2.8). The intersection of the two axes fell into one of four quadrants that define the shapes. A summary of the results for each shape is found in Table 4.2. More than half (53.8 percent) of all the selected gravels were prolate in shape and the oblate, equant, and bladed shapes made up the remainder relatively equally.

Table 4.2. Frequencies of Shapes for Experimental Gravels**.**

Shape	Frequency	Percent	Cumulative %
Oblate (disk)	14	17.5	17.5
Equant	14	17.5	35.0
Bladed	9	11.3	46.3
Prolate (roller)	43	53.8	100.0
Totals	80	100.0	100.0

Gravels were also categorized by a variable that was the product of the maximum linear dimension (MLD) or a-axis and the weight. This is a variable advocated by Andrefsky (1998:139) as an alternative method of core measurement. It was easy to calculate and provides a replicable measure of core morphology. Although the shapes were recorded, no attempt was made to compare debitage signatures of each type due to the limited number (n = 9) of biface manufacture experiments. See Table 4.3 for individual gravel shapes and MLD*weight variable**.**

Heat Treatment Experiment

The 20 percent sample of the debitage indicated that 25 percent of the debitage from the Kimble's Beach was thermally altered. The percentages of thermally altered pieces in each cortex class suggested that the heat treatment[3] was applied early in the reduction sequence, either in the whole pebble stage or more likely in the split pebble stage of reduction. It was decided that thermally altered stone should be included in the flintknapping experiment.

The use of heat treatment in prehistoric North American is well documented (Collins and Fenwick 1974; Crabtree and Butler 1964; Johnson 1987; Klippel 1970; Mandeville 1973; Mandeville and Flenniken 1974; Purdy and Brooks 1971). Researchers have made similar observations concerning heat treatment in the Middle Atlantic region from the Paleo-Indian to the Contact period (Hatch and Miller 1985; Katz 2000; Moore 1999; Rule and Evans 1981; Schindler, et al. 1982; Verrey 1986). Appropriate thermal alteration has been demonstrated to increase the workability of stone (Bleed and Maier 1980; Mandeville and Flenniken 1974), especially in pressure flaking (Moore 1999:72; Katz 2000:147-150; Crabtree 1964:1). As previously noted, increased luster of freshly fractured surfaces of heat treated stone was shown to occur along with an increase in workability compared to untreated stone. Although preforms and flakes are most easily and efficiently heated, the deliberate heat treatment of the complete range of materials from cobbles to flakes has been documented in ethnographic literature (Luedtke 1992:91-92).

The purpose of this phase of the research had two objectives. The first was to produce thermally altered material with increased workability rather than experimentally determine an optimal range of temperatures and heating times that would produce the same result for the raw material sample derived from the Delaware Bay. The second was to provide a comparative sample of known thermally altered pieces, to aid in the identification of the heat treated artifacts from Kimble's Beach.

Several studies indicated that for some cherts thermal alteration would take place at 250˚ C (Luedtke 1992; Schindler, et al. 1982). Because this temperature was within the capabilities of a home range, the process began in this analyst's kitchen. Initially, the heat treatment was conducted using a gas range with a maximum temperature of 550˚ F (288˚ C). Eight pebble cherts and jaspers, which had been previously split by the bipolar method, were selected for heat treatment. One half of each of the eight pieces was heat treated, the other untreated halves were retained as a reference. The pieces were laid on a two cm bed of sand in a metal pan, and were covered with a like amount of sand to prevent or minimize shock. Each piece was weighed and measured prior to the heating process. The temperature was initially set at 200˚ F (93˚ C) and materials were heated for half hour. The temperature was increased 50˚ F (10˚ C) every 15 minutes until the maximum (550˚ F) was reached. The material was heated for four hours and allowed to cool in the oven.

The results from this procedure were mixed. The two jasper specimens exhibited pronounced color change (reddening), while the five other cherts exhibited color change in varying degrees. The eighth piece, Munsell Rock Color N 5, dark gray, did not evidence any sign of color change. Test flakes from each of the heated pieces were removed by either the bipolar or freehand method. There appeared to be a small change in luster in all pieces, but not to the degree observed in the artifacts from the archaeological assemblage. Four of the specimens were then selected, and the same process was applied a second time. The four specimens were tested again, but any change in luster or increased workability was difficult to discern. There was no discernible loss of weight that could be measured by the Ohaus LS 200 digital scale whose accuracy is to .1 g. Different types of cherts vary in the amount of water they absorb and lose through heating. In Mandeville's (1973:192) experiments the water loss increased with temperature and varied in percentage by chert type from .0170-.3158 at 200˚ C to .01314-.05827 at 800˚ C. The most likely explanation for this lack of water loss in the gas range experiment is that the largest pebble (50.6 g) of the eight could have sustained a weight loss of .05 g or less which could not be detected by a scale of this sensitivity. However, based on these observations of color, luster, and workability, it was concluded that a higher temperature was required.

The survey of heat treatment literature in Luedkte (1992:90-96) and the experiments of Katz (2000) and Moore (1999) with Middle Atlantic lithic raw materials indicated that 350˚ C for four hours produced the desired thermal alteration with minimal risk of damaging the raw material. In addition, the experiments of Schindler et al. (1982:533) demonstrated that 350˚ C produced the optimal decrease in resistance to fracture, hence an increase in workability, for Pennsylvania Bald Eagle jasper. Based on the foregoing literature, it was decided that heating the material to 350˚ C for four hours should produce the desired luster and hence workability, but avoid damage. Fourteen of the gravels selected for the lithic manufacture experiments were split by the bipolar method. Six of this group were chosen to heat along with two whole pebbles for a total of eight. Only one half of each split pebble was heated, and the untreated halves were retained for reference and comparison. Again the material was cushioned by one to two cm of sand. The starting temperature was 200˚ C for 15 minutes, and raised by 50˚ C each half hour to 350˚ C where is was maintained for 4 hours. A computerized Bailey Top Loading Electric Kiln in the Ceramic Engineering Department of Rutgers University provided the heat source. The heating process was begun at 11 a.m. and was completed in 5 hours and 45 minutes. The material was allowed to cool overnight and removed the next morning.

The color changes were similar to that of the gas range experiments. The two jasper pieces underwent the greatest change (piece 19, 5YR 7/1 to 5YR 8/1 and N7 and piece 71, 10YR 5/4 to 10R 4/6), with the other pieces undergoing less change in color. As in the previous experiments, the gray colored pieces (numbers 70, 7 and 38) underwent the least change in color. Since these pebbles were initially glacial outwash from potentially diverse bedrock origins, the levels of impurities, whose oxidation (Luedtke 1992:94-95) causes the color change, varies for each pebble as it does for the parent chert deposits. The pieces were weighed again, and there was no measurable change in weight due to water loss which is most likely the result of the lack of sensitivity of the scale to changes less than .1g. Three of the pieces (numbers 7, 71 and 29) were utilized in the experimental knapping. No attempt was made to compare the knappability of the thermally altered material to their unaltered portions. The knapper reported that all three pieces, in his judgment, worked more easily than the non-thermally altered pebbles. The debitage from these three pieces also exhibited the characteristic luster on the freshly flaked surfaces seen in the archaeological artifacts from Kimble's Beach.

Knapping Experiment

A total of 80 pieces of Delaware Bay gravels were selected for the experiment in consultation with the knapper. Eight of these pieces were heat treated to produce the thermal alteration observed in the 20 percent sample of the debitage and the analysis of flaked lithics. A total of 21 pieces were selected for reduction by the bipolar method, to produce either flake blanks or split halves suitable for freehand percussion. The goal of the experiment was to produce bifaces (Late Woodland isosceles triangles) and unifaces (endscrapers and core scrapers) similar to those found at the site. Table 4.3 presents the experiments, goals and outcomes for each episode.

All of the knapping was conducted by Jack Cresson, a knapper with more than 40 years of experience in archaeology in southern New Jersey. He has an intimate knowledge of the technologies utilized by the prehistoric knappers on the Coastal Plains of New Jersey and conducts lithic workshops throughout the eastern United States. The experiments took place over portions of three days in Cresson's backyard workshop/laboratory. Each knapping episode was videotaped. The debitage from each individual experiment was collected from a white canvas drop cloth on which Cresson sat or knelt. The debitage was labeled and bagged by individual experiment, changes in technology (bipolar, freehand, pressure), change in percussor (hard hammer or antler), as well as by BRS. Five of the experiments that produced Late Woodland triangles were photographed and weighed at each BRS. In the other experiments objective pieces were photographed and weighed upon changes in technology or percussor.

Results and Problems Encountered

A total of 24 knapping experiments were attempted (Table 4.3). Thirteen of the reductions resulted in the manufacture of triangular projectile points (*n* = 9) and three types of scrapers (*n* = 4) (See Figure 4.4). Eleven of the reductions were abandoned, due

Figure 4.4. Chipped stone tools produced in the knapping experiments. Numbers refer to experiments (see Table 4. 3). Rows 1 and 2 are Late Woodland isosceles triangles. Bottom row: number 11, double-ended scraper; number 12, end tool; number 13, core scraper; number 14, core scraper; and number 16, core scraper.

Table 4.3. Results of the Knapping Experiments.

Exp#	Obj. Piece	R.Mat	Dimensions (mm)	Wt (gms)	Shape	MLD	TA	Blank	Goal	Result	Notes
1	14	Qite	58.9x42.4x37.8	130.2	Equant	7669	N	N/A	Bi	Failure	poor quality quartzite; discontinued after BP
2	37	Cht	47.9x36.1x27.9	63.8	Equant	3056	N	N/A	Bi	Failure	unable to get usable flakes; discontinued after BP
3	3	Cht	85.9x38.0x29.2	102.4	Prolate	8796	N	Flake	Bi	Failure	Broken in manufacture:BRS 0
3A	3	Cht	—	—	—	—	N	Flake	Bi	LW Tri	Completed LW isoceles triangle
4	7	Cht	52.9x31.3x25.4	47.2	Prolate	2497	Y	SP	Bi	LW Tri	Completed LW isoceles triangle
5	65	Cht	51.7x32.2x27.9	56.4	Prolate	2916	N	N/A	BI	Failure	poor quality material; discontinued after BP
6	16	Jas	64.7x31.4x26.7	43.9	Prolate	2840	N	Flake	Bi	LW Tri	Completed LW isoceles triangle
7	71	Jas	75.8x38.3x37.0	126.0	Prolate	9551	Y	SP	BI	LW Tri	Completed LW isoceles triangle
8	67	Cht	47.2x33.3x27.7	58.6	Equant	2766	N	N/A	Bi	Failure	Poor quality material; discontinued after BP
9	75	Cht	59.9x37.8x34.4	84.9	Prolate	5086	N	Flake	Bi	LW Tri	Completed LW isoceles triangle
10	58	Jas	66.7x39.4x29.5	120.1	Prolate	8011	N	Flake	Uni	Failure	Material too coarse; abandoned endtool scraper
11	32	Jas	78.2x41.9x39.8	156.2	Prolate	12215	N	Flake	Uni	Uni	Completed double-ended scraper
12	32	Jas	—	—	—	—	N	Flake	Uni	Uni	Completed end tool; flake from experiment #11
13	29	Cht	50.5x44.0X33.5	84.3	Equant	4257	Y	SP	Uni	Uni	Completed core scraper
14	6	Jas	44.1x38.4x34.2	88.7	Equant	3912	N	SP	Uni	Uni	Completed core scraper; poor result
15	31	Jas	56.5x40.6x28.0	76.9	Equant	4345	N	SP	Uni	Uni	Coarse material;unable to complete core scraper
16	12	Cht	50.8x46.0x32.1	55.5	Equant	2819	N	N/A	Uni	Uni	Abandoned: flakes carrying too far
17	48	Cht	53.2x35.4x31.2	65.4	Prolate	3479	Y	SP	Bi	LW Tri	Completed LW isoceles triangle
18	1	Cht	57.5x49.4x30.9	93.4	Oblate	5371	N	N/A	Bi	Failure	Poor quality material; discontinued after BP
19	36	Cht	47.4x45.7x30.7	73.1	Equant	3465	N	N/A	Bi	Failure	Poor quality material; discontinued after BP
20	73	Jas	42.8x34.3x25.2	55.4	Equant	2371	N	Flake	Bi	LW Tri	Completed LW isoceles triangle
21	47	Cht	59.0x32.9x26.0	60.1	Prolate	3546	N	Flake	Bi	LW Tri	Completed LW isoceles triangle
22	74	Jas	55.8x35.0x26.0	61.2	Prolate	3415	N	N/A	Bi	Failure	Poor quality material; discontinued after BP
23	49	Cht	48.9x31.5x21.4	54.6	Prolate	2670	N	Flake	Bi	LW Tri	Completed LW isoceles triangle

to poor quality of the lithic material (n = 10), and breakage in manufacture (n = 1). Two experiments (3A and 12) were continued from flake blanks that resulted from the reduction of gravels in previous experiments (3 and 11). A triangular projectile point resulted from experiment 3A and an endscraper (endtool) from experiment 12.

Reduction was initiated by the bipolar method for all experiments, including the thermally altered pieces which were heat treated as split pebble halves. A large quartzite

Table 4.4. Weights and Lithic Material of Small Stone Hammers Employed in the Experiments.

Hammerstone	Material	Weight (g)
1	Sandstone	155
2	Sandstone	137
3	Sandstone	88
4	Quartzite	112
5	Quartzite	194
6	Quartzite	110

hammer (more than 610 g) and a quartzite anvil were used for the initial bipolar processing. Small sandstone and quartzite hammerstones (less than 200 g) were employed in hard hammer reduction (Table 4.4). Two different sized deer antler tines were used to pressure flake the objective pieces. On a few occasions the knapper employed a compound flaker (nicknamed an “Ishi stick”) to bring additional power from arm and chest muscles to bear on small and difficult pieces (Whitaker 1994:150-151). Pieces of leather were used as an aid to grasp the small objective pieces especially in pressure flaking. The knapper used a small flat piece of wood on his thigh to provide a flat base for the almost completed projectile point during its final sharpening by pressure flaking.

Gravels were only partially reduced. They were split, and one section was directly reduced further into the desired form by hard hammer and pressure flaking. The alternate procedure was to further reduce one-half by the bipolar method into one or more flake blanks, which were then manufactured into the final form by hard hammer and pressure flaking. All material from the initial step not reduced into a biface or tool was bagged separately to be used as a type example to compare to the archaeological assemblage. The only exceptions to this procedure were experiments 3 and 3A and 11 and 12 discussed above.

Cherts were utilized in 14 of the 23 experimental attempts and in 7 of the 13 successful reductions. Jasper constituted 9 of the 23 attempts and 6 of 13 successful reductions. Four of the 13 successful reductions were from the thermally altered stone produced for this study (see section on *Heat Treatment Experiment*). Thermally altered pebbles were reduced in experiments 4, 7, and 17 to manufacture triangular projectile points and experiment 13 produced a core scraper. All of the experiments with thermally altered stone were successful, while only 9 of the 19 untreated pebbles were successful. This is somewhat misleading, since all of the thermally altered pebbles used in the experiments were split by the bipolar method prior to heat treatment, thus ensuring at least initial knappable quality prior to heat treatment. No such assurance was available for the untreated gravels used in the experiments. A good example of this uncertainty was experiment 1 on objective piece 14. This pebble was tested prior to the experimental knapping by removing an end with a hard hammer. This test revealed a high quality jasper interior beneath the cortex. In the initial experimental reduction, the pebble was split, revealing a coarse quartzite in the material behind the jasper. This experimental reduction was terminated due to the poor quality of the stone.

Individual reduction experiments were halted for several reasons, but poor material quality was responsible for the majority of these failures. Six of the reductions were stopped after the pebble was initially split due to the poor quality of the stone. One reduction ended as a manufacturing failure. One experiment came to an end after reduction by the bipolar method was unable to produce a useable flake blank. Three other experiments were halted when it became apparent that the material was too coarse and friable, or too brittle to produce the desired outcomes. The stone from the failed experiments was saved for later analysis.

Debitage Selection

Debitage from all the reductions were processed through a quarter-inch screen. Only debitage retained by this screen was analyzed to simulate archaeological recovery methods. Flakes larger than 2.54 cm were retained for analysis, although it is likely that these flakes would have been removed for use as expedient tools or further reduced. Pieces that were comparable to flaked lithic artifacts were removed (e.g. split pebble half) and analyzed and recorded as such (Appendices A and B). Individual debitage pieces less than 6.4 mm in greatest dimension were bagged by experiment number, BRS, and/or percussor.

Experimental Debitage Variables

The variables (flake attributes) applied to the debitage sets that resulted from the knapping experiments were selected from those demonstrated to have provided useful data to discriminate between reduction stages, types of reduction (biface, uniface, general bipolar core), and test typological definitions (bipolar, hard hammer, pressure, bifacial) of flake types (see Andrefsky Jr. 1998: Chapters 5 and 6; Shott 1994).

The debitage was initially sorted using the SRT (Sullivan III 1987; Sullivan III and Rozen 1985). Each detached piece was analyzed and measured based on its degree of completeness (Figure 4.5). The 12 flake attributes chosen for this study are flake termination type, weight, flake length, maximum width and thickness, striking platform types, crushing at point of applied force, presence/absence of a ventral platform lip, striking platform width and thickness, amount of dorsal cortex, and dorsal flake scar count (See Figure 4.5 and Table 4.5, Measured and Recorded Attributes by Debitage Type). These variables were chosen for their applicability in providing answers to the research questions, their amenability to be accurately measured given the constraints of the debitage (see below), and the replicability for future researchers. Additionally, raw material type, thermal alteration (yes/no), and percussor type were recorded for each category of debitage.

The small size of the gravels from the Delaware Bay imposed constraints on the types of measurements that can be accurately measured or discerned from the resulting debitage. The twenty percent sample indicated that 96 percent of the total debitage from

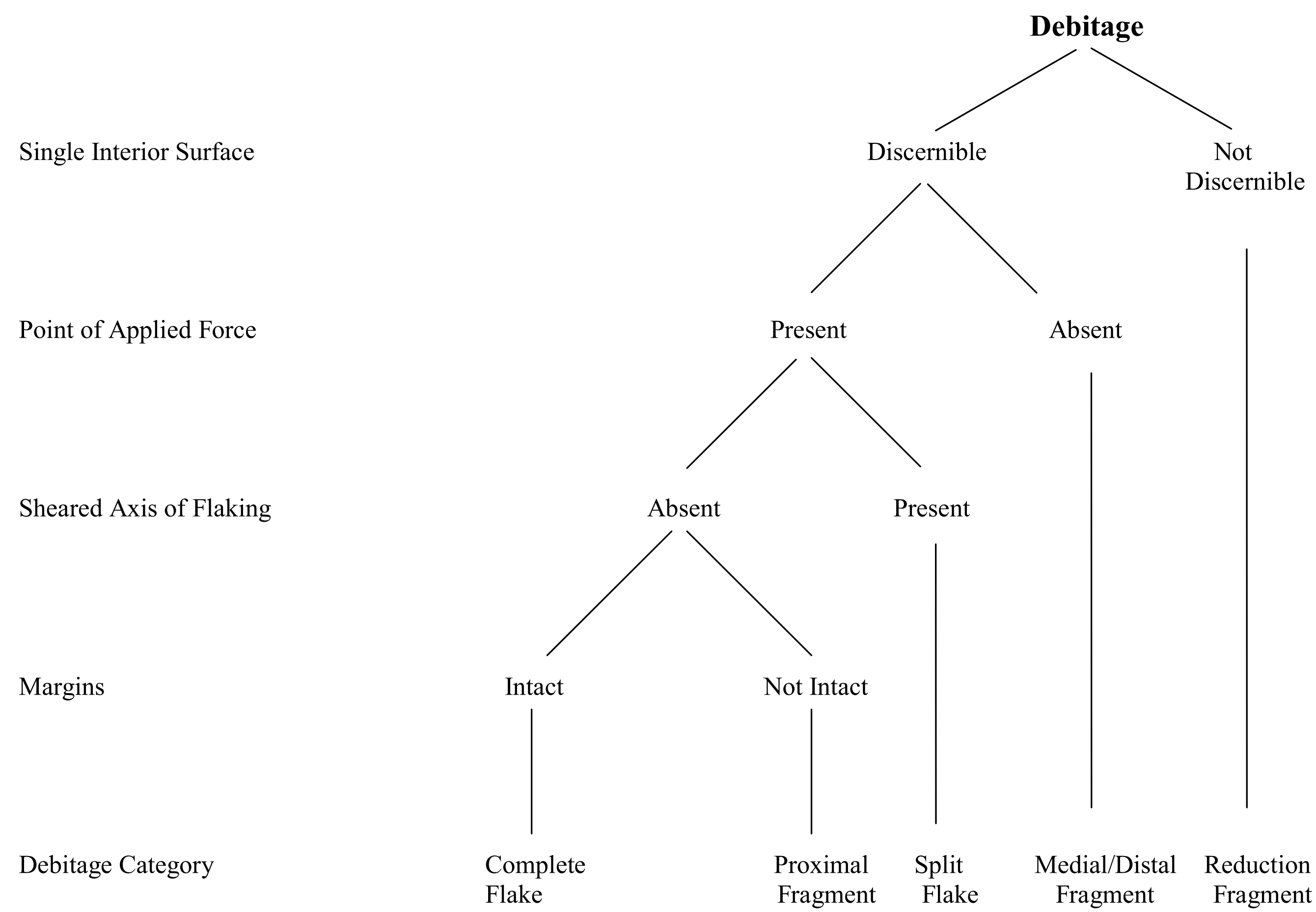

Figure 4.5. Hierarchial attribute key to define SRT debitage categories. After Sullivan and Rozen (1985), Sullivan (1987), and Kuijt et al. (1995).

Table 4.5. Measured Attributes by SRT Debitage Type.

	Termination Type	Weight	Maximum Length	Maximum Width	Maximum Thickness	Platform Type	Crushed	Lip	Platform Width Thickness	Dorsal Cortex	Dorsal Scars
Complete Flake	X	X	X	X	X	X	X	X	X	X	X
Proximal Fragment	X	X	X	X	X	X	X	X	X	X	X
Split Flake		X	X		X					X	
Medial Fragment		X		X	X					X	
Distal Fragment	X	X		X	X					X	
Reduction Fragment		X									

the site was less than 2.5 cm in length with 62 percent less than 1.5 cm. As a result, several flake attributes, such as ventral arch, platform angle, platform facet count, and size grade, that have demonstrated value in discrimination of reduction sequences or reduction types were not utilized for this study (Ahler 1989; Andrefsky 1983; Andrefsky Jr. 1986a; Dibble 1991; Magne and Pokotylo 1981; Pelcin 1997a; Pelcin 1997b; Pelcin 1997c). These attributes were too difficult to measure accurately and consistently, either because of the small flake size or the analyst's limitations. In the case of size grades, there may be too few examples in the larger sizes (greater than 2.5 cm) to provide a statistically valid sample. Patterson and Sollberger (1978:107) concluded that identification of eraillures, force lines, and concentrated bulbs of force were not useful for determining force application methods used to produce small flakes (6-18 mm in maximum dimension). Therefore, these characteristics were not considered in the attempt to discriminate hard hammer flakes from pressure flakes produced in this study.

In the following, the selected flake attributes are discussed and measurement guidelines are described.

Sullivan-Rozen Typology

Sullivan and Rozen (1985) proposed interpretation-free categories for debitage, which are mutually exclusive, to discriminate between generalized core reduction and tool manufacture. The relative proportions of four flake categories (whole and broken flakes, flake fragments, debris) were used to indicate these two different types of reduction. Sullivan (1987) later added a fifth category, split flakes. Although Sullivan and Rozen's results were challenged in several studies (Austin 1999; Bradbury and Carr

1995; Ingbar, et al. 1989; Kuijt, et al. 1995; Prentiss 1989; Prentiss 2001) there is general agreement that the SRT is useful for measurement of variation in these two types of reduction in lithic assemblages.

The heart of the SRT is the use of a key (Kuijt, et al. 1995:Figure 3; Sullivan III 1987:Figure 2; Sullivan III and Rozen 1985:Figure 2) to separate individual flakes into categories, based on the presence or absence of certain attributes (literally their degree of completeness). Such a key (Figure 4.4) was used for this study. This key utilizes the five flake categories of complete flake, proximal fragment, split flake, medial/distal fragment, and reduction fragment (Kuijt, et al. 1995:Figure 3). The term "reduction fragment" was substituted for non-orientable fragment to maintain continuity of physical form with the use of the term "core reduction fragment" in other sections of this study (Appendix A). The medial/distal fragment category was further separated into medial or distal fragments to facilitate other aspects of this analysis (Shott 1994:81). The attributes recorded and measured for each individual flake were determined by its SRT category (Table 4.5).

<u>Single Interior Surface</u>. Signs of positive percussion features, such as bulbs of percussion, force lines, and ripple marks on just one surface of a flake are indications of a single interior or ventral surface. The absence of a single interior surface is indicated by multiple occurrences of these features, or if they cannot be discerned with confidence (Sullivan III and Rozen 1985:758). A piece without a discernible interior surface is designated as a reduction fragment.

<u>Point of Applied Force</u>. On a piece of debitage with an intact striking platform, the point of force will be found at the intersection of the bulb of percussion and the striking platform. In the case of an incomplete striking platform, the point of applied

force is indicated by the origin of the force lines radiation. A piece that lacks a striking platform indicates the absence of the point of applied force, and is classified as a medial/distal fragment (Kuijt, et al. 1995:120; Sullivan III and Rozen 1985:758).

Sheared Axis of Flaking. A piece with a sheared axis of flaking that possesses a striking platform and a termination, but is truncated by a longitudinal fracture with a part of one lateral margin intact, is considered a split flake. A piece on which this feature is absent is classified as either a complete flake or a proximal fragment (Kuijt, et al. 1995:120).

Margins. A debitage margin is considered intact if the distal end exhibits a feather, hinge, or plunging termination, and any lateral breaks do not interfere with the measurement of the width. A complete flake is a piece with a complete striking platform, intact lateral margins, and a feather, hinge, or plunging termination. A piece with a complete striking platform and incomplete lateral margins and/or a step termination is classified as a proximal fragment (Kuijt, et al. 1995:120; Sullivan III and Rozen 1985:759).

Medial and Distal Fragments. A medial fragment is absent a striking platform and possesses a step termination, but portions of the lateral margins are present, the ventral/dorsal surfaces are discernible, and the direction of force is apparent. A distal fragment lacks a striking platform, but possesses an intact termination other than stepped, and is broken medially.

Log-Linear Model

Patterson (1978, 1982, 1990) argued that the pattern of flake size distribution may be employed to discern bifacial reduction activities on archaeological sites, especially if bifacial artifacts representing different stages of completion are absent. An irregular pattern of distribution may indicate a different lithic reduction activity, such as core reduction, or that a mixture of debitage from different manufacturing processes is present in the debitage assemblage. Patterson's (1990) model is based on debitage assemblages derived from bifacial and core reduction experiments.

Patterson (1990) determined that bifacial reduction produced a concave curve form when percentages of size classes are plotted on a simple linear graph. In bifacial reduction, smaller flake size percentages are greater than those of larger flake sizes (Figure 4.6). The characteristic concave curve is obtained whether the assemblage represents one bifacial reduction event or a combination of such events. Flake size distributions for other lithic reduction activities, such as core reduction, are different from bifacial reduction and give an irregular pattern when graphed (Figure 4.7). Patterson (1990:551) argues that only bifacial reduction produces an exponential flake size distribution curve.

Patterson (1990:551) concluded that a semi-log linear type of equation best fit the exponential curve produced by his experimental data. The equation is:

$$log\ (P)=a+bS,$$

where P = percentage of total flakes, S = flake size, a = the Y intercept when X is 0, and b = the slope. If bifacial reduction is represented by the assemblage, it will take the form of a fairly straight line with a negative slope when plotted on semi-log paper or produced by a computer program (Figure 4.8). The *Y* axis is plotted as a logarithmic scale of percent of total pieces of debitage and *X* axis is a linear scale of flake size classes.

The procedure is fairly straightforward with debitage sizes quantified through the use of size templates (Patterson 1990), various sized screens (Baumler and Downum 1989; Behm 1983), or individual measurements. The percent of total flakes for each size class is calculated and arranged in a table. Patterson (1990: 553) used classes with five mm intervals with the size class 10-15 mm being the smallest. He utilized this flake size interval since he concluded that larger intervals are too coarse to obtain a precise curve. Flakes of less than 10 mm were eliminated due to the incomplete recovery of these pieces with the 1/4 in screen commonly used in archaeological excavations.[4] All mathematical calculations and graphing were accomplished with the mid-point of each size class (e.g. 10-15 mm = 12.5 mm).

In his review of debitage analysis, Shott (1994:91-95), who praised the clarity and simplicity of this model, tested the log-linear model on the published data sets of Baumler and Downum (1989), Behm (1983), and Tomka (1989), among others. He demonstrated that Behm's (1986:Table 1) data on biface reduction generally fit the log-linear model, with concave distributions and fairly straight lines upon conversion to a logarithmic percentage, with steeper negative slopes for more advanced reduction. However, Baumler and Downum's (1989:Table 1) data on core reduction also yielded a concave distribution contradicting Patterson's corollary that other types of lithic reduction will yield irregular distributions. Tomka's (1989:Table 1) core reduction data

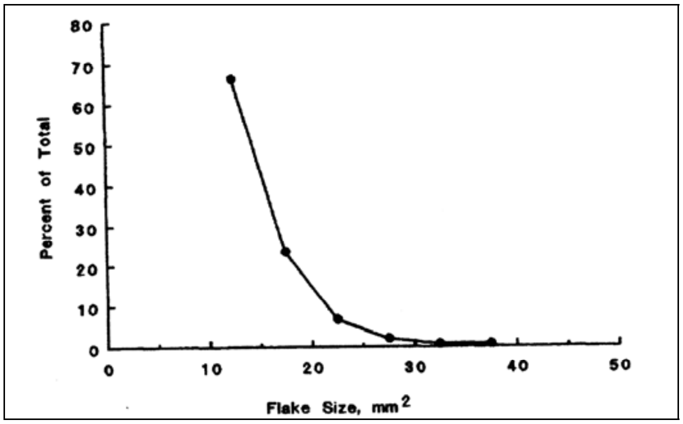

Figure 4.6. Patterson's (1990: Figure 1) flake-size distribution for bifacial reduction, Exp. 1I.

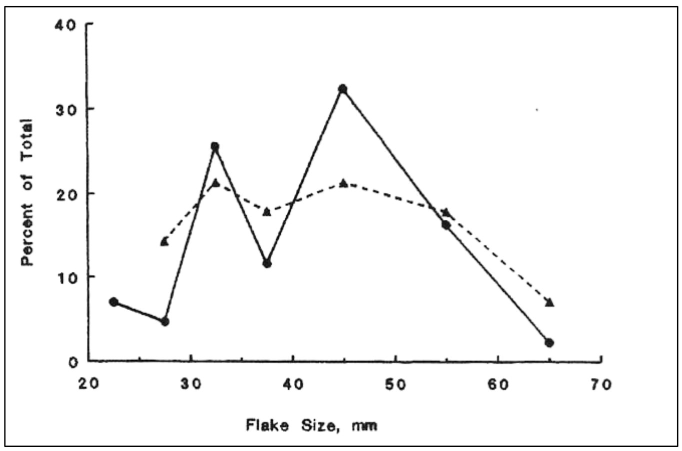

Figure 4.7. Patterson's (1990: Figure 2) flake-size distribution for primary reduction of two platformed cores.

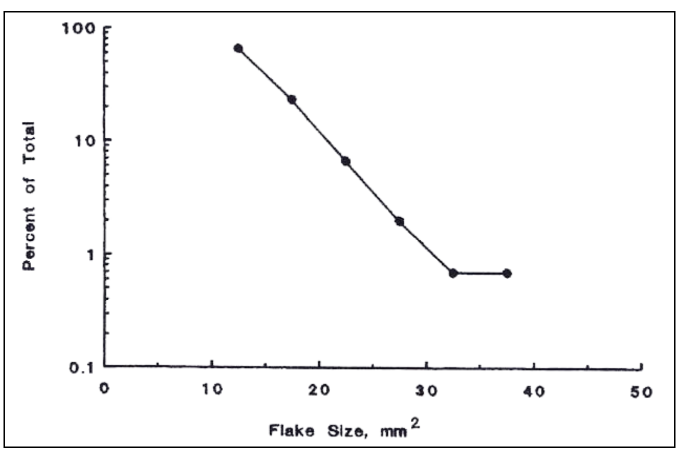

Figure 4.8. Patterson's (1990: Figure 3) semi-log plot of bifacial reduction, Exp.1I.

does produce an irregular pattern but so does his dart manufacture data (Shott 1994:Figure 4). It must be noted that Tomka (1989:137) screened his experimental assemblage with a quarter-inch hardware cloth, thus only partially collecting the smaller size class 1-10 mm, while Baumler and Downum (1989:104) and Behm (1986:12) utilized screens as small as one mm and 3.3 mm respectively, thus capturing a much greater proportion of smaller sized flakes. However, Shott (1994:94) concluded, while the model was promising, the conflicting results derived from some data sets required the model undergo additional experimental study.

In the Middle Atlantic region the log-linear model was applied to both local pebble and imported lithic materials at the Lums Pond site (7NCF-18) Early Woodland component, (Petraglia, et al. 1998) and the Archaic-Middle Woodland (Petraglia, et al. 2002) Hickory Bluff Site (7CK411), both in Delaware. At Lums Pond the results gave a concave curve with some variation between the local pebbles and imported Iron Hill Jasper (Figure 4.9). The percentages were plotted on a semi-log graph. The results suggested that bifacial reduction was a major lithic activity at the site, especially for the imported Iron Hill Jasper (Petraglia, et al. 1998:355-356). At Hickory Bluff 588 cores (340 multidirectional and 248 bipolar) were recovered (Petraglia, et al. 2002:Table 12.31) along with partially completed bifaces. The large number of cores would seem to suggest that flake production was a major activity at this site. However, the graphing of the debitage size classes also produced concave curves for all of the pebble material (Figure 4.9). This is the same confounding result obtained by Shott (1994) for some core reduction data. No experimental knapping with the local pebble cherts and quartz was undertaken to produce a baseline for comparison in either study.

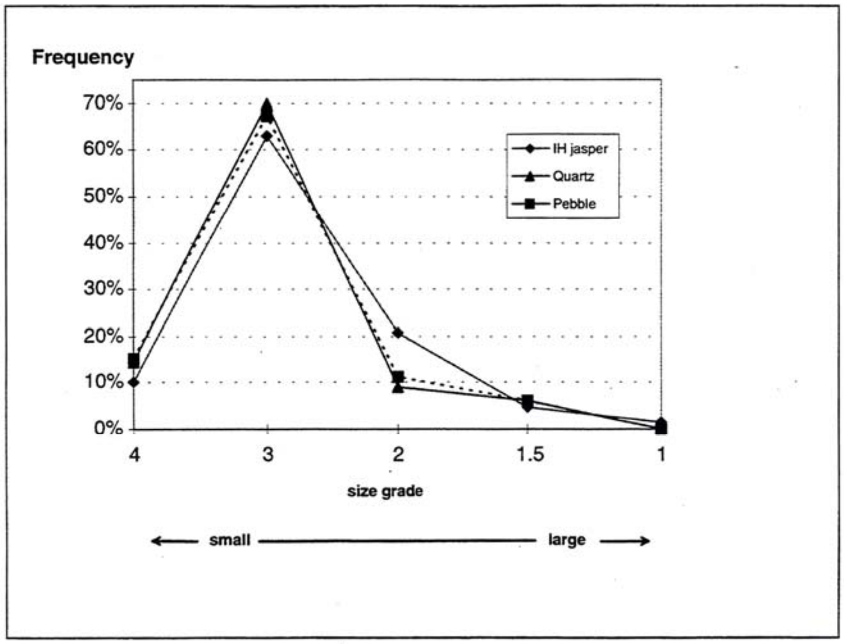

Figure 4.9. Size grade frequencies of debitage by raw material type recovered from Area 1, Lums Pond (7 NC F-18). Size Grades as follows: 1=2.54 cm; 1.5=2 cm; 2=1.27 cm; 3=.64 cm; and 4=.33 cm (Petraglia et al 1998: Figure 98).

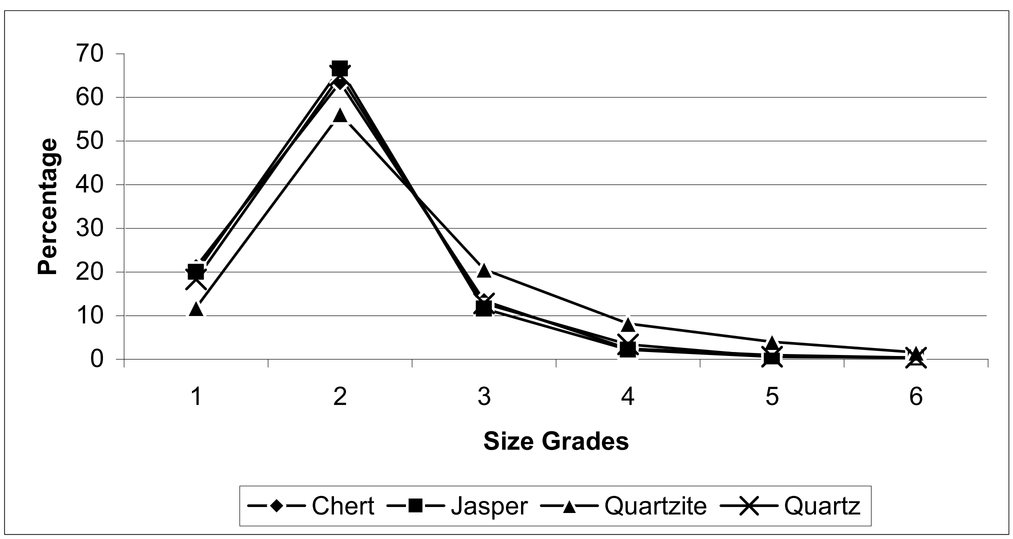

Figure 4.10. Size grade frequencies of debitage by raw material type recovered from Hickory Bluff (7 CK 411). Size Grades as follows: 1=<10 mm; 2=10-20 mm; 3=20-30 mm; 4=30-40 mm; 5=40-50 mm; and 6=>50 mm. Adapted from Petraglia el al (2002: Figure 13.16).

In this study, experimental debitage resulting from biface and scraper production was measured individually (see Table 4.5 for key to measurements). Following Tomka (1989:145), a maximum dimension was utilized in all calculations. This was computed with the "Transform" function of SPSS which selected the larger of the three possible linear measurements. The procedures followed those of Patterson (1990) with five mm intervals, a midpoint of individual size class ranges used for all computations and graphing, and only debitage 10 mm or larger was included in this aspect of the study. Graphing was accomplished with SPSS and Excel computer programs.

In order to compare the debitage derived from the tool manufacture experiments in this study to those generated by freehand and bipolar reduction, data from Mohney's (2004) reduction of 24 river pebbles (12 bipolar and 12 freehand) to obtain flakes were used to compute the reduction curves for these processes. In Mohney's (2004) experiments, flakes were classified by SRT category. All complete flakes were measured in all three linear dimensions, while the other categories were measured to obtain only a maximum size. All Mohney's (2004) flake measurements for individual pieces were converted into size classes in this study utilizing the greatest linear dimension or the maximum size. All computations and graphs of these size classes were produced as discussed above.

Flake Terminations

Four flake termination types generally recognized by flintknappers and lithic analysts were recorded separately for each platform bearing flake (Cotterell and Kamminga 1987:684; Crabtree 1972:22). Three of the types, feather, hinged, plunging (also referred to as overshot or outrepasse') terminations, are found on the distal ends of complete flakes. The fourth type, a step termination, is an indicator of an incomplete flake, which was either broken in the knapping process or by taphonomic processes such as trampling (Cotterell and Kamminga 1987:691). The mechanics (arc of detaching blow and the force exerted downward and outward) responsible for these terminations differ from each other and tell us something about the forces involved in their detachment (Cotterell and Kamminga 1987:698; Whittaker 1994:106-109). Wenzel and Shelley (2001:118) concluded that high frequencies of step and hinge terminations were indications of poor or low quality raw materials, which is a problem encountered in the Delaware Bay gravels collected for experiment. Dibble and Whitaker (1981:287-289), in their experiments, found that exterior platform angle most greatly effects termination type. As a result, they concluded that core morphology is the key to termination types produced by knapping. Based on geometry, they reasoned that convex surfaces were likely to result in the most feather terminations.

Terminations are important, in that they tell us something about the raw materials, skill of the knapper, and the detachment forces. Feather terminations are desired, in that they allow subsequent detachments of flakes from the core to proceed smoothly. Step and hinge terminations leave irregularities that are obstacles to knapping. Overshot terminations result in material taken from the opposite face of the core, providing an impediment to further knapping (Whittaker 1994:106-109).

The following discussion of the four termination types (Figure 4.11) is based on the work of Crabtree (1972) and Cotterell and Kaminga (1979; 1987). A feather termination results when the crack that forms the flake moves parallel to the side of the

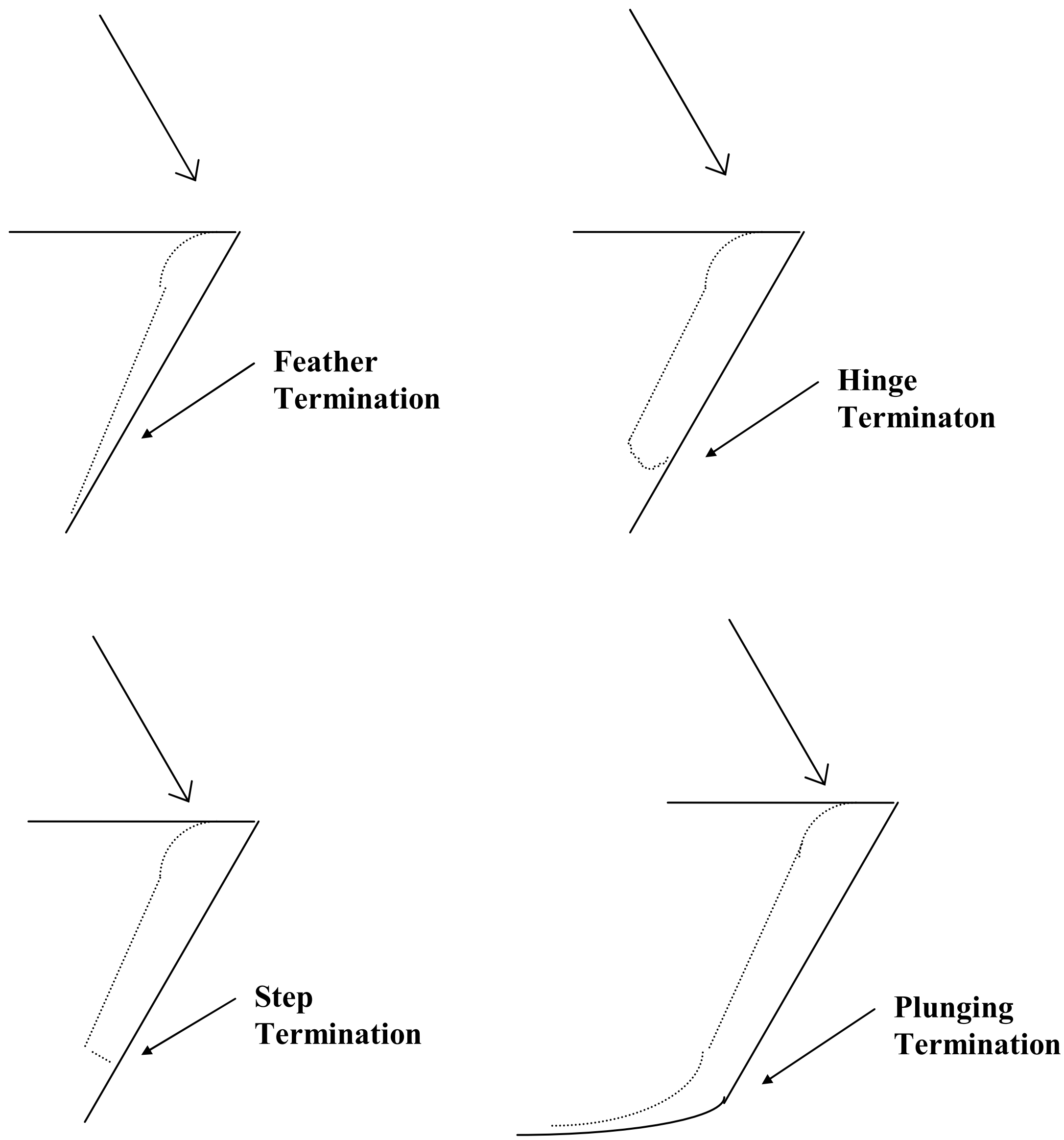

Figure 4.11. Flake termination types (illustration after Whittaker 1994).

objective piece, and then turns slightly inward to result in a smooth sharp (feathered) edge. It is an indication that the force propagating the crack exited smoothly, and can be produced by a variety of force angles (Cotterell and Kamminga 1987:699). A step fracture terminates at a right angle break at the point of truncation of the flake (Crabtree 1972:93) It is the result of insufficient force in propagation of the initiating crack, or the result of a substantial flaw in the raw material (Cotterell and Kamminga 1987:700). A hinge fracture terminates a flake at right angles to the long axis with a rounded or blunt break (Crabtree 1972:68). This termination is usually the result of an increase in outward pressure in the initiation of the flake. It often occurs on a detached piece taken from a flatish face of the objective where the resulting wider flake dissipates the force of propagation (Cotterell and Kamminga 1987:700-701). A plunging termination occurs when the distal end plunges or turns into the objective piece. The distal end of the objective piece detaches as part of the flake, and the process is intensified if the objective piece ends in a sharp corner (Cotterell and Kamminga 1987:701). Cotterell and Kaminga (1979:106) reported Crabtree's observation that in pressure flaking it often occurs when the indentor is placed too far from the face of the objective piece, thus directing the propagating crack toward the end of the piece. If the objective piece is a biface, a remnant of the bifacial edge will be present on the proximal end.

Weight and Linear Dimensions

The variables of length, width, maximum thickness, and weight were selected as indicators of the stage of reduction. Magne and Pokotylo (1981:38) concluded that weight covaries with linear measurements, and it is the most important single size variable used to indicate reduction stages. However, linear flake size is also an effective indicator of reduction stages and different reduction types (Amick, et al. 1988; Mauldin and Amick 1989; Odell 1989; Stahle and Dunn 1982). The four attributes are relatively easy to measure and replicate. They may be statistically analyzed individually, or in combination, to investigate their usefulness as indicators of the stage of reduction, or to discriminate between reduction types.

Measurements of length, width, and thickness were taken for all complete flakes and proximal fragments or platform remnant bearing (PRB) flakes (Magne and Pokotylo 1981:35). Length and width were measured with the ventral portion facing the analyst, the proximal end up, and the distal end down. The point of impact and the striking platform were used to orient the measurements of length and width, to ensure consistency of measurement and replicability (Figure 4.12). All linear measurements were made with a stainless steel Mitutoyo dial caliper to within .05 mm.

Weight. All debitage pieces were weighed on an Ohaus LS200 digital scale to within .1 g.

Length. Length was measured from the point of impact in a line perpendicular to the width of the striking platform from the proximal to the distal end (Figure 4.13).

Width. Maximum width was measured in a straight line perpendicular to the line of flake length measurement at the widest point of flake (Figure 4.13).

Thickness. Thickness was measured as the maximum distance from the ventral to dorsal side perpendicular to the line of flake length measurement.

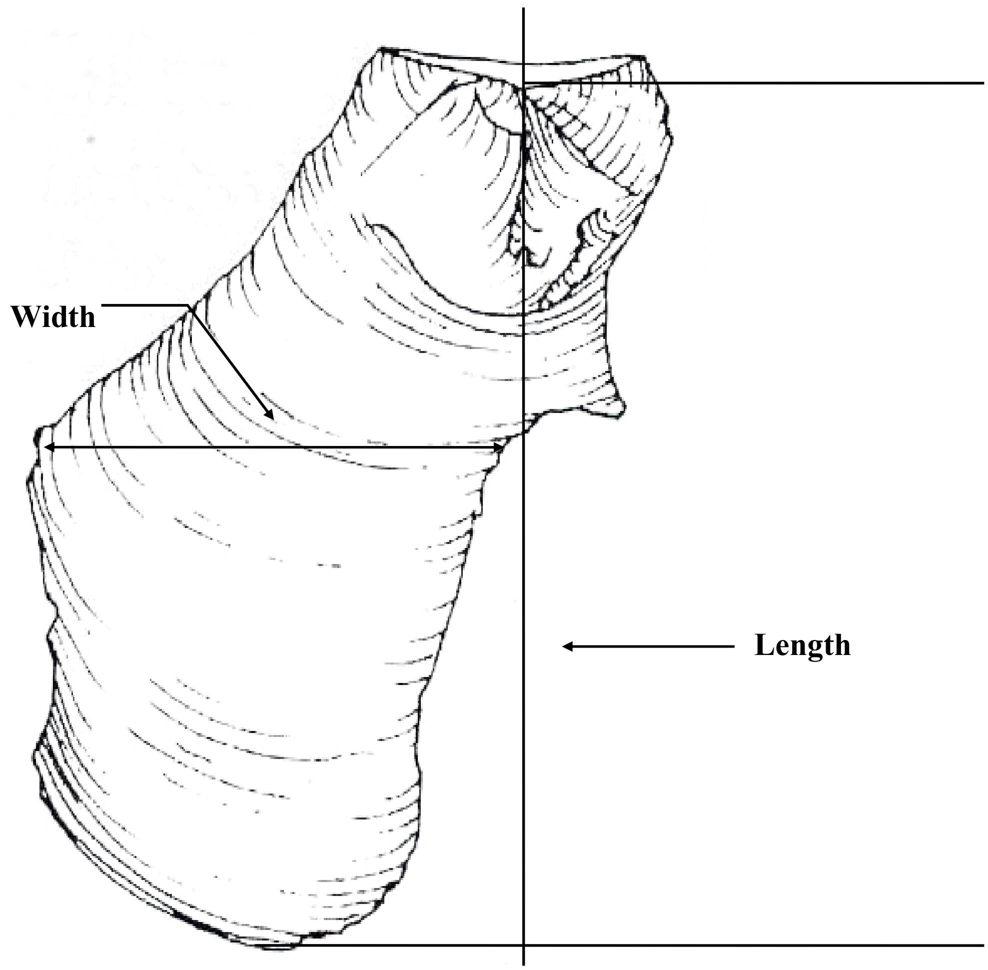

Figure 4.12. Linear measurements for length and width (illustration adapted from Andrefsky 1998).

Striking Platforms

A striking platform is the table or surface area of a flake that received the force to detach it from the objective piece (Crabtree 1972:84). This feature is often present on the detached flake, and contains the point of applied force. It is a key attribute of debitage and has been typed and measured in a variety of ways (Andrefsky Jr. 1998:88-96; Magne and Pokotylo 1981:Table 6; Shott 1994:80-81). Striking platforms have been categorized by type and number of facets or scars, as well as measured for length, width, and thickness, and exterior and interior platform angles.

The relatively small size of the Delaware Bay gravels used by the indigenous residents of KBS and in the knapping experiment (Table 4.1) impose constraints on the types of measurements and counts that can accurately be conducted on the resulting small sized debitage (less than 2.5 cm). Although external striking platform angles were successfully shown to vary inversely with reduction stages (Dibble and Whittaker 1981), they are very difficult to measure (Pelcin 1997b:755; Shott 1994:80). Many platform angles studies are the product of controlled experiments with uniform cores (Dibble and Whittaker 1981; Pelcin 1997a; Pelcin 1997b; Pelcin 1997c). The resulting flat platforms from these experiments were relatively easy to measure for platform angle. Since most platforms have a rounded or slightly irregular shape, it is difficult to find a position on the platform that intersects the dorsal surface that can be measured and replicated. Andrefsky (2001a:10-11) reported that in experiments at Washington State University, analysts were not able to replicate platform angle measurements that they had made previously on the same pieces of debitage. These difficulties would only be exacerbated with the small size of the debitage. It was the consideration of these factors that led this analyst to reject the idea of using platform angles.

The number of facets on a platform have been used successfully to infer stages of reduction, and to separate core from biface reduction (Magne and Pokotylo 1981; Morrow 1984; Tomka 1989). As with platform angle measurements, there are problems associated with the determination of this attribute. The first difficulty is in actually distinguishing what is a facet. Often there are minute step fractures and facets on a platform, which make it difficult to arrive at an accurate and replicable count. If it could be determined exactly what constitutes a facet, the small size of the debitage makes counting, even with a 10X magnification, a difficult task. It would appear that platform angle and scar count might be more easily applied to an assemblage of flakes greater than 2.5 cm, but the preceding caveats would still apply.

This study uses platform types augmented with measurements of width and thickness. In addition, the absence or presence of a platform lip and crushing at the point of impact was recorded for each piece of debitage with a striking platform. Platform angles were eliminated due to the difficulty of measurement, and a typology was constructed that will differentiate between single and multiple facet platforms without actually having to count the number of facets, or differentiate between the various scars, facets, and step fractures found on a platform.

Striking platforms have been categorized by type to infer biface reduction stages and to differentiate core from bifacial reduction (Andrefsky Jr. 1998:89; Gilreath 1984; Parry and Kelly 1987:290-292; Shott 1994:80; Whittaker and Kaldahl 2001:54). However, a major difficulty arises in the definition of types; depending on the criteria used to discriminate types, there can be a potentially large number of platform types. Following Andrefsky (1998:92-96), a four part platform typology (cortical, flat, faceted, and abraded) was chosen that encompassed the variety of platforms represented in the knapping experiment and the archaeological assemblage. Gilreath (1984) found that the bifacial reduction of an obsidian cobble resulted in the highest proportion of cortical platforms in the first stage of reduction. In the Gilreath study, the six platform types, coupled with the degree of platform preparation, produced the highest correlation in a discriminant analysis used to identify reduction stages. The early stages of bifacial reduction of small cortex covered gravels would appear intuitively to also produce the highest number of cortical platforms. However, in the knapping experiment, the bipolar method was used to produce either a split pebble or flake blanks in the Blank stage and both forms possess potential non-cortical striking platforms (see Figures 5.17 and 5.18). Consequently, it was anticipated that Preform I and II stages would possess high proportions of flat platforms. It would be expected that bipolar reduction of pebble gravels to produce flakes for expedient tools will produce relatively higher proportions of cortical platforms (Koldehoff 1987:166).

Crushing at the point of applied force or point of impact is considered a trait of hard hammer percussion (Crabtree 1972:44). This assertion is only partially borne out by Hayden and Hutchings (1989:247-248), who found that in their experiments crushing was almost always a by-product of hard hammer percussion, although it was not produced in every case. Sixty five percent (Hayden and Hutchings 1989:Table 3) of the experimentally produced hard hammer flakes had some characteristic crushing at the point of applied force. Callahan (1979:91) observed that crushing of platforms with a hard hammer was common, especially with smaller platforms. Chandler and Ware (1976:25) concluded that crushing at the point of applied force is one of the most effective means of discriminating percussion flakes from pressure and soft hammer flakes.

Lipping has been shown to be rare on hard hammer flakes (Hayden and Hutchings 1989:Table 3; Henry, et al. 1975:Table 1), but relatively more frequent on pressure and soft hammer flakes (Odell 1989:Figure 3). Whittaker (1994:185) views a ventral platform lip, along with other morphological characteristics, as characteristic of a bifacial thinning flake. Lipping by itself cannot be used to identify an individual flake as to the means used to detach it from the objective piece, but in concert with other variables it may be used to discriminate between flake populations. This attribute is relatively easy to assess (Figure 4.13), and its identification by data collectors has proven to be highly replicable (Odell 1989:167-168).

The relative proportions of crushing and lipping considered together should aid in the differentiation of hard hammer from pressure and soft hammer flake populations, and hence, give an indication of which manufacturing stages in biface production are represented in the assemblage. A relatively high proportion of crushing and a low percentage of lipping would be indicative of hard hammer percussion and early stage reduction. Conversely, a high proportion of lipping relative to crushing would indicate pressure or soft hammer flaking as the primary means of detachment used in the later stages of reduction. Relatively high proportions of both in an assemblage would indicate a mixed flake population, suggesting that the complete process of biface manufacture took place at this location.

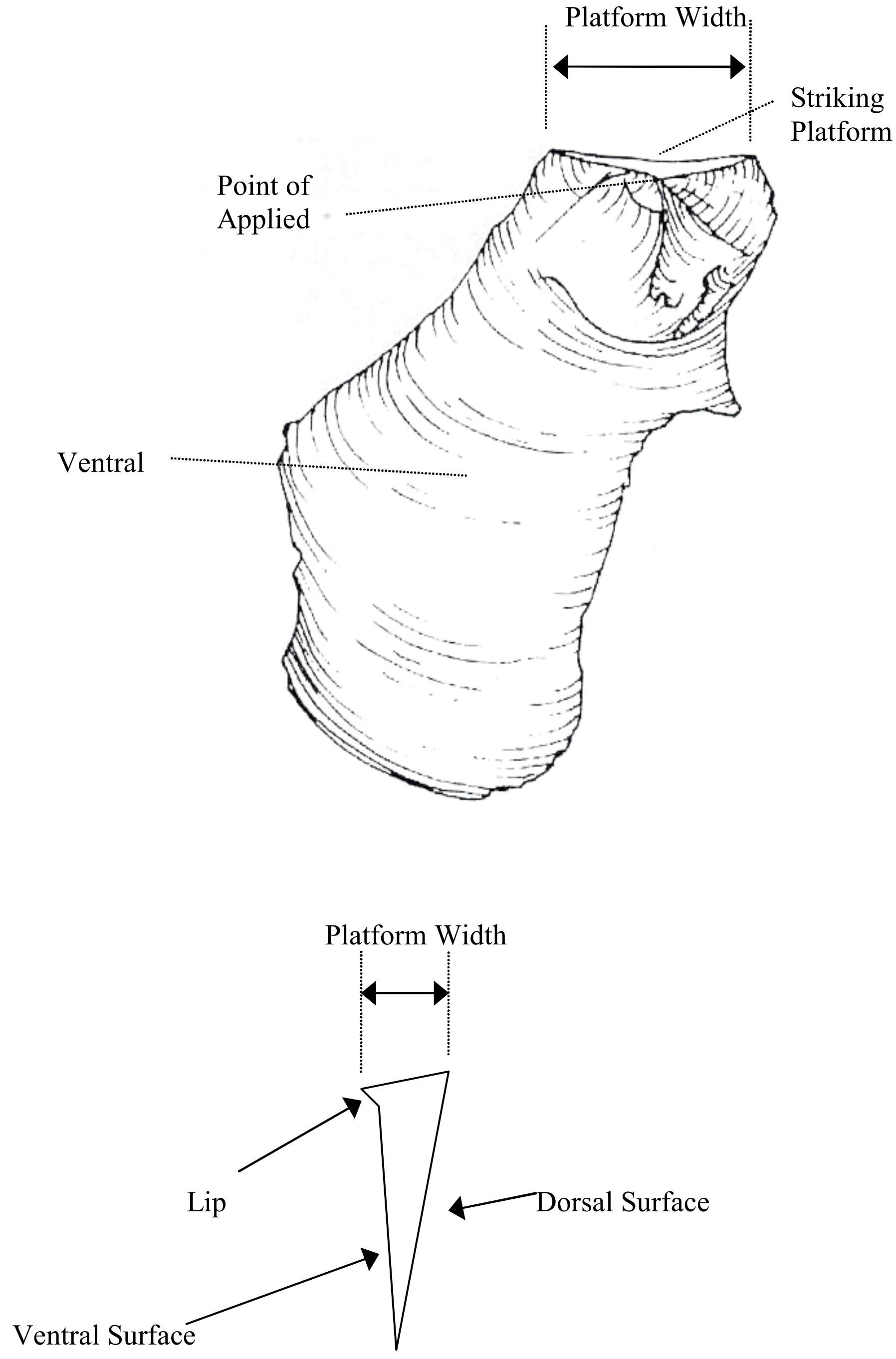

Figure 4.13. Measurements of platform width and thickness and locations of striking platform, lip, and point of applied force. Illustration adapted from Andrefsky (1998).

Platform width and thickness have shown to be effective in discriminating between reduction strategies and bifacial reduction stages (Odell 1989:185). Chandler and Ware (1976:25) found that platform size was one of the best variables to discriminate between percussion and pressure flaking. Magne and Polotylo (1981:36) demonstrated that striking platform width correlates well with other measures of size and varies between early and late stages in biface reduction. Dibble (1997:154) found that flake weight increased with platform width and thickness. He reasoned that platform area, which he calculated by multiplying platform width and platform thickness, would retain the influence of both in a single variable. This relationship held true in both experimentally produced flakes and those from archaeological assemblages (Dibble 1997:156). Striking platform width and thickness are easy to measure and replicate (Andrefsky Jr. 1998:92), and were included in the initial analysis (Figure 4.13).

In the following the striking platform types and measurements used in this phase of the research are described.

Platform Types. The four platform types chosen for this study are cortical, flat, faceted, and abraded. A platform type identification key is shown in Figure 4.14.

A striking platform is considered cortical if it consists entirely of the unmodified remnant cortex from the pebble or cobble from which it was struck, except for crushing. No preparation is evident on the platform. A flake with a cortical platform may have a 100 percent cortex on its dorsal surface, as in the case of freehand hard hammer reduction of a gravel for biface production or in production of flakes through bipolar core reduction (Johnson 1989:127). A cortical platform may be produced by detaching a piece from the

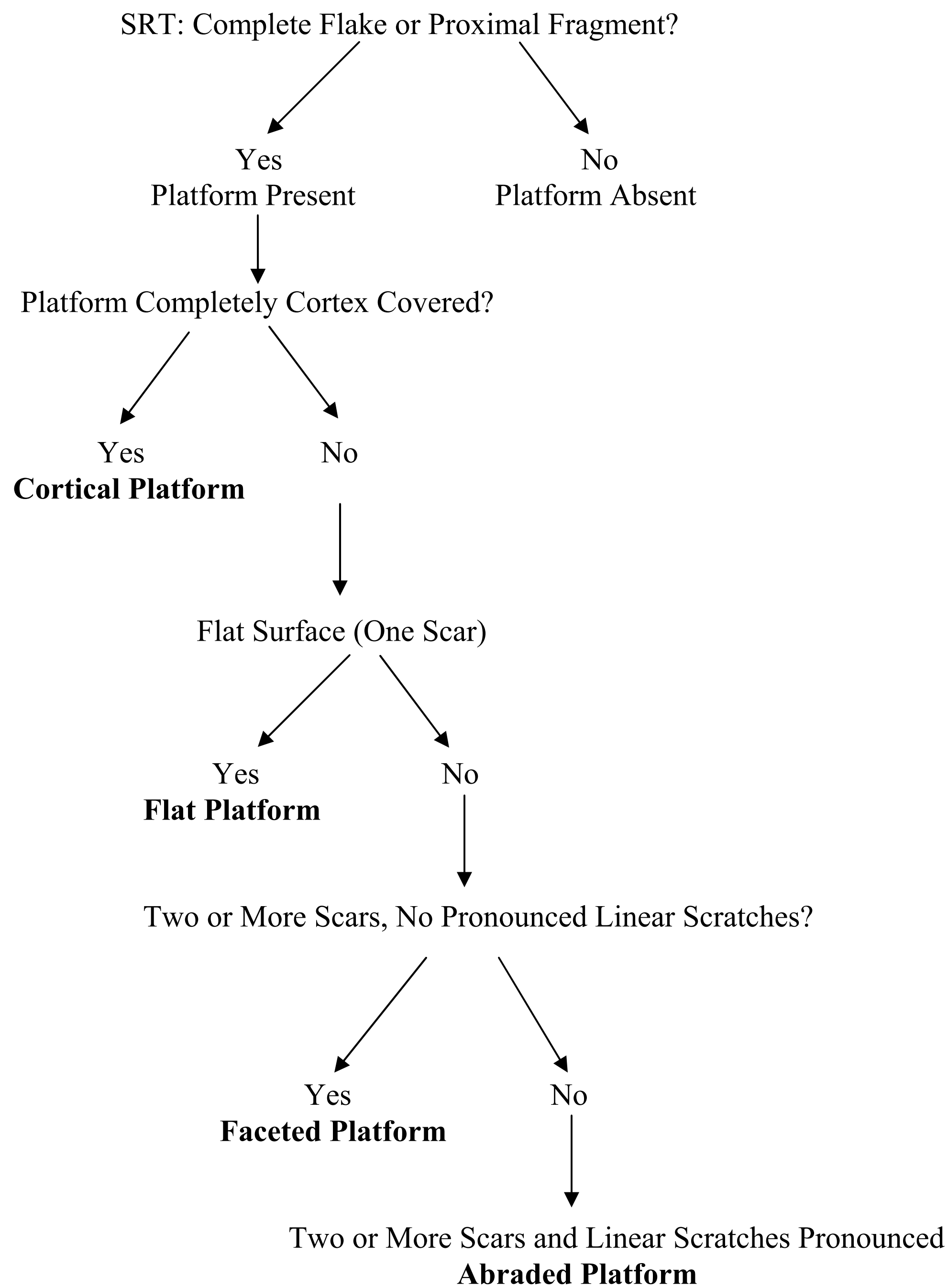

Figure 4.14. Platform type identification key. Types shown in bold print.

dorsal surface of a split pebble, but in this case the dorsal surface of the derived flake should have little or no cortex.

A flat platform has a relatively smooth flat surface. It is normally associated with flake removals from unidirectional cores (Andrefsky Jr. 1998:95). In this experimental assemblage, it is expected that flat platforms with some amount of dorsal cortex will be indicative of early stage bifacial reduction of split pebbles and flake blanks.

A faceted platform is one that consists of two or more facets or scars from previous removals. This type of striking platform may be rounded with numerous small facets and step fractures. Due to the difficulties previously discussed, no attempt is made to count the actual number of facets. A platform with some remnant cortex, but with multiple facets will be considered a faceted platform. Discerning between one facet and two or more is easily accomplished and replicable. Multi-faceted platforms are considered to be indicative of the later stages of biface manufacture, as they bear the scars of previous flake removals and trimming (Gilreath 1984; Morrow 1984:21). Magne and Pokotylo (1981:38) concluded that platform scar count was one of the most useful indicators of stages of core and bifacial blank reduction in their experiments.

An abraded platform is multi-faceted with visual evidence of grinding to strengthen the platform. This preparation is usually prior to pressure and soft hammer flaking. The grinding or abrasion is evidenced by pronounced linear scratches, smoothing, and rounding on the platform and is readily discernible from a non-prepared faceted platform under 10X magnification. In the knapping experiment for this project, Cresson lightly abraded the edges of the biface with a piece of sandstone or a quartzite hammerstone just prior to pressure flaking. This action consisted of one or two light strokes parallel to the edges of the piece. This study has noted little in the way of evidence for abrading on the flakes examined from other areas of the site and from the preliminary examination of the debitage from the beach face assemblage. Cresson's practice is consistent with other flintknappers (Crabtree 1975:8; Whittaker 1994:167-176). Platform grinding is considered a sign of the late stage manufacture of bifaces (Gilreath 1984; Morrow 1984:21).

Crushing. Crushing occurs when the stone directly below the point of applied force or point of impact is pulverized (Hayden and Hutchings 1989:240). In addition to the crushed appearance, the area of the point of applied force often manifests a crazed, whitish look.

Lipping. A lip is an extension of the striking platform on the ventral surface below the point of applied force. To be considered a lip, it must be associated with the detaching force, rather than as a result of flaws in the raw material (Odell 1989:192-193). If the projection is capable of stopping a fingernail drawn along the ventral surface just underneath the striking platform, is it considered a lip.

Striking Platform Width and Thickness. A striking platform contacts the dorsal and ventral surfaces as well as the lateral flake margins (Figure 4.13). The striking platform width is measured as a distance across the striking platform from lateral margin to lateral margin. Striking platform thickness is measured as a maximum distance from the dorsal to ventral surfaces on a line perpendicular to the striking platform width (Andrefsky Jr. 1998:92; Odell 1989:190-191). All measurements were taken with a caliper on complete flakes and proximal fragments and recorded to the nearest .05 mm.

Dorsal Cortex

One of the fundamental principles in lithic analysis is that stone tool manufacture is a reductive process (Collins 1975:19). Because the exterior of a piece of weathered stone must be removed in the reduction of any pebble, cobble, or boulder, the initial flakes produced will contain cortex on their dorsal surface. As the reduction process continues, succeeding flakes will have less and less cortex, until flakes removed from the interior will have no remnant cortex on dorsal surfaces. It is inferred that cortex on the dorsal surface of flakes is indicative of early stages of reduction while those with little or no dorsal cortex are products of later stages (Andrefsky Jr. 1998:101-102).

Cortex cover was among the most important variables found by Magne and Polotylo (1981:40) to discern stages of biface manufacture, especially to distinguish the initial stages. Amick, et al. (1988:33) also found it valuable in discriminating early stage reduction. Odell (1989:185) found that analysis of cortex cover can be used to differentiate between the earliest and latest stages of biface and core reduction sequences. Tomka (1989:141-142) discovered that dorsal cortex percentage could distinguish between multidirectional cores, dart points produced from flake blanks, and bifaces manufactured from a cobble. Mauldin and Amick (1989:72-73) utilized dorsal cortex percentage combined with size categories based on maximum flake dimension to discriminate between reduction stages in the production of bifacial blanks from cobbles. A study of the Hickory Bluff site (7KC411) on the OCP of Delaware employed percentage of cortex cover and size grades to infer the completeness of reduction trajectories (Petraglia, et al. 2002). Johnson (1989:Table 3) and Morrow (1984:Figure 1) utilized percentage of cortex cover classes, in conjunction with platform types, to discern the length of biface production trajectories in gravel based lithic industries. Generally, cortex percentages amounts recorded for individual flakes proved to be a useful variable in debitage analysis especially when combined with size and platform types.

The measurement of the percent of cortex cover presents some difficulties. All of the referenced studies used percentage categories of cortex cover, such as the six categories of 0, 1-25, 26-50, 51-75, 76-99, and 100 percent (Magne and Pokotylo 1981:Table 6). The number of categories varied from three (Johnson 1989; Morrow 1984), to four (Odell 1989; Tomka 1989) to six (Magne and Pokotylo 1981). However, a problem exists in discriminating between the percentage classes, especially in six class categories. Although the two extremes of zero percent cortex and one hundred percent cortex are simple to discern, it is more difficult to differentiate the intermediate classes. It is apparent that attempting to discern between 23 percent and 27 percent, which represents two distinct categories, would be extremely difficult. Andrefsky (1998:102-103) recommends the use of a mechanical device such as a computer digitizer to solve this problem. However, this solution is prohibitively expensive in terms of money and time for any sizable collection of flakes. It with this in mind that a four part typology used by both Odell (1989) and Tomka (1989) was chosen, which requires an assessment of no cortex present, complete cortex, and categories of 1-50 percent and 51-99 percent.

<u>Cortex Categories</u>. Each individual flake was classified into one of four categories based on the amount of dorsal cortex present. It is an ordinal variable in which the two extremes of remnant cortex are coded as “0”, for zero cortex and “3”, for 100 percent cortex. Thus, the higher the number, the greater the amount of remnant cortex on a flake. The two intermediate categories are coded as “1” for 1- 50 percent

cortex and “2”, for 51-100 percent cortex. It is relatively easy to place flakes in these categories; only in discriminating between categories “1” and “2” is there any potential difficulty. A dot grid normally used in computing areas on maps and aerial photographs, can effectively be used on flakes when it is difficult to distinguish between these categories (Andrefsky Jr. 1998:Figure 5.12). However, the 50 percent dividing line between the categories was easy to assess, and it was not necessary to use this method. Remnant cortex on the striking platform was not considered when assessing flakes for this attribute.

Dorsal Flake Scars

The number of dorsal flake scars, as with dorsal cortex, varies with the reduction stage of an objective piece. In this case, however, dorsal flake scar count varies inversely with the stage of reduction. The early stages produce flakes with either all cortex or cortex with a single scar, while in the later stages flakes contain progressively less cortex but multiple scars, until there is no cortex present and only multiple scars from successive flake removals (Andrefsky Jr. 1998:104-107; Magne and Pokotylo 1981:36). Magne and Poklotylo (1981:38 and 40) found that dorsal scar count was among the key variables useful in discriminating bifacial reduction patterns, while Odell (1989:178) found it had only limited usefulness for discriminating between stages of biface manufacture.

Mauldin and Amick (1989:73-76) discovered that the general pattern of increasing number of flake scars as reduction progresses was confounded by the size of the flakes. Larger flakes produced in the earlier stages of bifacial core reduction tended to have more scars than smaller flakes produced later in the sequence. Thus, the relationship of dorsal scar count to bifacial reduction sequences is not as straightforward as it first appears. Their study does suggest that dorsal scar count combined with the percentage of cortex cover can effectively model bifacial core reduction. This study also indicated that the number of flake scars over two did not significantly alter the frequency of cortex cover.

Counting flake scars from deliberate flake removals can be complicated by shattering, breaks, and the occurrence of small scars that emanate from the platform during percussion flaking. Mauldin and Amick (1989:74) attempted to solve this problem by counting only flake scars five mm in length. The small size of the debitage from both the experiments and the Kimble's Beach assemblage made measurement of scar length problematic. It was decided to proceed, as with faceted platforms, by limiting the count to easily discernible occurrences most likely to possess potential significance for the analysis. Considering the findings of Mauldin and Amick (1989:74-75) noted above, the largest flake scar count category was more than two flake removals.

<u>Dorsal Flake Scar Categories</u>. This study utilized an ordinal scale with four flake scar categories. The categories are complete cortex, one scar, two scars, and more than two scars. A dorsal surface completely covered with cortex was coded as "0". A dorsal surface with one scar was coded "1" , two flake scars was coded "2", and more than two flake scars was coded "3". Following Odell (1989:194-195) only scars that possessed features such as points of applied force, negative bulbs of percussion, or terminations and scars separated by dorsal ridges were counted. Scars resulting from edge damage emanating from a margin (either before or after the flake was removed), breaks, and ridge

scars were eliminated. All of the categories were relatively easy to ascertain and replicable.

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1. Flake typologies still remain useful tools in lithic analysis. Barber (2004) employed flake morphology to infer the completeness of lithic reduction sequences on Late Woodland sites in Virginia while Boisvand Bennett (2004) utilized distinctive debitage associated with the manufacture of parallel flaked bifacial tools to discriminate Paleo-Indian deposits from those of the Archaic period. Scott (1991) made use of flake typologies to differentiate lithic reduction activities when mass analysis (Ahler 1989) of debitage from seven sites in Oregon indicated that the same lithic reduction process occurred at these obviously different site types.

2. These sprats were a cause of concern since no visible signs of their attachment were apparent on the cortex of any lithic artifact in the assemblage. Oysters were present in the faunal assemblage so a similar pattern likely existed in the Late Woodland period. The Haskins Shellfish Resource Laboratory, Rutgers University indicated that few of these sprats are ever preserved and undoubtedly those found on the artifacts decayed away unlike the shell of the mature form which can survive for 1000's of years (Eric Powell, personal communication 2003). The sprats were easily removed and could be eaten if one wished.

3. The terms heat-treatment and thermal alteration are often used interchangeably (Luedtke 1992:91). In this paper the process of intentionally heating stone to improve its flaking properties will be referred to as heat treatment and the resulting stone treated by this process will be referred to as thermally altered.

4. The separation of experimental flakes with a .25 in screen in this study verified this conclusion, as well as that of Kalin (1981) and Baumler and Downum (1989), that the greatest percentage of these smaller pieces (<10 mm) are not recovered with this size screen.

CHAPTER 5

ANALYSIS OF THE EXPERIMENTAL DEBITAGE

In this chapter of the study, the debitage derived from this project's experimental biface and uniface manufacture and Mohney's (2004) bipolar and freehand reduction of chert gravels to obtain usable flakes, were analyzed statistically. In the initial section, the data derived from both set of experiments were tested using Patterson's (1978, 1982, 1990) log-linear model to determine if the different reduction types could be separated. Next, the Sullivan and Rozen flake typology (Sullivan and Rozen 1985; Sullivan 1987) data were used with discriminant analysis to determine if it could be used to separate the debitage derived from tool manufacture from that of bipolar and freehand reduction to produce usable flakes. Then data from various debitage variables recorded (see Chapter 4, *Experimental Debitage Variables*) were analyzed to determine if they could be used to (1) separate biface from uniface manufacture, (2) discriminate between BRS stages, (3) establish the length of the biface reduction sequence, (4) determine the starting form, either split pebble or flake blank, in tool manufacture, (5) separate debitage produced by hard hammer percussion and pressure flaking, and/or (6) establish an experimental production rate of the amount of debitage produced by the reduction of one gravel in the tool making experiments and in the bipolar and freehand reduction experiments.

Appropriate statistical methods, both univariate and multivariate, were employed throughout the study. In some cases, variables were altered to improve their usefulness in providing answers to particular research questions. Dorsal cortex was collapsed into two and three categories, platform types combined into three types from four, and SRT combined into four categories from five. Platform types (3 categories) and dorsal cortex (3 and 2 categories) were combined into two new variables of platform types/dorsal cortex amount (6 and 9 categories). These changes were made when the variables, as originally constructed, violated the assumptions of statistical tests of confidence, or they made intuitive sense in answering the questions under consideration.

All analyses of the experimental debitage, both successful and unsuccessful, are presented along with the basic data used in each analysis. This was done so that future researchers may use the results in their own studies, correct any errors made in the statistical procedures employed or the interpretation of the results, and to provide a body of comparative data for use in new experiments, fresh analysis, and regional studies.

Log-Linear Results

In this portion of the study, the size class data derived from the flakes produced by the knapping experiments to manufacture tools for this study and Mohney's (2004) bipolar and freehand chert gravel reduction experiments to produce usable flakes were tested using Patterson's (1978, 1982, 1990) log-linear model to determine if these different reduction types could be differentiated. Following Patterson's (1990) log-linear model, debitage was partitioned into 10 size classes (size grades) of five mm intervals based on their greatest linear dimension. The classes ranged from 10-15 mm to 50-55 mm, with mid-points used in mathematical calculations and to plot graphs. Detached pieces produced as a result of the experiments that would be classified as a CSA (Appendices A and B) were not considered in the modeling. See Chapter 4, *Log-linear Model* for a more complete discussion. The size classes and midpoints used in this study are presented in Table 5.1

Table 5.1. Size Class Ranges and Midpoints.

Size Class	Size Range (mm)[1]	Midpoint (mm)
1	6.4-10	8.2
2	10-15	12.5
3	15-20	17.5
4	20-25	22.5
5	25-30	27.5
6	30-35	32.5
7	35-40	37.5
8	40-45	42.5
9	45-50	47.5
10	50-55	52.5

Note: Size class 1 not utilized in the plots or calculations.

The size class frequency and the percentage of the total flakes were computed for all pieces of debitage included in the study. They were first computed for each individual experiment. These results were then combined into totals for all biface and uniface experiments, and the biface and uniface results were combined into a single group. Biface experiment 3 and uniface experiment 16 were included, although they were abandoned due to breakage in manufacture and material defects respectively. Partially completed tools were also recovered archaeologically. The biface and uniface results are presented in Tables 5.2 and 5.3. The size class data derived from Mohney's (2004) experiments in bipolar and freehand reduction of alluvial gravels are presented in Table 5.4. Flakes less than 10 mm in greatest dimension were removed from the resulting debitage by Mohney. He reasoned that smaller flakes would be not be deemed useful as tools by prehistoric knappers.

Table 5.2. Frequencies of Experimental Debitage from Tool Manufacture for This Study in Size Classes.

Exp.#	Blank	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	Total Flks
3(bi)	flk	5 35.7	3 21.4	1 7.1	1 7.1	1 7.1	2 14.3			1 7.1	14
3a(bi)	flk	1 50	1 50								2
4(bi)	sp	12 42.9	6 21.4	4 14.3	3 10.7		2 7.1			1 3.6	28
6(bi)	flk	9 52.9	6 35.3		2 11.8						17
7(bi)	sp	32 49.2	20 30.8	5 7.7	6 9.2	1 1.5	1 1.5				65
9(bi)	flk	16 55.2	6 20.7	5 17.2		1 3.4		1 3.4			29
10(un)	flk	14 63.6	5 22.7	2 9.1		1 4.5					22
11(un)	flk	21 52.5	9 22.5	3 7.5	5 12.5	2 5.0					40
13(un)	sp	2 28.6	3 42.9	1 14.3	1 14.3						7
14(un)	sp	4 44.4	1 11.1	1 11.1	1 11.1	1 11.1		1 11.1			9
15(un)	sp	9 47.4	4 21.1	1 5.3	4 21.1		1 5.3				19
16(un)	[1]	19 51.4	7 18.9	10 27.0	1 2.7						37
17(bi)	sp	10 38.5	9 34.5	4 15.4	3 11.5						26
20(bi)	flk	7 31.8	9 40.9	3 13.6	3 13.6						22
21(bi)	flk	9 45.0	3 15.0	3 15.0	2 10.0	1 5.0		1 5.0	1 5.0		20
23(bi)	flk	16 76.2	4 19.0	1 4.8							21

Key to abbreviations: bi=biface; un=uniface; flk=flake; and sp=split pebble. [1]Free hand reduction from a whole pebble. The size class cells for each experiment contain the number of pieces in that class and the proportion of the total flakes for each experiment. Size classes in mm. experiment.

Table 5.3. Size Class Data for Composite Experimental Tool Manufacture for This Study.

	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	Total Flks
Biface Exps.	117 48.0	67 27.5	26 10.7	20 8.2	4 1.6	5 2.0	2 .8	1 .4	2 .8	244
Uniface Exps.	69 51.5	29 21.6	18 13.4	12 9.0	4 3.0	1 .7	1 .7			134
Totals Bi/Un	186 49.2	96 25.4	44 11.6	32 8.5	8 2.1	6 1.6	3 .8	1 .3	2 .5	378

Note: Size class cells present number and percentage data. Size classes in mm.

Table 5.4. Debitage Size Class Data from Experimental Bipolar and Freehand Core Reduction (Mohney 2004).

	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	Total Flakes
Bipolar	147 51.4	75 26.2	48 16.8	11 3.8	2 .7	2 .7	1 .3		286
Free-hand	151 53.9	76 27.1	33 11.8	12 4.3	5 1.8	2 .7		1 .4	280
Totals	298 52.7	151 26.7	81 14.3	23 4.1	7 1.2	4 .7	1 .2	1 .2	566

Note: Size class cells present number and percentage data. Size classes in mm.

The experimental size class data for bifaces and unifaces for this study were plotted on a linear graph (Figure 5.1). Both resulted in a concave curve with no remarkable irregularities. The same data with a semi-log plot (Figure 5.2) produced fairly straight lines for the upper end of the line in the first four class sizes in the 10-30 mm range. The lower end, or tail of the line, which represented the larger class sizes (30-55 mm) was somewhat irregular for biface debitage, and less so for the uniface data. The geometry of the original objective piece, the employment of the hard to control bipolar technique to produce single or multiple usable flake blanks, and the overall low percentage of flakes in the larger class sizes contribute to this tail end variation. Overall,

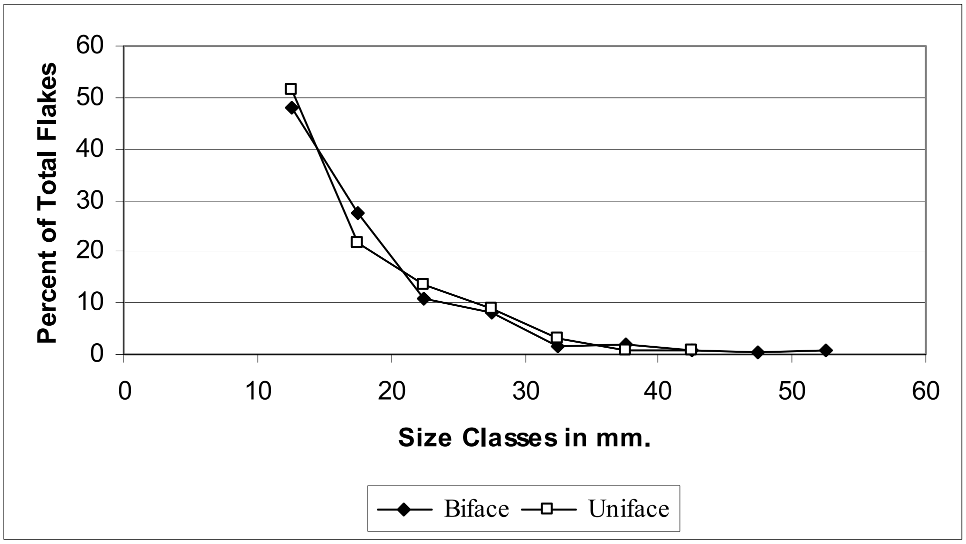


Figure 5.1. Plot of flake size classes for experimental biface and uniface production (≥10 mm).

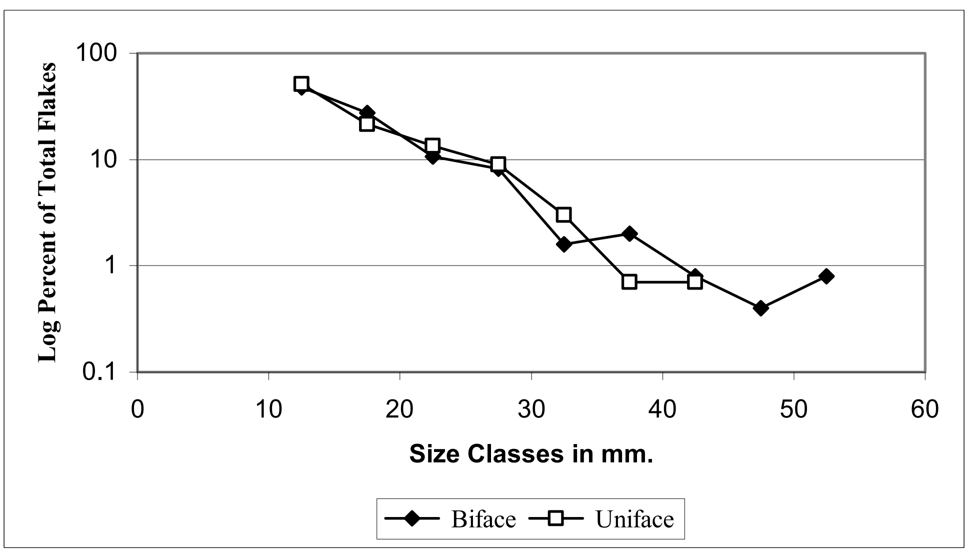


Figure 5.2. Semi-log plot of flake size classes for experimental biface and uniface production (10 mm).

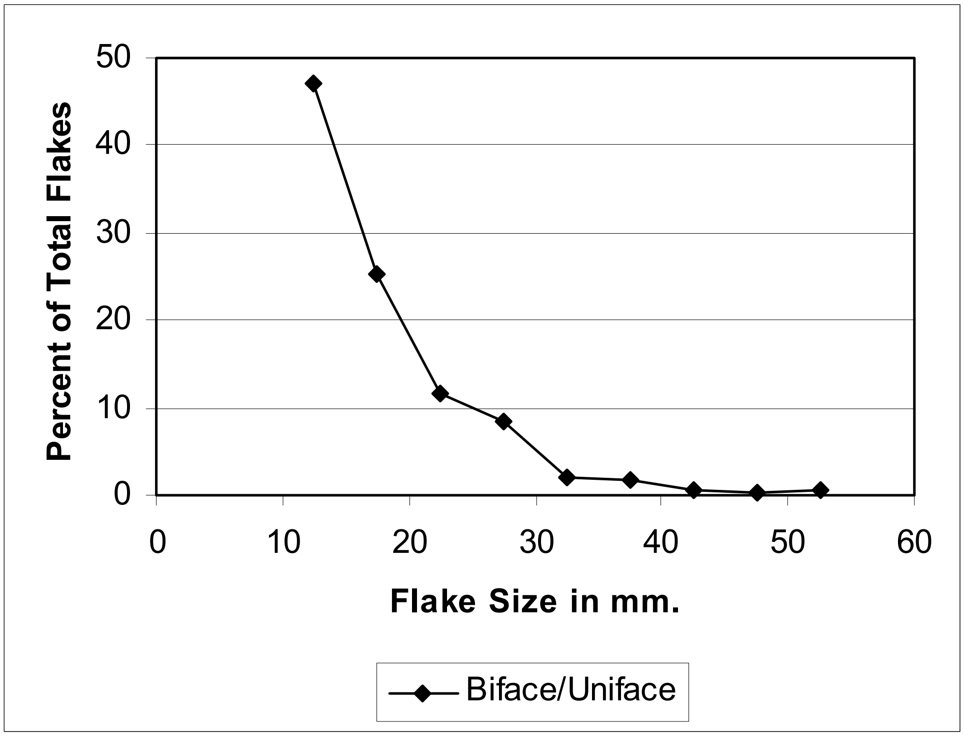


Figure 5.3. Plot of flake size classes for combined experimental biface and uniface production (≥10 mm).

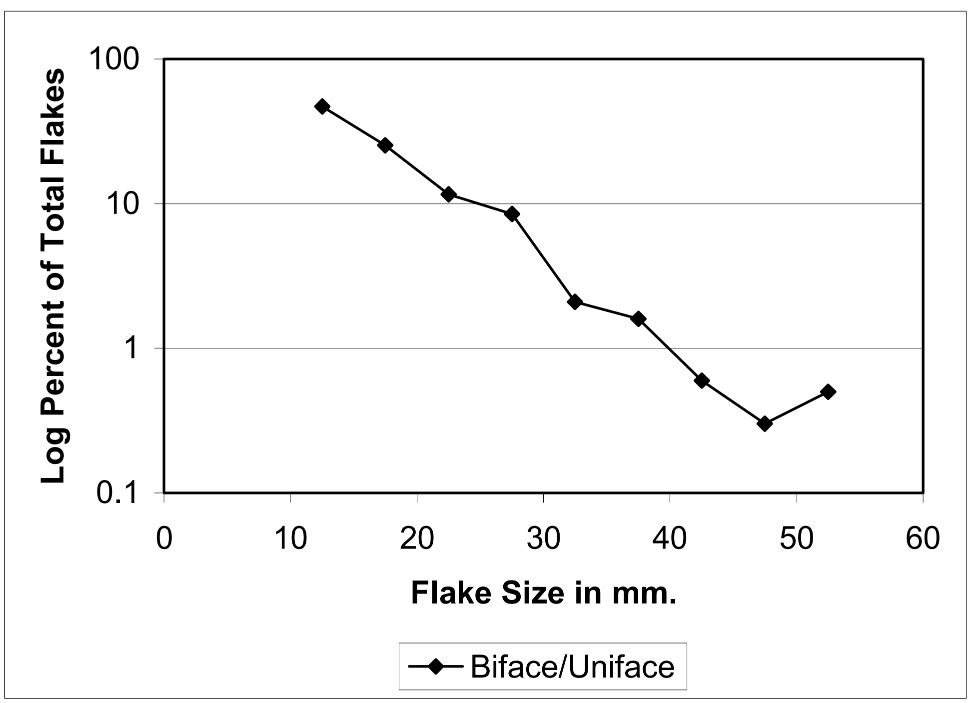


Figure 5.4. Semi-log plot of flake size classes for combined experimental biface and uniface production (≥10 mm).

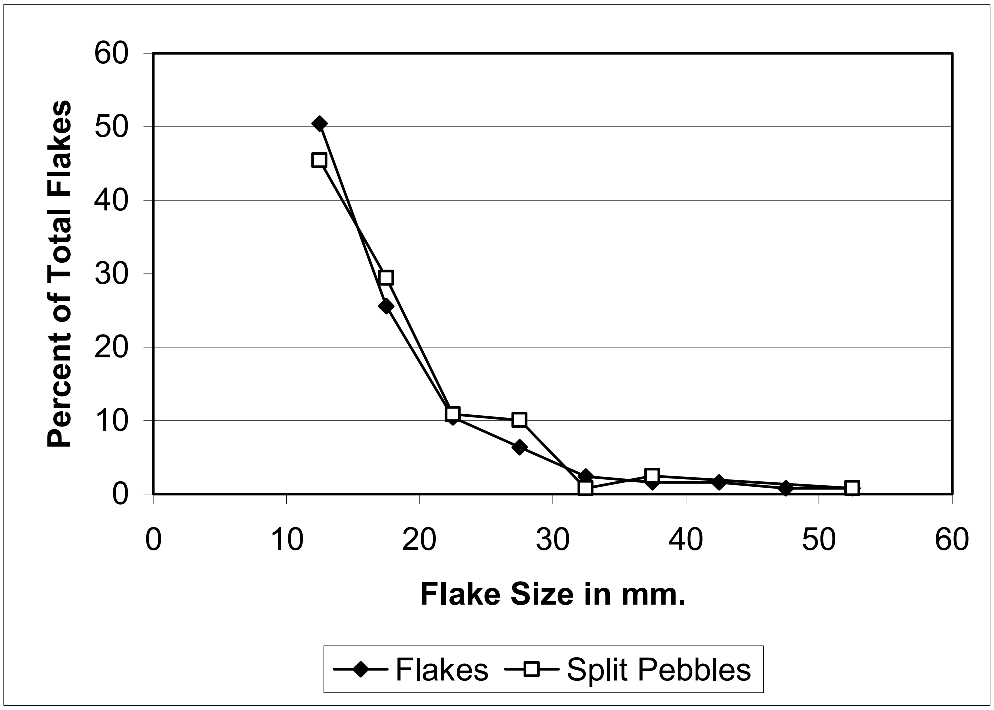


Figure 5.5. . Plot of flake size classes for combined experimental biface production from split pebble and flake blank starting forms (≥10 mm).

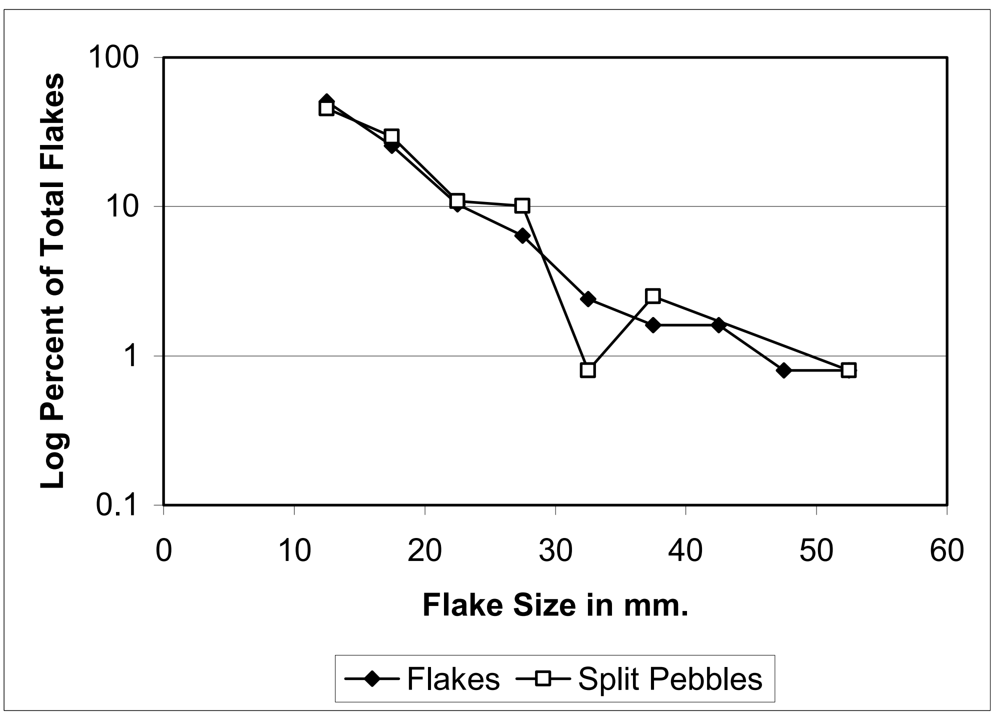


Figure 5.6. Semi-log plot of flake size classes for combined experimental biface production from split pebble and flake blank starting forms (≥10 mm).

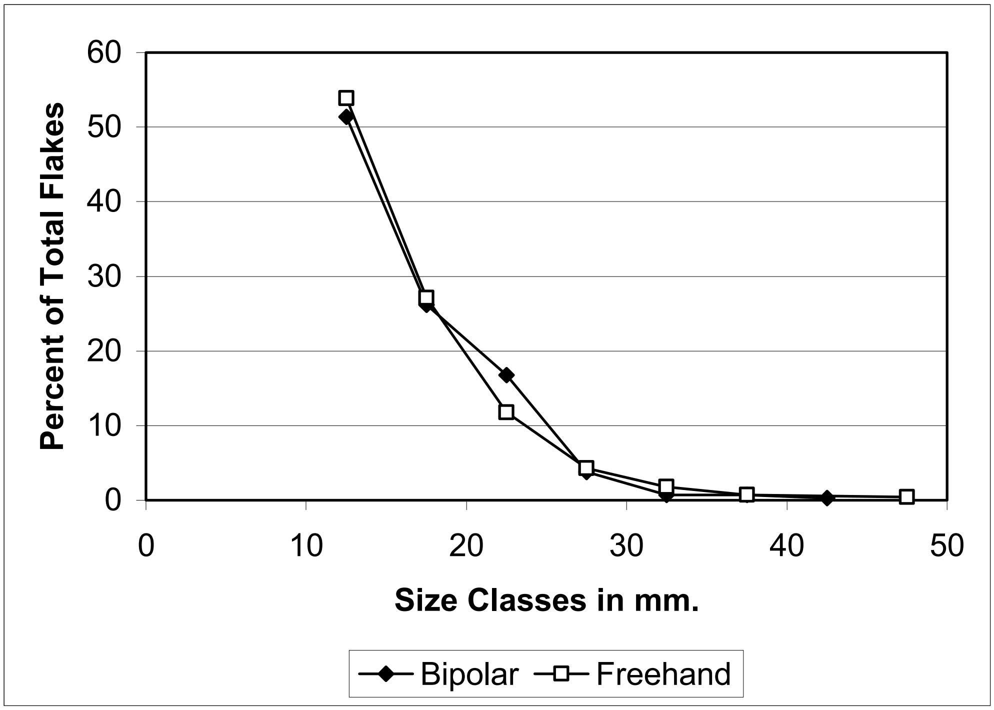


Figure 5.7. Plot of flake size classes for experimental bipolar and freehand gravel reduction (≥10 mm).

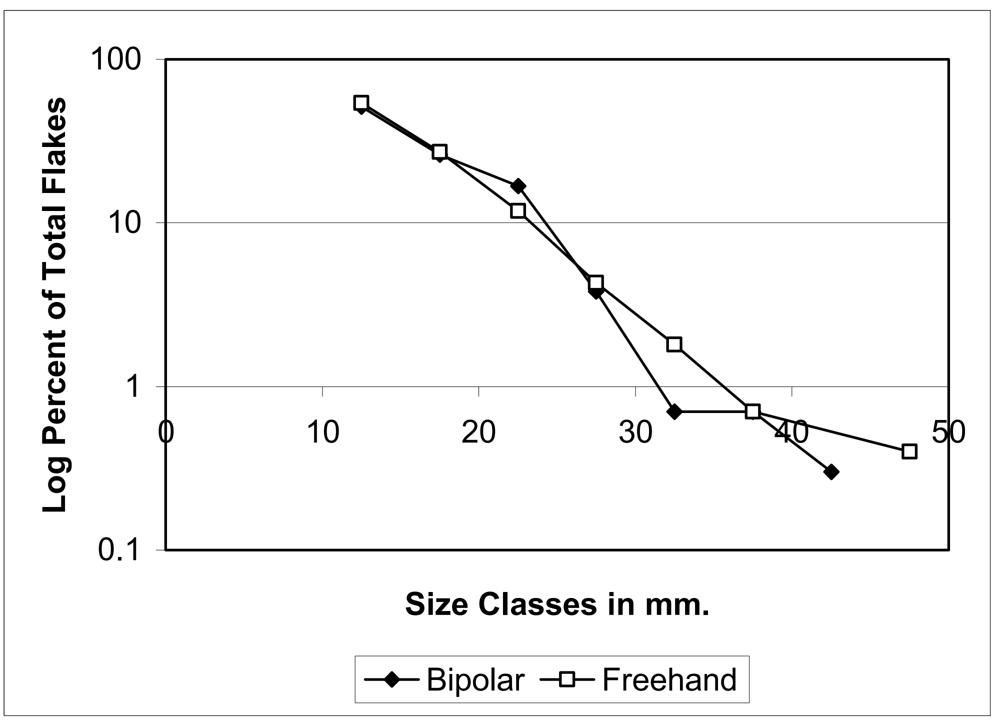


Figure 5.8. Semi-log plot of flake size classes for experimental bipolar and freehand gravel reduction (≥10 mm).

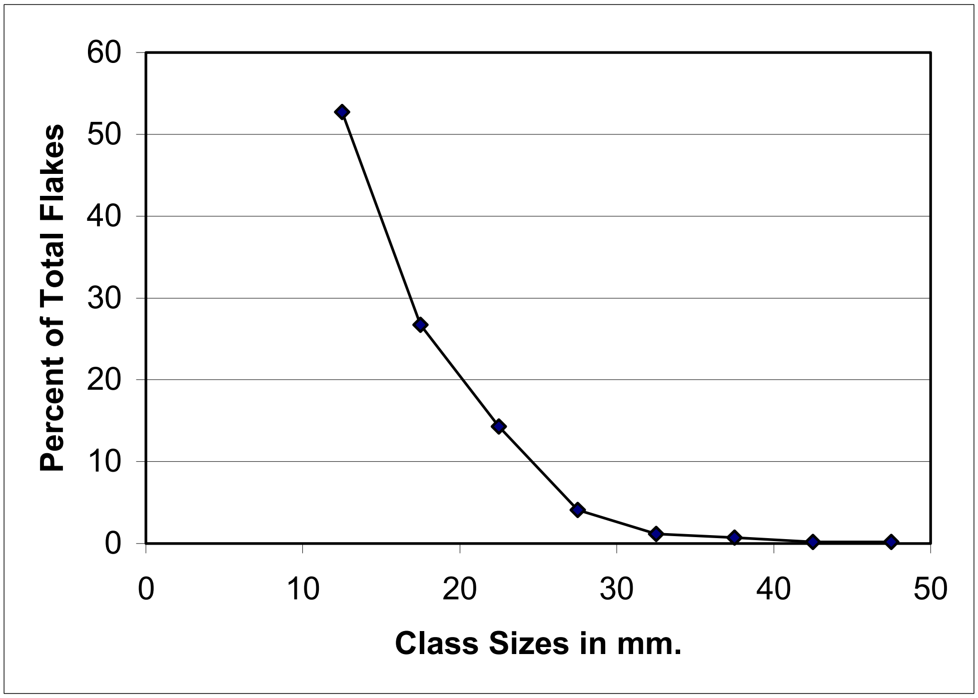


Figure 5.9. Plot of flake size classes for combined experimental bipolar and freehand gravel reduction (≥10 mm).

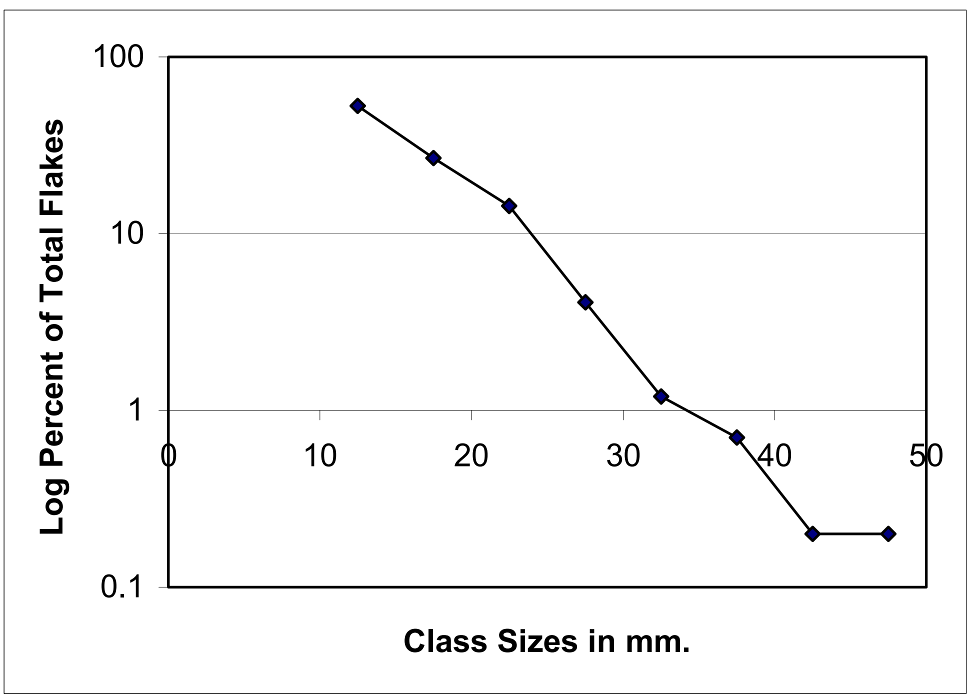


Figure 5.10. Semi-log plot of flake size classes for combined experimental bipolar and freehand gravel reduction (≥10 mm).

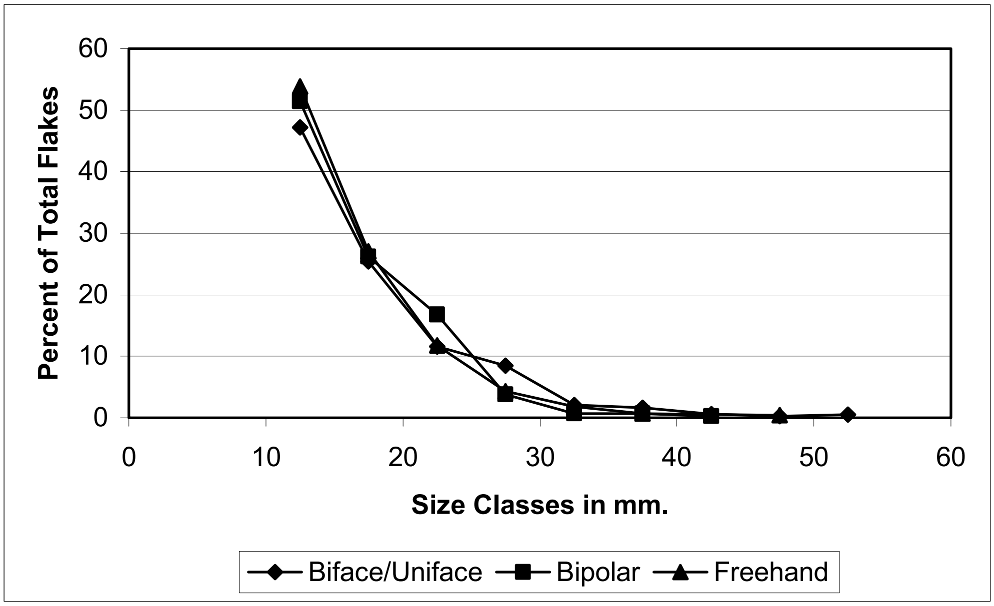


Figure 5.11. Plot of flake size classes for combined experimental uniface and biface production and bipolar and freehand gravel reduction (≥10 mm).

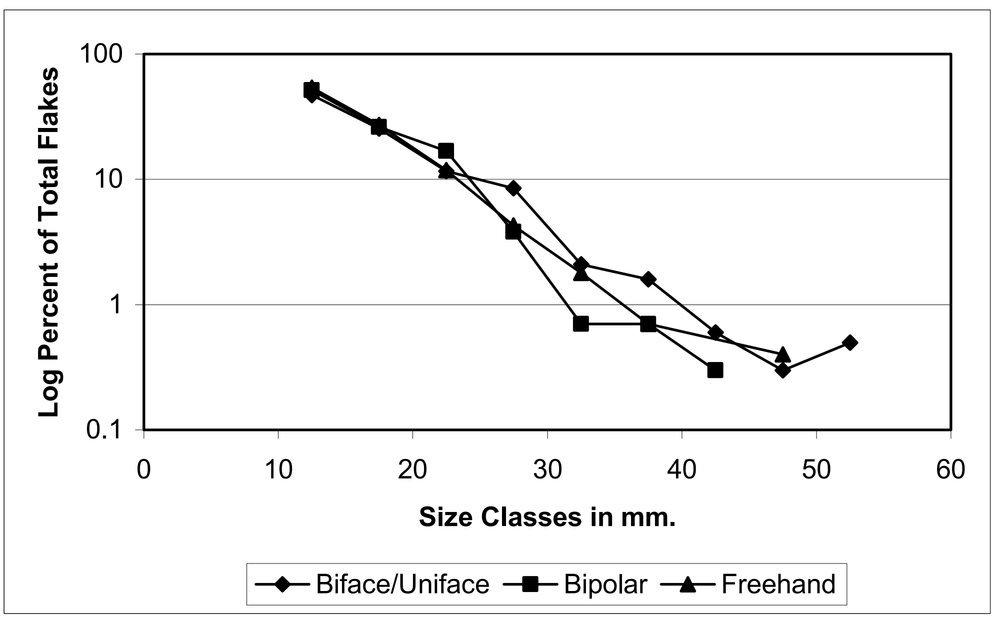


Figure 5.12. Semi-log plot of flake size classes for combined experimental uniface and biface production and bipolar and freehand gravel reduction (≥10 mm).

the biface and uniface plots are similar in form, which reinforces Shott's (1994:93) conclusion that Baumler and Downum's (1989) data on scraper production fit the log-linear model well, and is similar to bifacial reduction in trajectory.

The 20 percent sample of the archaeological debitage indicated only 3.8 percent of the debitage was in the size class range larger than 25 mm in greatest dimension, while this class size range comprised 13.8 and 13.4 percent of the experimental biface and uniface debitage respectively. This would seem to indicate the initial reduction of pebbles was conducted elsewhere, or that a majority of flake blanks were further reduced to produce formal tools, or smaller expedient flake tools or removed for use at another location. Ahler (1989a) removed larger flakes from his replication assemblages that might have been used by native knappers to control for size.

To further explore this similarity in biface and uniface production trajectories, debitage data from both sets of experiments were combined into one group and plotted (Figure 5.3). The results are essentially that of a concave curve with a small irregularity in the 25-30 mm size class. This irregularity is more evident in the semi-log plot of the same data (Figure 5.4). The line is fairly straight, except for the tail end in the 50-55 mm size class range, which only consists of two flakes.

Flake size class data were calculated for biface experiments based on the two starting forms of a split pebble or flake blank. Data from both forms were plotted on a simple linear graph (Figure 5.5). The flake blank yielded a slightly more uniform curve than the split pebble. The difference was in the size range 20-30 mm, with a slightly higher percentage (20.9) of flakes in this range for the split pebbles than for the flake blanks (16.8 percent). The semi-log plot yielded a fairly straight line for the flake blanks, but a more irregular line for the split pebbles (Figure 5.6). All Patterson's (1990) biface reproduction experiments were conducted with a flank blank as a starting form, so it is not unexpected that this study's flake blank data more nearly approximates a straight line. In addition to the very different starting geometry of the two forms, the split pebble halves were all thermally altered. These two factors could have influenced the final output in terms of numbers of flakes in the various size ranges.

Data derived from Mohney's (2004) core reduction experiments were plotted on a linear graph (Figure 5.7), which yielded a concave curve for freehand reduction, and a slightly irregular curve for bipolar reduction. The semi-log plot of the same data yielded a fairly straight line for freehand reduction, and a somewhat irregular line for bipolar reduction (Figure 5.8). To further explore this data, the results from bipolar and freehand reduction were combined and plotted (Figure 5.9). The result was a concave curve with no irregularities in form. This data plotted on a semi-log graph yielded a fairly straight line with an irregularity at the tail for the largest size range of 51-55 mm (Figure 5.10). The results were similar to those obtained for the Hickory Bluff site in Delaware (Petraglia et al. 2002) discussed in Chapter 4. Although the Hickory Bluff site yielded 588 cores, the debitage size class data from the site gave a concave curve form when plotted suggesting that tool manufacture was the major lithic reduction activity at the site.

The flake size class data for the combined biface/uniface experiments, freehand, and bipolar core reduction were plotted. Although all three trajectories approximated a concave curve, the freehand core data produced the smoothest curve on a linear graph (Figure 5.11). The combined biface/uniface data approximated a concave curve with the bipolar data the least regular, but still approximating the form of a concave curve. When plotted as a semi-log graph the freehand cores yielded a rather straight line with a deviation at the tail end (Figure 5.12). As was expected from the curves, the combined biface/uniface data yielded a somewhat straight line with a downward slope, and the bipolar data were the most irregular, but still a downward slope. It should not be surprising that freehand core reduction from these experiments produced a concave curve, since the gravels were reduced until flakes could no longer be detached, which essentially duplicates the earlier stages of biface production.

The biface and uniface size class data conform to the general pattern of the log-linear model. Plotted on a linear graph, the data approximated a concave curve form. The semi-log plots of the same data yielded fairly straight lines with negative slopes, with an irregular tail representing larger size classes as Patterson (1990:555) predicted. However, the corollary proposed by Patterson (1990:550-551), that lines yielded by plotting data derived from other than bifacial reduction will produce irregular patterns, is not borne out by these experimental results. Bipolar and freehand core reduction of gravels yielded results similar enough to bifacial and unifacial reduction, making it unlikely these methods of reduction can be differentiated by the use of the log-linear model with any confidence. The reduction of gravels for flakes evidently produces a quite different pattern than that of a platformed core reduction, which Patterson (1990: Figure 4.6) used as an example to illustrate an irregular pattern. The results suggest that the small size and form of alluvial gravels, whether reduced by bipolar or freehand techniques to produce flakes, or manufactured into bifacial and unifacial tools, yields similar concave curve forms when size class data are plotted on a linear graph and fairly straight lines with negative slopes when plotted on a semi-log graph. It is concluded that size class data plots will not provide any help in understanding the behaviors behind the production of CSA and debitage recovered from the BF locus.

SRT Results

Experimental Data. The debitage assemblages used in this portion of the study were the result of experimental tool manufacturing episodes undertaken for this research, and gravel reduction experiments conducted by Kenneth Mohney (2004). The 22 tool manufacturing episodes, complete and incomplete, were used to produce bifaces (LW triangles) and unifaces (scrapers and core scrapers) similar to those recovered from the BF locus of the KBS. The details of these experiments were discussed previously in Chapter 4, *Lithic Experiments*. The purpose of comparing and contrasting data derived from these two different sets of replicative experiments utilizing alluvial chert and jasper gravels is to determine if the SRT can discriminate between tool manufacture and general bipolar and freehand reduction.

Mohney's (2004) reduction experiments ($n = 24$) of fluvial Onondaga chert gravels to produce flakes to serve as expedient tools provided the bipolar and freehand data. There were 12 knapping episodes for each technique. The goal of the gravel reduction experiments was to determine the smallest size of pebble raw material from which freehand reduction yields more usable flakes than bipolar reduction. Mohney (2004) published the maximum length of the pebbles he collected for reduction and the original four category typology (complete, proximal, flake fragment, reduction fragment) of Sullivan and Rozen (1985). No other dimensions, weights, or geometric shapes were reported for the gravels. Data comparing the two experimental sets of gravels for maximum length is presented in Table 5.5. Although relatively smaller in maximum length, 11 of the 24 gravels used in Mohney's (2004) experiments were within the range

Table 5.5. Summary Statistics for Greatest Dimension of Gravels in SRT Study.

Experiments	N	Range (mm)	MN	S.D.
Patterned Tool	22	42.8-85.9	57.1	11.24
Bipolar/Freehand	24	23.7-59.6	40.3	10.16

Table 5.6. Frequency of SRT Categories for Biface and Uniface Experiments and Summary Data for Combined Tool Assemblage.

Experiment and Starting Piece*		Goal	Complete		Proximal		Flk Fragment		Red Fragment		Total Flakes
			N	%	N	%	N	%	N	%	
2	Flk	Biface	8	40.0	1	5.0	9	45.0	2	10.0	20
3	Flk	Biface	5	23.8	7	33.3	7	33.3	2	9.5	21
3a	Flk	Biface	6	60.0	2	20.0	1	10.0	1	10.0	10
4	SP	Biface	18	42.9	17	40.5	6	14.3	1	2.4	42
5	Flk	Biface	0	0.0	0	0.0	0	0.0	1	100.0	1
6	Flk	Biface	3	14.3	6	28.6	11	52.4	1	4.8	21
7	SP	Biface	41	50.6	16	19.8	21	25.9	3	3.7	81
8	Flk	Biface	1	33.3	0	0.0	2	66.7	0	0.0	3
9	Flk	Biface	18	52.9	7	20.6	8	23.5	1	2.9	34
10	Flk	Uniface	11	37.9	7	24.1	10	34.5	1	3.4	29
11	Flk	Uniface	31	58.5	11	20.8	11	20.8	0	0.0	53
13	SP	Uniface	6	54.5	5	45.5	0	0.0	0	0.0	11
14	SP	Uniface	10	83.3	2	16.7	0	0.0	0	0.0	12
15	SP	Uniface	16	76.2	2	9.5	3	14.3	0	0.0	21
16	SP	Uniface	19	46.3	13	31.7	8	19.5	1	2.4	41
17	SP	Biface	19	54.3	11	31.4	5	14.3	0	0.0	35
18	Flk	Biface	0	0.0	1	50.0	1	50.0	0	0.0	2
19	Flk	Biface	1	25.0	0	0.0	0	0.0	3	75.0	4
20	Flk	Biface	24	63.2	4	10.5	9	23.7	1	2.6	38
21	Flk	Biface	18	64.3	4	14.3	6	21.4	0	0.0	28
22	Flk	Biface	0	0.0	1	25.0	0	0.0	3	75.0	4
23	Flk	Biface	18	72.0	4	16.0	3	12.0	0	0.0	25
Totals			273	50.9	121	22.6	121	22.6	21	3.9	536
Mean			12.41		5.50		5.50		.96		24.35
S.D.			10.91		5.17		5.24		1.05		19.48

*Note: Flk=flake blank; SP=split pebble half.

of the patterned tool experiments. It is not anticipated that the difference in maximum length will influence the proportions of SRT flake categories. The SRT data for the two sets of experiments are contained in Tables 5.6, 5.7, and 5.8[2].

In addition, bipolar reduction data reported by Kuijt et al. (1995:Table 2) were used to validate the classification functions developed in the discriminant analysis. This data and the data recorded for the tool manufacturing experiments were in the form of the five category SRT proposed by Sullivan (1987). In addition to the original four categories, a fifth category of "split flake" was incorporated into the typology. In order

Table 5.7. Frequencies of SRT Categories for Bipolar Reduction of Onondoga Chert Gravels (Mohney 2004).

Experiment	Complete N %	Proximal N %	Flk Fragment N %	Red Fragment N %	Total Flakes
1C*	1 5.9	0 0.0	15 88.2	1 5.9	17
9C	1 4.3	0 0.0	12 52.2	10 43.5	23
10C	1 14.3	0 0.0	6 85.7	0 0.0	7
11C	3 23.1	0 0.0	6 46.2	4 30.8	13
14C	1 2.9	0 0.0	19 55.9	14 41.2	34
15C	8 18.6	5 11.6	22 51.2	8 18.6	43
17C	2 13.3	1 6.7	9 60.0	3 20.0	15
18C	2 20.0	0 0.0	7 70.0	1 10.0	10
19C	5 17.2	0 0.0	19 65.5	5 17.2	29
21C	5 16.7	5 16.7	17 56.7	3 10.0	30
22C	3 21.4	0 0.0	9 64.3	2 14.3	14
25C	4 6.9	0 0.0	43 74.1	11 19.0	58
Totals	36 12.3	11 3.8	184 62.8	62 21.2	293
Mean	3.0	.92	5.17	15.33	24.42
S.D.	2.17	1.93	4.53	10.33	15.11

* Note: Suffix "C" added to original experiment numbers to avoid confusion with patterned tool experiments.

to make this data comparable to the gravel reduction experiments, two conversions were necessary. Because split flakes possess a ventral and dorsal surface, but not a complete striking platform, they were categorized as flake fragments for this portion of the analysis. Bipolar flakes recorded were incorporated into the complete flake category

Table 5.8. Frequencies of SRT Categories for Freehand Reduction of Onondoga Chert Gravels (Mohney 2004).

Experiment	Complete N %	Proximal N %	Flk Fragment N %	Red Fragment N %	Total Flks
2C*	3 37.5	1 12.5	2 25.0	2 25.5	8
5C	8 72.7	1 9.1	2 18.2	0 0.0	11
6C	1 25.0	1 25.0	2 50.0	0 0.0	4
7C	14 42.4	5 15.2	13 39.4	1 3.0	33
8C	7 70.0	0 0.0	3 30.0	0 0.0	10
12C	4 100.0	0 0.0	0 0.0	0 0.0	4
13C	24 27.0	12 13.5	38 42.7	15 16.9	89
16C	0 0.0	0 0.0	0 0.0	2 100.0	2
20C	17 42.5	10 25.0	13 32.5	0 0.0	40
23C	10 41.7	6 25.0	5 20.8	3 12.5	24
24C	27 65.9	5 12.2	9 22.0	0 0.0	41
26C	2 10.0	2 10.0	9 45.0	7 35.0	20
Totals	117 40.9	43 15.0	96 33.6	30 10.5	286
Mean	9.75	3.58	8.00	2.50	23.83
S.D.	9.01	4.08	10.54	4.44	24.81

*Note: Suffix "C" added to original experiment numbers to avoid confusion with patterned tool experiments.

for the tool manufacturing experiments, because they possessed an intact striking platform and a termination. Additionally, Mohney (2004) presented only data for flakes equal to or larger than 10 mm in greatest dimension, while the data of Kuijt et al. (1995) and the tool data were given for all flakes equal to or larger than 6.4 mm. This was not considered a problem in the analysis, because the study of differences in proportions of SRT categories between flakes larger than 6.4 mm (*n* = 536) and equal to or larger than 10 mm (*n* = 402) in the experimental composite or patterned tool categories was demonstrated to be minimal. The flakes equal to or larger than 6.4 mm are 2.6 percent lower in complete flakes, 1.0 percent higher in proximal fragments, 2.1 percent higher in flake fragments, and 0.5 percent lower in reduction fragments compared to flakes equal to or larger than 10 mm. The differences between the two groups of flakes in regards to SRT four category proportions is not considered significant (χ^2 = 1.09478, df = 7, p = .826 >.05). This result confirms the conclusion of Kuijt et al. (1995:122) that the patterning of SRT categories is not flake size dependent.

The combined SRT data for each of the four reduction strategies (Table 5.9) was plotted by cumulative flake percentages to gauge differences and similarities. The Ogive curves produced from this data suggested that the composite biface and uniface

Table 5.9. Frequencies of SRT Flake Categories for Composite Experimental Assemblages.

Composite Assemblages	Complete N %	Proximal N %	Flk Fragment N %	Red Fragment N %	Total Flakes
Biface	180 48.8	81 22.0	89 24.1	19 5.1	369
Uniface	93 55.7	40 24.0	32 19.2	2 1.2	167
Bipolar	36 12.3	11 3.8	184 62.8	62 21.2	293
Freehand	117 40.9	43 15.0	96 33.6	30 10.5	286

assemblages were similar in their overall proportions of flake categories. However, both of these assemblages appear to be distinct from the bipolar assemblage, and somewhat less distinct from the freehand assemblage (Figure 5.13). To test the null hypothesis that the cumulative proportions of the reduction strategies are statistically the same, a two-tailed Kolmogorov-Smirnov test was computed for each pair of composite assemblages (Norusis 1994a:312). This is a nonparametric test applicable to ordinal data, such as the flake categories (Thomas 1986b:322-326). The Kolmogorov-Smirnov test examines the largest absolute difference in cumulative proportions between two samples, and determines the probability (P) that the null hypothesis is likely.

The results of Kolmogorov-Smirnov tests suggested that the null hypothesis was very likely true for the biface and uniface assemblages. These tests also suggested that the other composite pairs were statistically dissimilar, thus the null hypothesis was extremely unlikely (P<.01) for these pairs (Table 5.10). In consideration of these results, the two tool categories (biface and uniface) were combined into one composite category, patterned tools, following Austin (1999:56), Prentiss and Romanowski (1989:Figure 1), and Carr and Bradbury (2001:134). This patterned tool category could now be used in both three group and two group discriminant analyses to attempt to distinguish it from bipolar and freehand gravel reduction. However, the largest absolute difference between

Table 5.10. Results of the Kolmogorov-Smirnov Test of Cumulative SRT Flake Categories (4) for Paired Experimental Reduction Assemblages.

Experimental Assemblage Pairs	Null Hypothesis*
Biface/Uniface	Very Likely
Biface/Bipolar	Very Unlikely
Biface/Freehand	Very Unlikely
Uniface/Bipolar	Very Unlikely
Uniface/Freehand	Very Unlikely
Bipolar/Freehand	Very Unlikely
Patterned Tool/Bipolar	Very Unlikely
Patterned Tool/Freehand	Very Unlikely

*Note: The likelihood of the null hypothesis being true is indicated with descriptive terms.[3]

freehand reduction and the patterned tool category is relatively small (.176), compared to the absolute difference between patterned tool and bipolar reduction (.575). This appears

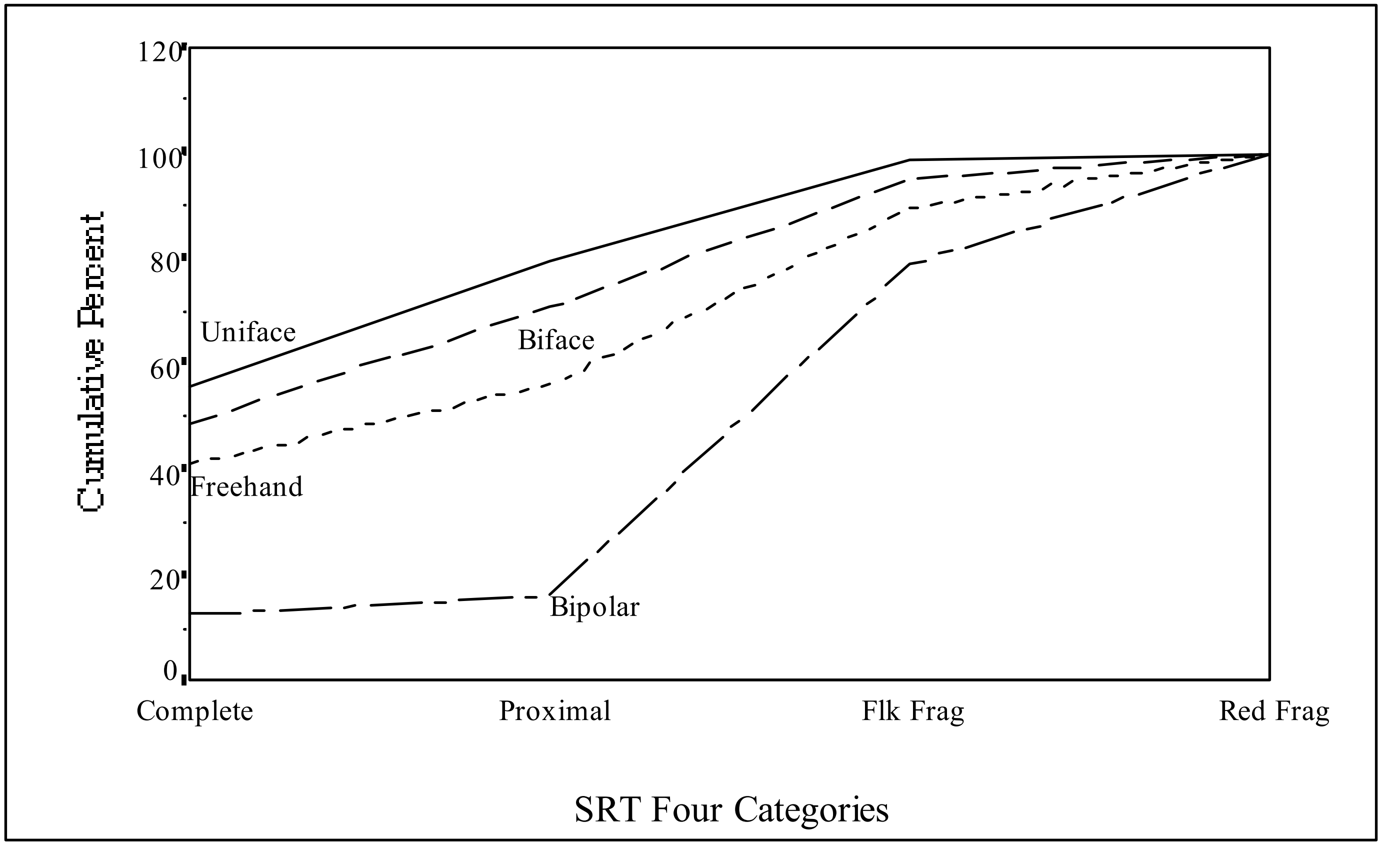


Figure 5.13. Cumulative percentages of SRT flake categories (4) for composite biface, uniface, bipolar, and freehand experimental reductions

to presage the difficulty in developing successful discriminant functions to separate these three reduction methods.

Examination of the data from Tables 5.6 and 5.9 indicate certain differences between the three groups. Patterned tools are characterized by a high percentage of complete flakes and proximal flakes and low percentages of flake fragments and reduction fragments. Bipolar reduction possesses distinctly lower percentages of complete and proximal flakes compared to patterned tool and freehand reduction, and a much higher percentage of flake fragments and reduction fragments. Freehand reduction had similar but lower percentages of complete and proximal flakes, with relatively larger percentages of flake fragments and reduction fragments compared to patterned tools. Freehand reduction is between bipolar reduction and patterned tool manufacture in the relative percentage of flake categories. Freehand reduction is closer to patterned tools in its percentage of complete and proximal flakes, and more similar to bipolar reduction in its higher percentage of flake and reduction fragments.

Discriminant Analysis. Discriminant analysis is a statistical technique that is encompassed within the area of statistics known as multivariate analysis. Other techniques in multivariate analysis seek to find some patterning in the data without any prior knowledge of how the patterning will be manifested. However, discriminant analysis assumes a prior knowledge of group identities, and attempts to distinguish these groups based on functions derived from linear combinations of independent (predictor) variables. These functions attempt to maximize the differences between the groups (Norusis 1994b:1; Shennan 1990:286-288).

Discriminant analysis may be used to distinguish between two groups or three groups. In a two group analysis there is one discriminant function, and in a three group analysis there may be two discriminant functions. The math underlying discriminant analysis is rather lengthy, but statistical computer packages such as SPSS derive the functions, as well as other statistical information which aid in evaluating the functions, the discriminating power of the independent variables, and the resulting classifications. The derived *unstandardized canonical discriminant function coefficients* (Table 5.14) can be directly applied to the raw data in the independent variables to compute a classification score, or *discriminant Z score* to classify a new case. The formula to obtain this Z score is

$$Z_{jk} = a + W_1X_{1k} + W_2X_{2k} + \ldots + W_n\,W_{nk}$$

where Z_j = discriminant Z score of discriminant function j for case k, a = intercept or constant, W_i = discriminant coefficient for independent variable I, and W_{ik} = independent variable I for case k. This Z score is then compared to a cutting score for a two group analysis, or plotted on a two dimensional territorial map, which gives the boundaries of the cutting score for each function in a three group analysis. A territorial map is produced by SPSS when two functions are developed. A concise summary of discriminant analysis is found in Shennan (1990:286-288), while Norusis (1994b:1-46) provides a precise description of the statistics and procedures available in discriminant analysis. Hair et al. (1995:178-255) offers a detailed discussion of multivariate theory and the interpretation of statistics produced during a discriminant analysis. See Austin (1999), Prentiss (1998), Bradbury (1995), and Amick (1988) for applications of discriminant analysis in distinguishing lithic reduction methods in experimentally produced debitage.

Discriminant Analysis Classification. A series of two group and three group discriminant analyses were conducted to determine if the Sullivan and Rozen flake categories (Sullivan III 1987; Sullivan III and Rozen 1985) could successfully distinguish among patterned tool production, freehand, and bipolar reduction of alluvial chert gravels. The known experimental groups were the dependent, or grouping variable, and the four SRT flake categories provided the independent variables. In each analysis four independent variables were entered simultaneously into the calculations, rather then one at a time as in the stepwise method. This method was chosen to test the classification value of the SRT categories as a whole rather than determine which variables contribute the most to classification. All groups were considered to have an equal chance of selection in the determination of prior probabilities, and the within groups covariance matrix was used for classification. Both Fisher's classification coefficients and *unstandardized canonical discriminant functions* were derived, as either can be used for direct classification of new cases.

Three Group Classification. The first attempt at discrimination was a multiple discriminant analysis (MDA) of three groups: patterned tool, bipolar reduction, and freehand reduction. This produced a rather mediocre classification percentage (Table 5.11) of 69.6 (n = 32/46). The bipolar classification percentage of 91.7 (n = 11/12) was very good, but the classification percentage of the pattern tool group was a relatively low 59.1 (n = 13/22), while the freehand group was only slightly better at 66.7 percent (n = 8/12). The relatively low correct classification rate was considered marginally

Table 5.11. Classification of Three Group MDA of Experimental Pattern Tool and Bipolar and Freehand Reduction.

Predicted Group Membership								
Group	Number of Cases	Patterned Tool N	%	Bipolar Reduction N	%	Freehand Reduction N	%
Patterned Tool	22	13	59.1	1	4.5	8	36.4
Bipolar Reduction	12	0	.0	11	91.7	1	8.3
Freehand Reduction	12	3	25.0	1	8.3	8	66.7
Percent of grouped cases correctly classified: 69.6%							

successful, because it exceeded the priors or the chance of selection if all groups were placed into the largest class. The priors for the patterned tool group were 48 percent, with bipolar and freehand core reduction at 26 percent each. Although, the correct classification percentage of the three groups met the guideline of at least one-fourth greater than could be had by chance (Hair et al. 1995:204-205), this analyst did not believe the results justified the use of the discriminant functions, especially for patterned tools.

Examination of the classification table reinforces the perception from the cumulative flake percentages discussed previously. Eight of the patterned tool group were misclassified as freehand, and only one as bipolar. Three experiments from the freehand group were misclassified as patterned tool, and one as bipolar, and one bipolar experiment was misclassed as freehand. This pattern of misclassification is not surprising, given the intermediate position of the freehand group in the previous discussion of cumulative percentages. It becomes even more pronounced when the scatter plot of scores for this classification is examined (Figure 5.14). The separation of the group centroids for the patterned tool and bipolar groups is great enough for discrimination, as only one case from either group is misclassed into the other group.

The centroid for the freehand group is intermediate between the two other groups, but closer to the patterned tool group. The separation is not as great, hence, the misclassifications are on both extremes of the freehand distribution. It is also not surprising that all but one of the misclassified patterned tool and bipolar experiments were placed in the freehand group. The canonical discriminant functions evaluated at group means or group centroids for the three group classification are found in Table 5.12. Function 1 shows the greatest distance between the three groups, with Function 2 providing some discrimination between freehand reduction and the similar scores of patterned tool and bipolar reduction.

Table 5.12. Group Centroids of Canonical Discriminant Functions for Experimental Patterned Tool, Bipolar, and Freehand Groups.

Groups	Function 1	Function 2
Patterned Tool	.85782	-.08169
Bipolar	-1.67714	-.06333
Freehand	.10446	.21309

A model provided by discriminant analysis, to be considered useful, should not only have a good overall successful classification percentage (at least one-fourth greater than is achieved by chance), but it should classify all three groups reasonably well (Hair et al 1995:205). The slightly-under 70 percent classification percentage for the overall percentage is acceptable, but that is mainly due to the distinct differences between bipolar reduction and the other two groups. The successful classification rate of the freehand and patterned tool groups is not acceptable for this study. This analysis was instructive, because it indicated strong differences between bipolar and patterned tool groups, and suggested an overall similarity of freehand reduction to patterned tool

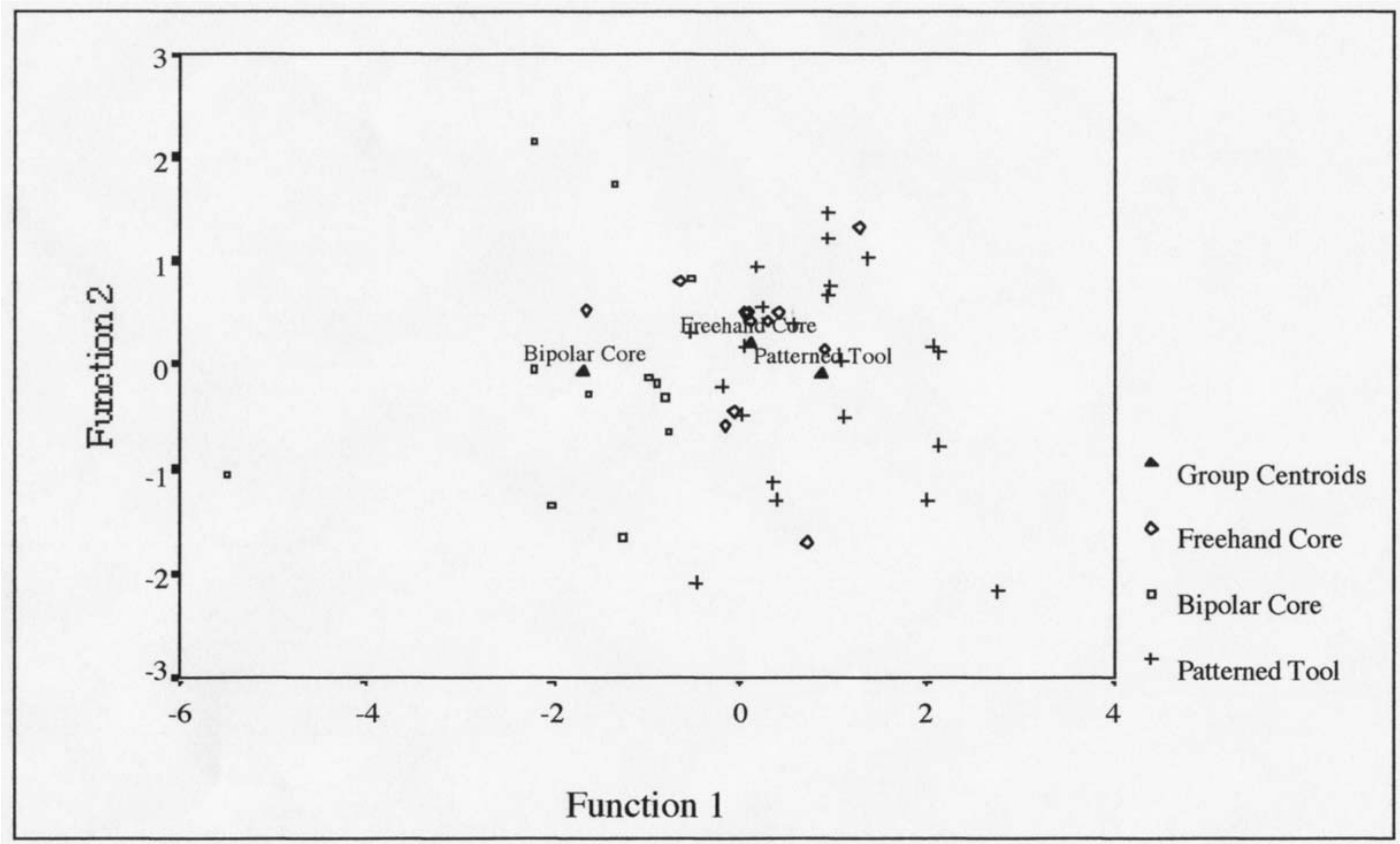


Figure 5.14. Scatter plot of discriminant functions for the three group analysis of experimental patterned tool, bipolar and freehand gravel reduction episodes.

manufacture. It appears that the dynamics of freehand reduction and patterned tool manufacture from fluvial gravels are similar enough that the Sullivan-Rozen typology cannot be utilized to successfully discriminate between the two with a degree of certainty. Two MDA's were conducted with the SRT typology to discriminate between bipolar, freehand groups, and the patterned tool group, divided by starting form (split pebble and flake). These analyses produced essentially the same results with either starting form as the third group, which suggests this variable does not effect the model to any appreciable degree.

Two Group Classification. A two group discriminant analysis was conducted for each of the following pairs: patterned tool and bipolar reduction; patterned tools and freehand reduction; and bipolar and freehand reduction. All classification results attained a threshold of one-fourth greater than the percentage that could be obtained by chance, if all cases were assigned to the group that comprised the greatest percentage of all analyzed cases. However, the frequencies of artifacts (n = 29) associated with patterned tool manufacture (bifaces and unifacial scrapers) comprises 28 percent of the CSA's (n = 105). Artifacts (n = 25) associated with bipolar reduction (bipolar cores, bipolar citrus flakes, split pebbles) are 24 percent of the chipped stone. Freehand cores (n = 4) comprise only four percent of the chipped stone. This data strongly suggests that the manufacture of tools and bipolar reduction of river gravels to obtain flakes were the predominant lithic reduction activities at the BF locus of the KBS. Therefore, only the two group discriminant analysis of patterned tool and bipolar reduction is fully reported.

The overall classification success rate (33/34) for the patterned tool and bipolar groups was 97 percent (Table 5.13). The bipolar group was classified successfully at 100 percent and the pattern tool group was successfully classified at 95.5 percent, with one case, experiment 6, misclassified. Experiment 6 produced a relatively low percentage of complete flakes and proximal flakes (42.9) and a relatively higher percentage (57.1) of flake fragments and reduction fragments (see Table 5.6). Examination of the *unstandardized canonical discriminant functions coefficients* (Table 5.14), used to classify new cases, indicates that flake fragments are the highest weighted value in the classification equation. Even with this power, the posterior probability for membership in the bipolar group for Experiment 6 was .5008, membership in the patterned tool group .4992, and because there are only two groups the posterior probabilities sum to one (Norusis 1994b:12). The discriminant Z score of .3588 fell just short of the cutoff score for the patterned tool group of <.3578. This is illustrative of how just a few flakes in a small assemblage can alter the results of a classification.

The misclassification of experiment 6 suggests that small assemblages of debitage, which may only represent a single knapping episode, may be difficult to successfully classify by a discriminant analysis. However, an examination of the numbers of flakes in the experimental assemblages (Tables 5.6 and 5.7) indicates that the mean of these individual episodes of lithic reduction of fluvial gravels in either group is 24. It is very likely that the Kimble's Beach assemblages in 14 of the excavation units (equal to or greater than 48 pieces) are the result of several such knapping episodes (Table 6.37). The range of debitage in these 14 excavation units is 49-534 pieces (chert and jasper only), and should provide a more representative distribution for discriminant analysis.

Table 5.13. Classification of Two Group Discriminant Analysis of Experimental Pattern Tool and Bipolar Reduction.

Predicted Group Membership					
Group	Number of Cases	Patterned Tool N	Patterned Tool %	Bipolar Reduction N	Bipolar Reduction %
Patterned Tool	22	21	95.50	1	4.5
Bipolar	12	0	0.03	12	100
Percent of grouped cases correctly classified: 97.06%					

The group centroids for the canonical discriminant function are -.85940 for the patterned tool group, and 1.57289 for the bipolar group. These group means are separated by almost two standard deviations (S.D. = 1.54), so the excellent classification percentage is not surprising. Figure 5.15 is a histogram of the discriminant scores that displays the group centroids, classification boundary, and the classification of the individual cases by the discriminant function. The *unstandardized canonical discriminant function coefficients* used to calculate the discriminant Z score (see pages 214-215) for new cases is presented in Table 5.14. A cutoff score for a two group analysis with equal probabilities is calculated by adding the two group means and dividing by two. If a discriminant Z score is less than .3575 it is classified in the patterned tool group, and if greater than .3575 it is classified in the bipolar group**.**

Validation of Discriminant Models. The classification utility of the two group discriminant analysis was internally and externally validated by the application of the unstandardized coefficients from Tables 5.14 to several test assemblages of known cases. One set of assemblages was a random combination of classified experimental cases and

```
                        Canonical Discriminant Function 1
       8 +                                                               +
         |                                                               |
         |                                                               |
F        |                                                               |
r      6 +                              1                                +
e        |                              1                                |
q        |                              1  2                             |
u        |                              1  2                             |
e      4 +                              1  2                             +
n        |                              1  2                             |
c        |                        11    1  2                             |
y        |                        11    1  2                             |
       2 +                      1 11    1  1 2   2                       +
         |                      1 11    1  1 2   2                       |
         |                   1111111 111   1 2 2 222   2           2     |
         |                   1111111 111   1 2 2 222   2           2     |
          X---------+---------+---------+---------+---------+---------X
        out       -4.0      -2.0       .0        2.0       4.0       out
  Class   1111111111111111111111111111111112222222222222222222222222222
Centroids                          1           2
                                (-.85794)   (1.57289)

 Key:1=Patterned Tool; 2=Bipolar Reduction. Each case is represented by
 two vertical numbers. The rows of 1's and 2's below the X axis
 indicate the group to which the scores are assigned.
```

Figure 5.15. Histogram of classification scores for two group discriminant analysis of patterned tools and bipolar reduction.

Table 5.14. Unstandardized Canonical Discriminant Function Coefficients for Two Group Discriminant Analysis of Patterned Tool and Bipolar Groups.

Flake Category	Function 1
Complete	-.0637
Proximal	-.0904
Flake Fragment	.1201
Reduction Fragment	.0562
Constant	-.2845

the other was the bipolar data published by Kuijt et al. (1995:Table 2). Experimental cases were selected for inclusion in the test assemblages from a table of random numbers (Shennan 1990:Table D) until the sum of the flakes included in the assemblage was equal to or greater than 100 pieces. Because it is reasonable to assume that an archaeological assemblage is the result of several episodes of lithic reduction, rather than one discrete event, this procedure was adopted to test the discriminant functions ability to classify such composite assemblages. The major caveat to this approach is that a model usually attains better results with the sample used to develop it, than with cases from another sample (Norusis 1994b:14). A standard practice is to divide the sample into two groups using one to develop the model and the other to test the power of classification (Hair et al. 1995:209-210). This approach was deemed impractical due to the relatively small number of cases (n = 34) compared to the minimum of cases equal to or greater than 100 thought to be logical by Hair et al (1995:196) for this procedure. Nevertheless, the overall sample does exceed the recommended minimum size of three cases for each variable (Hair et al. 1995:210). The chosen method of developing multiple subsets from the original sample has been suggested by some researchers as an alternative means of internally validating discriminant functions (Hair et al. 1995:196). Table 5.15 presents the data for these composite test assemblages.

Five assemblages were developed for each group (a total of 10) and were classified by use of the discriminant coefficients (Table 5.15) developed in the two group analysis. The validation of the two group analysis of patterned tool and bipolar groups, with the composite test assemblages from Table 5.15, returned an overall 100 percent successful classification. Examination of the data for the test assemblages indicates that the patterned tool group has a high percentage (71.5) of complete and proximal flakes, and a relatively lower percentage (28.5) of flake fragments and reduction fragments. The bipolar group is nearly the opposite with a relatively lower percentage (14.5) of complete and proximal flakes, and a high percentage (85.5) of flake fragments and reduction fragments.

Table 5.15. SRT Data for Composite Test Assemblages Used to Validate Discriminant Analyses.

Test Assemblages	Complete N %	Proximal N %	Flk Fragment N %	Red Fragment N %	Total Flakes
pt1	58 56.3	20 19.4	24 23.3	1 1.0	103
pt2	58 46.0	38 30.2	28 22.2	2 1.6	126
pt3	57 44.2	33 25.6	34 26.3	5 3.9	129
pt4	63 50.4	31 24.8	27 21.6	4 3.2	125
pt5	59 44.4	23 17.3	39 29.3	12 9.0	133
Totals	295 48.0	145 23.5	152 24.7	24 3.9	616
Mean	59	29	30.4	4.8	123.2
S.D.	2.35	7.38	6.03	4.32	11.71
bp1	12 10.9	0 0.0	66 60.0	32 29.1	110
bp2	16 14.4	11 9.9	60 54.1	24 21.6	111
bp3	14 12.6	0 0.0	78 70.3	19 17.1	111
bp4	13 12.7	1 1.0	63 61.8	25 24.5	102
bp5	11 10.9	0 0.0	59 58.4	31 30.7	101
Totals	66 12.3	12 2.2	328 61.1	131 24.4	537
Mean	13.2	2.4	65.6	26.2	107.0
S.D.	1.92	4.83	7.37	5.36	5.05

Note: pt=patterned tool; bp=bipolar.

Table 5.16. SRT Data for Bipolar Reduction of Trachydacite Cobbles (Kuijt et al. 1995).

Experiment	Complete N %	Proximal N %	Flk Fragment N %	Red Fragment N %	Total Flakes
1	11 15.9	1 0.2	19 27.4	39 56.5	70
2	3 4.2	0 0.0	34 48.5	33 47.1	70
3	5 10.2	0 0.0	24 48.9	20 40.8	49
4	5 17.2	0 0.0	15 51.7	9 31.0	29
5	5 13.5	0 0.0	16 43.2	16 43.2	37
6	2 5.5	0 0.0	19 52.7	15 41.6	36
7	9 21.5	0 0.0	15 35.7	18 42.8	42
8	3 8.5	0 0.0	18 51.4	14 40.0	35
9	6 13.3	0 0.0	20 44.4	19 42.3	45
Totals	49 12.3	1 0.02	180 44.9	183 42.9	413

The bipolar reduction data of nine experimental assemblages published by Kuijt et al. (1995:Table 2) were used to externally validate the bipolar component of the two group analysis (Table 5.16). This data was similarly configured to that obtained by Mohney (2004) in the relative ratio of complete and proximal flakes to the flake fragments and reduction fragments. However, the percentages of flake fragments and reduction fragments were somewhat different. The bipolar reduction experiments of Kuijt et al. (1995), produced almost equal percentages of flake fragments (43.3) and reduction fragments (42.9), while Mohney's (2004) experiments produced a higher percentage of flake fragments (62.8) and a lower percentage of reduction fragments (21.2). Ahler (1989:Table 2) conducted 40 experiments in the bipolar reduction of Knife River Flint cobbles to obtain flakes. These experiments produced 19.3 percent shatter (reduction fragments), which is similar to the 21.2 percent rate in Mohney's (2004) experiments. The variance between the results published by Kuijt et al. (1995) and Mohney (2004) may be attributable to differences in raw material (trachydacite versus Onondaga chert), gravel geometry (neither study published shape or dimensions), the relative skill or technique of the knapper, and/or analyst bias or error. Given the similar combined percentage of flake fragments and reduction fragments (Kuijt et al 1995 = 86.2 percent; Mohney 2004 = 84.0 percent), and the strong association of 0.58705 between these two variables (1.0 represents complete correlation) in the pooled within-groups correlation matrix (statistics produced as byproduct of discriminant analysis), it was concluded that the two samples were comparable, although somewhat different in composition. The successful classification rate for this sample was 100 percent (9/9) for the two group analysis. These results reinforced the conclusions concerning the overall similarities of the two samples. The group centroid of the discriminant *Z* scores for this bipolar data was 2.90 with a range of 1.704 - 5.462 for the individual experiments, both of which were well above the cutoff score of .3575 for classification as bipolar reduction.

Discussion. The internal validation of the discriminant functions with the composite test assemblages drawn from the original sample, and the external validation with the bipolar data from Kuijt et al. (1995), reaffirm that the function successfully discriminates between patterned tool and bipolar groups. The results of the three group analysis suggest that the discrimination of freehand reduction from the other two groups is problematic. Examination of the cumulative percentages of flake categories for the three groups (Figure 5.12) and the scatterplot of discriminant scores (Figure 5.13) suggests that the freehand group may not be adequately separated from the two other groups, especially patterned tools, to discriminate with confidence utilizing SRT categories alone. The addition of other variables such as platform type, dorsal cortex amount, metric dimensions, or dorsal flake scars may add to the discrimination power of the analysis (Austin 1999; Ingbar et al. 1989; Prentiss 1998; Tomka 1989). However, of these variables, only size class is available from the data published by Mohney (2004), and based on the difficulty encountered in separating freehand reduction from patterned tools, as reported in the log-linear section of this chapter, this avenue of analysis was not undertaken.

The three group analysis, while demonstrating promise for future experiments with additional variables in conjunction with the four SRT flake categories, will not be applied to the results of the analysis of the archaeological assembly. This is due in part to the only moderately acceptable results (69.6 percent correct classification), and the suggestion by the low proportion of CSA's associated with freehand reduction of gravels that it played only an occasional limited role in the lithic technology of Kimble's Beach.

In consideration of the successful results (97 percent correct classifications) with four Sullivan-Rozen flake categories in the two group discriminant analysis of patterned tool and bipolar reduction, and the preponderance of CSA's associated with patterned tool and bipolar reduction (52 percent), the decision was made to include the four SRT flake categories in the set of attributes to record for the archaeological debitage assembly from Kimble's Beach.

Simulated Archaeological Assemblages. Although the experimental assemblages provided data for the classification of patterned tools and bipolar reduction, single episode reduction is not the norm in archaeological assemblies. Most archaeological assemblies are

the result of several reduction episodes, and often contain debitage produced by different techniques (Austin 1999:56; Ingbar et al. 1989:118). In order to determine how these assemblages might be classified by a discriminant analysis, simulated composite assemblages of varying proportions of patterned tool and bipolar reduction were created. Following Austin (1999:56-59), three simulated assemblages were created, which contained the following ratio of patterned tool to bipolar flake categories: 75: 25; 50:50; and 25:75. Each assemblage was composed of 200 pieces of debitage, with the proportions of SRT flake categories taken from Tables 5.6 and 5.7 for patterned tool and bipolar reduction.

The mixed assemblages were computed with the following formula:

$$S=\sum(A*p_r)*p_{cZ}$$

where S= a simulated assemblage of one SRT flake category, A= the size of the assemblage, p_r=proportional representation of flakes from a reduction strategy, and p_c the proportion of flakes from one SRT flake category. Using the procedures outlined above, the following is an example that was used to compute the number of flake fragments for an assemblage with a ratio of 25:75, patterned tool to bipolar gravel reduction.

$$S_{\text{flake fragments}}=\sum([200*.25]*.26) + ([200*.75]* .628 = 105$$

The proportions of SRT flake categories for the three simulated composite assemblages with the indicated ratios were computed with this formula. The proportions of SRT flake categories for these simulated assemblages, and the composite patterned tool and bipolar reduction assemblages are presented in Table 5.17.

Table 5.17. SRT Flake Category Data for Composite Patterned Tool (biface/uniface), Bipolar, and Simulated Mixed Assemblages of Patterned Tool and Bipolar (25:75, 50:50, 25:75).

Composite Assemblages	Complete N	Complete %	Proximal N	Proximal %	Flk Fragment N	Flk Fragment %	Red Fragment N	Red Fragment %	Total Flakes
Patterned Tool	273	50.9	121	22.60	121	22.6	27	3.9	536
Bipolar	36	12.3	11	3.8	184	62.8	62	21.2	293
PT/BP 75:25	82	41.0	36	18.0	65	32.5	17	8.5	200
PT/BP 50:50	63	31.5	26	13.0	86	43.0	25	12.5	200
PT/BP 25:75	44	22.0	17	8.5	105	52.5	34	17.0	200

The flake category data was inserted into the formula for classifying new cases (pages 214-215) and the discriminant function score was calculated for each simulated mixed assemblage. The discriminant *Z* score for each of these assemblages and the group centroids for patterned tool and bipolar groups are presented in Table 5.18.

The results of the classification of the mixed assemblages indicated that 75:25 ratio of patterned tool to bipolar reduction debitage is classified in the patterned tool

Table 5.18. Discriminant *Z* Scores for Simulated Mixed Assemblages in Two Group Analysis.

Composite Assemblages	Z Score
Patterned Tool	-.85794
Bipolar	1.57289
PT/BP 75:25*	-.00040
PT/BP 50:50	5.08560
PT/BP 25:75	9.89720

*cutoff ratio for classification as patterned tool

category. However, additional calculations indicate that changing the ratio by just five percent (70:30) would result in a discriminant *Z* score of 1.0919, and classification in the bipolar group. Based on the results of the mixed assemblage classification, it was concluded that the two group discriminant analysis can separate "pure" experimental patterned tool and bipolar reduction assemblages, but cannot discriminate mixed assemblages of the two groups accurately. Austin (1999:59) and Jeske (1993:143) reached similar conclusions in their attempts to discriminate between reduction strategies.

Discriminant analysis with SRT flake categories as independent variables may be useful in intrasite analysis to separate loci of patterned tool manufacture from that of bipolar reduction to produce flakes, but it must be augmented to detect mixed assemblages. It appears that an examination of the relative percentage of SRT flake categories in a simple graph, in comparison to experimental composite pattern tool and bipolar data, can provide a relative indication of the degree of mixing. Figure 5.16 gives the relative positions of the three mixed assemblages in Table 5.17, along with the composite patterned tool and bipolar assemblages. Interpolation of the lines in this graph should provide an indication of the relative degree of mixing of the two reduction

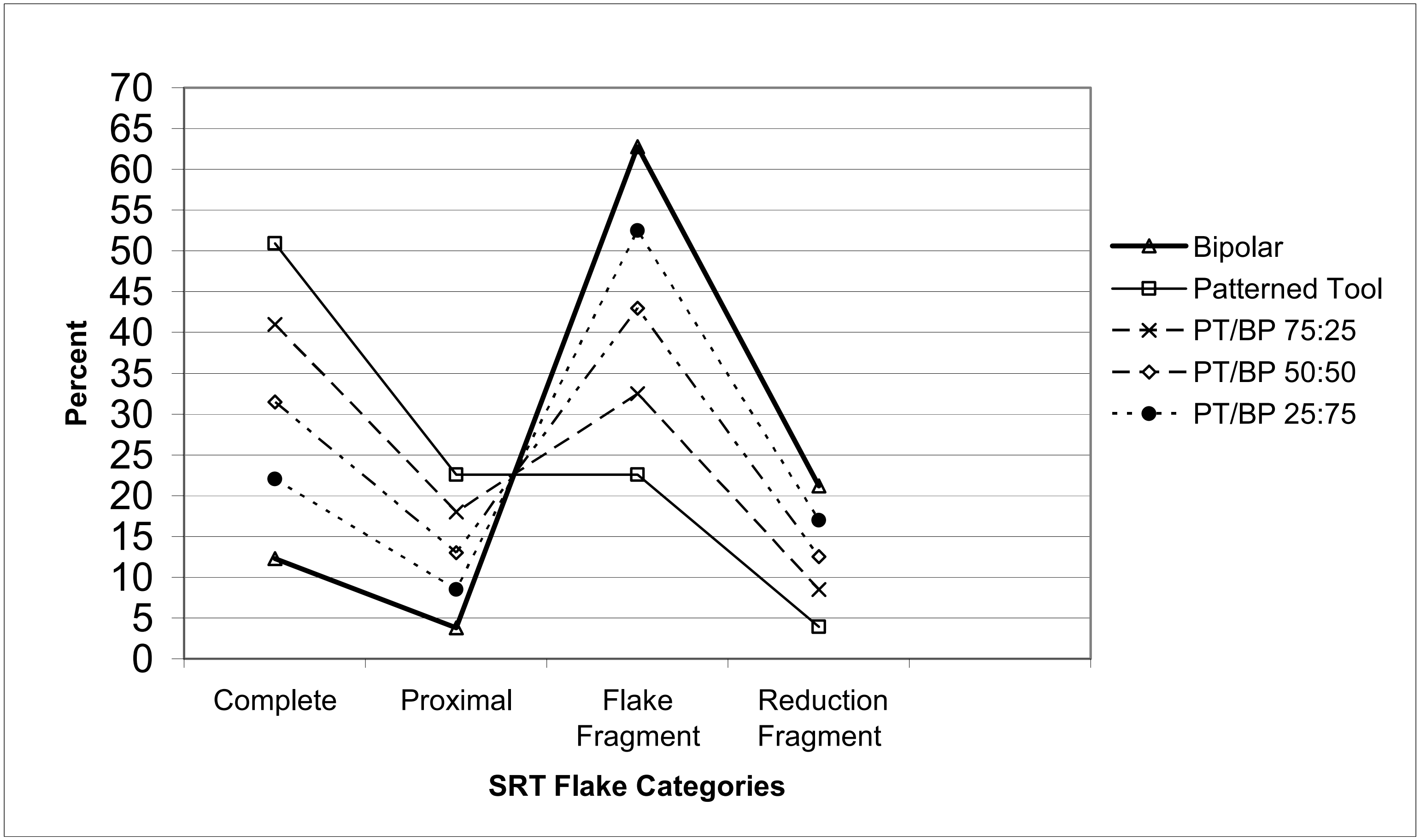


Figure 5.16. Comparison of SRT flake category (4) percentages for composite assemblages of patterned tool, bipolar and mixed assemblages of patterned tool production and bipolar reduction (75:25, 50:50, 25:75

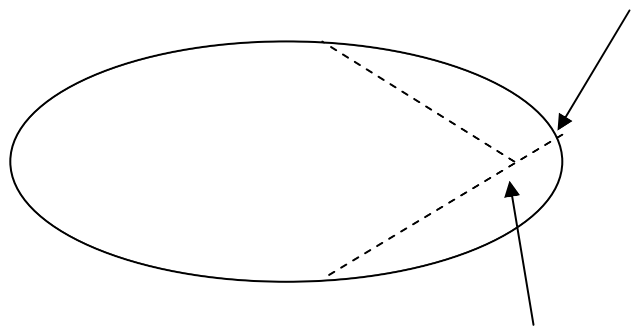
strategies, either in an excavation unit assemblage of debitage, or the site assemblage as a whole.

Starting Forms

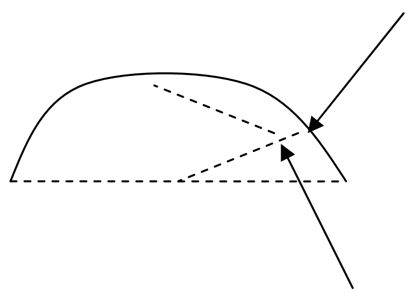
Selected independent variables were statistically analyzed to determine if they could differentiate between the two starting forms, split pebble (SP) and flake blank (FLK), which were used to manufacture patterned tools in the lithic reduction experiments. Statistical analyses were conducted with ratio and ordinal data derived from the experimental debitage. All patterned tool experiments, complete and incomplete, were analyzed in this portion of the study.

The starting forms were categorized into two main types based on the degree of reduction and morphology of the objective piece. The SP is one half of a pebble split by the bipolar method (Figure 4.1). The resulting halves of the pebble are then reduced with a hard hammer (Figure 5.17), and pressure flaked with a deer antler to one of the pattern tool forms. Splitting of a cobble or pebble is essentially the same process with similar results, so the term split pebble was used to indicate both forms.

Flake blanks are the result of the further bipolar reduction of a pebble to produce more usable material for tool manufacture. The products of this further bipolar reduction are categorized into three general forms of flake blanks: spall-like, citrus, and medial (Figure 5.18 A-C). The spall-like flake blank is similar in morphology to the SP, with a rounded dorsal surface covered with cortex and a relatively flat ventral surface. The main difference between the two is that the spall-like flake blank is thinner in cross-section than the SP. The citrus flake blank is a typical result of bipolar reduction



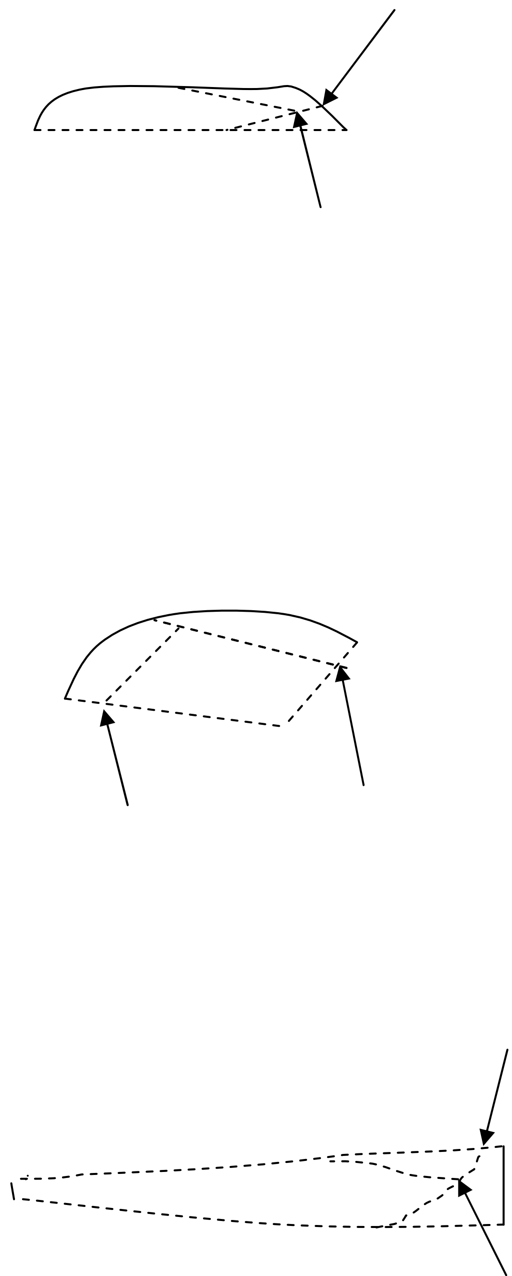
A. Freehand reduction of a gravel.



B. Split pebble as a starting form.

Figure 5.17. Generalized flaking patterns shown in cross-section: (A) reduction of a whole gravel by freehand percussion to obtain usable flakes; (B) reduction of a split pebble by freehand percussion for pattern tool manufacture.

Key: ——— Cortex -------- Non-cortical flake scar → Direction of blow



A

B

C

Figure 5.18. Generalized flaking pattern of three flake blank types shown in cross-section: (A) Spall-like flake blank; (B) Citrus-like flake blank; (C) Bipolar medial flake blank. Key: ——— Cortex; ---------Non-cortical flake scar; ⟶ Direction of blow.

(Binford and Quimby 1963:297-298; Flenniken 1981:42). Its morphology is that of a section of an orange, with two scarred (ventral) surfaces parallel to each other forming a "V" shape where they intersect and a rounded segment (dorsal) covered with cortex. The medial flake blank either results from the bipolar reduction of a citrus form, or a pebble from which a spall has been removed. The former flake blank may have cortex on one longitudinal margin (Figure 5.18 C) while the latter may possess a cortical margin partially or completely along the circumference of the flake between the dorsal surface, which contains the scar from the spall removal, and the ventral surface (not illustrated). In the experiment these three forms were not differentiated, but were simply categorized as FLK's.

Discriminant Analysis . The composite ordinal attributes of dorsal cortex percentage, platform types, flake scars, and size class (6.4-55 mm) for the two starting forms were plotted by cumulative flake percentages to gauge differences and similarities. See discussion pages 211-213, *SRT Results,* for procedures. Inspection of the ogives given by these variables suggested they were similar for both starting forms. The Kolmogorov-Smirnov tests reinforced this initial observation (Table 5.19). The likelihood of the null hypothesis that there are no significant differences between the two starting forms for the tested variables being true at the .05 significance level is indicated with descriptive terms.[3] Although platform types of four categories (Table 5.20) did not meet the significance level of .05, the two tailed probability of .108 for platform types, derived from the Kolmogorov-Smirnov test, coupled with a chi-square test (χ^2= 6.693, df=3, p =.08 > .05) for this attribute, suggested some promise for use of this

Table 5.19. Results of the Kolmogorov-Smirnov Test of Cumulative Percentage of Selected Ordinal Attributes of Composite Experimental Assemblages of Starting Forms
.

Ordinal Variables	Null Hypothesis
Platform Types (4 cats.)	Not Very Likely
Dorsal Flake Scars	Extremely Likely
Size Class (8.2-52.5 mm)	Extremely Likely
Dorsal Cortex %	Extremely Likely

variable in discriminant analysis. Both tests indicated that this attribute was just slightly outside the chosen significance level of .05.

Table 5.20. Frequencies of Platform Types of Four Categories by Starting Form for Composite Experimental Assemblages of Patterned Tools.

Composite Assemblages	Cortical N	%	Flat N	%	Faceted N	%	Abraded N	%	Total Flakes
Split Pebble	73	37.6	53	27.3	64	33.3	4	2.1	194
Flake Blank	61	30.7	44	22.1	91	45.7	3	1.5	199

A discriminant analysis was applied to the 22 patterned tool experiments for starting forms with platform types of four categories. The variable was entered simultaneously with equal probabilities and both unstandardized coefficients, and Fisher's linear discriminant functions were derived. This discriminant analysis produced an overall correct classification rate (Table 5.21) of 86.36 percent (19/22). Both groups

Table 5.21. Classification of Two Group Discriminant Analysis of Starting Forms of Experimental Pattern Tool Manufacture with Platform Types of Four Categories.

Predicted Group Membership					
Group	Number of Cases	Split Pebble N	%	Flake blank N	%
Split Pebble	7	6	85.7	1	14.3
Flake blank	15	2	13.3	13	86.7
Percent of grouped cases correctly classified: 86.36%					

were above the one-fourth level of improvement over the priors, which is the classification obtained simply by guessing that all cases were flake blanks or split pebbles.

To perform an internal validation of the classification results, 10 composite test assemblages of equal to or larger than 100 pieces were developed and tested utilizing the procedures previously discussed for validation (pages 221-226, *SRT Results*). The *unstandardized canonical discriminant function coefficients* were used to obtain a classification score for each composite test assemblage. A cutoff score of .31615 was obtained, all cases larger than .31615 were assigned to the SP group, and those with a score less than .31615 were assigned to the FLK group. All five (100 percent) of the split pebble assemblages were correctly classified, but only one of the five FLK (20 percent) assemblages were correctly categorized. The overall classification rate was 60 percent (6/10 cases). The discriminant function failed to correctly predict group membership of the composite test assemblages at an acceptable level (90 percent). Therefore, the discriminant results were not validated, and cannot be used with confidence to separate SP from FLK as a starting form with the platform types of four categories employed in disciminant analysis. This result may be attributable to the relatively small size of the SP sample (n =7), which can result in an upward bias in classification accuracy for this starting form (Hair et al. 1995:210). The use of discriminant analysis to separate the starting forms must await a larger sample of split pebble cases.

<u>Ratio Variables</u>. The ratio variables of length, maximum width and thickness, and weight were analyzed to determine their usefulness in classifying the two starting forms by their debitage. In this portion of the analysis, only debitage equal to or greater

than 25.4 mm in greatest dimension were considered. The 20 percent sample indicated that only 3.8 percent of the debitage examined was larger than 25.4 mm in greatest dimension. In the 22 lithic experiments, larger pieces comprised 13.8 percent of the biface and 13.4 percent of the uniface (scraper) assemblages. This difference in larger pieces seems to indicate the initial reduction of pebbles was conducted elsewhere, or that a majority of flake blank were further reduced to produce formal tools, or smaller expedient flake tools or removed for use at another location, or all three behaviors were manifested at the KBS. As a result, flakes larger than 25.4 mm in greatest dimension were excluded from this portion of the study. The means and standard deviations for the four ratio variables are presented in Table 5.22. A two sample *t* test indicated the differences in these measures of the debitage derived from the starting forms were significant at the .05 level (Table 5.23). This suggested that these ratio variables could be used to separate the two starting forms if a discriminant analysis determined that the assemblage was the result of patterned tool manufacture. However, when the mean of each variable, plus one standard deviation, is presented as an "error plot

Table 5.22. Summary Data for Length, Width, Thickness, and Weight of Experimental Debitage (≤25.4 mm) for Starting Forms.

Variables	Starting Forms	N	Mean	S.D
Length (mm)	SP	185	12.93	4.97
	FLK	204	11.99	4.46
Width (mm)	SP	195	12.21	4.10
	FLK	214	11.17	3.93
Thickness (mm)	SP	211	3.13	1.92
	FLK	249	2.66	1.36
Weight (g)	SP	216	0.53	0.94
	FLK	260	0.33	0.44

Figures 5.19, 5.22.5.20, 5.21, and 5.22) there is an almost complete overlap in all four measures. It seems highly unlikely that the debitage resulting from the reduction of

Table 5.23. Two Sample *t* test of Length, Width, Thickness, and Weight for Experimental Debitage (≤25.4 mm) of Starting Forms.

Variable	*t* -value	d.f.	2-tail significance
Length	1.97	390	.05
Width	2.62	407	.009
Thickness	3.10	458	.002
Weight	2.96	474	.003

(these two starting forms to manufacture patterned tools could be classified in an archaeological assemblage with these ratio measures.

Platform Types. The knapper, Jack Cresson, began to reduce an SP starting form by striking off flakes from the cortical covered dorsal face of the piece (Figure 5.17 B). The FLK forms were reduced differentially depending on their individual morphology (Figures 5.18 A-C). These observations suggested that reduction of an SP starting form would produce a greater proportion of flakes with cortical platforms and zero percent dorsal cortex than FLK reduction. To test the hypothesis concerning platform types and dorsal cortex percentage, a new variable was constructed which contained nine categories based on platform type and amount of dorsal cortex. Due to the low number of abraded platforms (*n* = 7), they were combined into the faceted category, which resulted in a three platform type variable. Likewise, dorsal cortex percentage was collapsed into three categories: zero percent, one to fifty percent, and fifty one to one hundred percent. The chi-square test results for the differences in proportions between categories, as well as the number of pieces and the percentage of each category, for each starting form, are presented in Table 5.24.

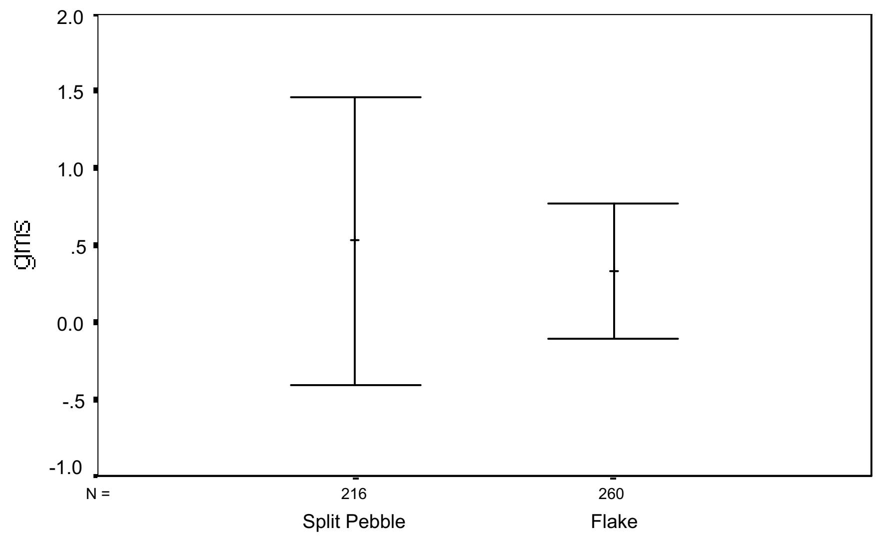


Figure 5.19. Weight: mean and one standard deviation of the debitage derived from the composite experimental assemblages (≤ 25.4 mm) by starting form.

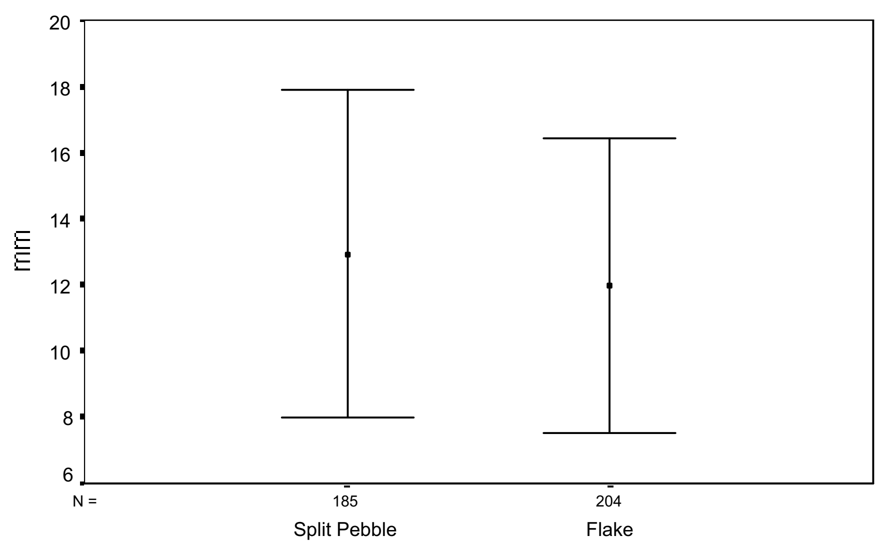


Figure 5.20. Length: mean and one standard deviation of the debitage derived from the composite experimental assemblages (≤ 25.4 mm) by starting form.

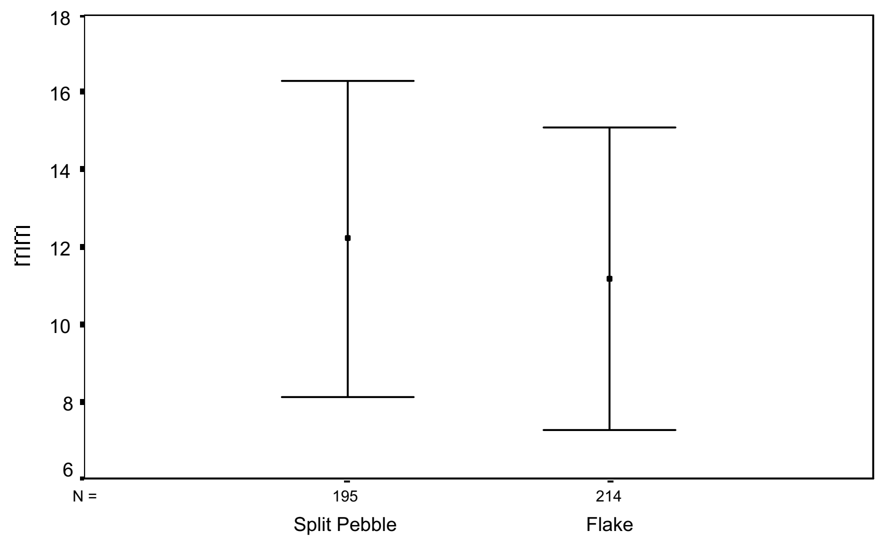


Figure 5.21. Width: mean and one standard deviation of the debitage derived from the composite experimental assemblages (≤ 25.4 mm) by starting form.

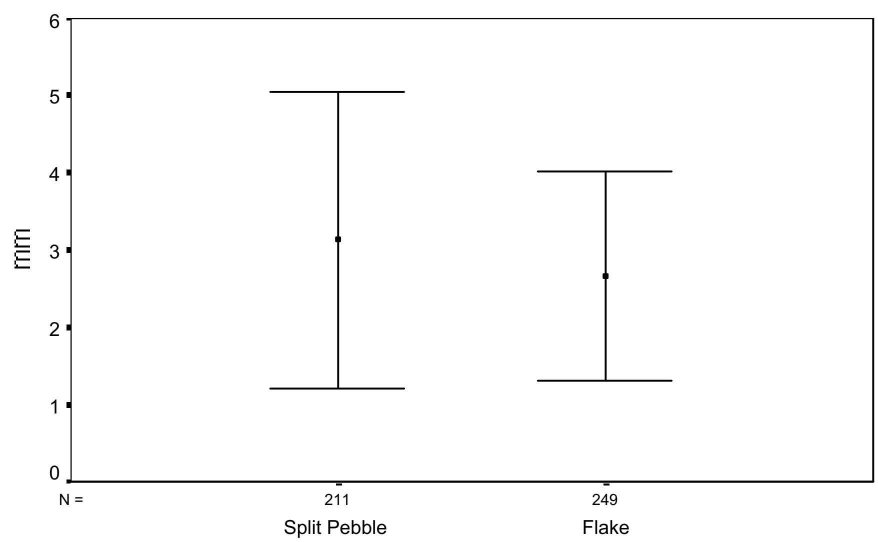


Figure 5.22. Thickness: mean and one standard deviation of the debitage derived from the composite experimental assemblages (≤ 25.4 mm) by

Table 5.24. Frequency of Platform Types/Dorsal Cortex Flakes by Starting Form. (≤25.4 mm)

Category	SP % (*n* .)	FLK % (*n* .)	Category	SP % (*n* .)	FLK % (*n* .)
Cortex/0%	17.1 (29)	16.7 (29)	Flat/51-100%	7.6 (13)	2.3 (4)
Cortex/1-50%	6.5 (11)	2.9 (5)	Faceted/0%	23.5 (40)	35.6 (62)
Cortex/51-100%	7.6 (13)	5.2 (9)	Faceted/1-50%	10.0 (17)	10.9 (19)
Flat/0%	17.6 (30)	14.4 (25)	Faceted/51-100%	5.3 (9)	4.0 (7)
Flat/1-50%	4.7 (8)	8.0 (14)			
chi-square = 14.895 d.f. = 8 prob. = .061 >.05					

The difference in the proportion of flakes with a cortical platform/zero percent dorsal cortex for the SP (17.1 percent) and FLK (16.7 percent) starting forms is slight (.4 percent). The greatest difference between the two forms (12.1 percent) is in the category faceted platforms/zero percent dorsal cortex (SP = 23.5 percent and FLK = 35.6 percent). The probability determined by the chi-square test for the combined platform/dorsal cortex variable is slightly greater than the .05 significance level. The use of these categories to separate the starting forms demonstrates some promise, but it is somewhat problematic in testing the hypothesis concerning the knapping strategy used to reduce SP forms.

The above result is most likely due to the similarity of two forms that are encompassed by the FLK category to the SP form. The two flake forms (spall-like and citrus) contain large areas of cortex on the dorsal face, and zero percent cortex on the ventral surfaces (Figure 5.18 A-C). If flaking was initiated on the dorsal face of these forms, they would produce flakes in the category cortex/zero percent dorsal cortex, which would be difficult to distinguish from the similar flakes struck from SP forms. The variety of FLK forms were not recorded for each individual experiment, so it is not possible to compare individual types to the SP form. The results of the analysis of starting forms for dorsal cortex percentage in the following portion of this study suggests why the combined platform type and dorsal cortex percentage did not meet expectations.

Dorsal Cortex. An analysis of the proportion of dorsal cortex on the debitage resulting from the reduction of SP and FLK starting forms was no more successful than the previous efforts above. The chi-square statistic for dorsal cortex (3 categories) percentage (χ^2= 3.654, df=3, p = .301 > .05) indicated that it was very likely the two samples were indistinguishable for this attribute. The results of a Kolmogorov-Smirnov test gave a two tailed probability of .896, which suggested the two forms were extremely likely to be similar for dorsal cortex cover. This data strongly suggest that the proportions of dorsal cortex cover are not useful to distinguish between the two starting forms. However, the similarities in proportions between the two forms for this attribute suggest its usefulness in the identification of gravels as the source of lithic raw material. The proportion of pieces with at least some cortex was 43.1 percent for SP, and 37.8 percent for FLK forms. Regardless of which strategy was used in the manufacture of patterned tools the proportion of pieces with at least some cortex should be approximately 37 percent or higher, if the entire reduction sequence was conducted on the site. This proportion, as well as CSA's from reduction, should indicate the use of alluvial gravels as a source of lithic raw materials. Lesser proportions may indicate a partial reduction sequence, and in the absence of CSA's (Appendix A), the consideration of other sources of stone as the lithic raw material for the knappers of the KBS.

Biface and Uniface Production

Selected recorded attributes of the composite experimental debitage were analyzed to discover if they could be used to determine the proportion of biface (triangular projectile points) and unifacial scraper manufacture in the BF debitage assemblage. Ordinal variables of platform types (three types), dorsal cortex percentage, dorsal flake scars, the combined platform types/dorsal cortex percentage, and the ratio attributes of length, maximum width, maximum thickness, platform width and thickness, and weight were examined. In previous analyses, neither size classes (page 169-170) nor SRT (Table 5.10 and Figure 5.13) could be used successfully to separate these two tool manufacturing assemblages. Of the 22 experiments, 16 episodes had the goal of producing a biface, and six episodes the goal of producing a form of unifacial scraper (Table 5.6, *SRT Results*). Only debitage equal to or smaller than 25.4 mm in greatest dimension were considered in this portion of the study.

The proportions of the above four ordinal variables for the composite experimental biface and uniface manufacture assemblages are presented in Tables 5.25, 5.26, 5.27, and 5.28. The attributes of dorsal cortex percent, platform types (3 categories), and platform types/dorsal cortex percent categories show significant differences (.05 level) between the two tool types, while dorsal flakes scars did not.

Table 5.25. Frequencies of Dorsal Cortex Percentage Categories for Biface and Uniface Composite Experimental Assemblages of Patterned Tools (≤25.4 mm).

Composite Assemblages	0% N	0% %	1-50% N	1-50% %	51-99% N	51-99% %	100% N	100% %	Total Flakes
Biface	206	65.8	60	19.2	19	6.1	28	8.9	313
Uniface	69	46.9	40	27.2	25	17.0	13	8.8	147
chi-square = 21.445 df = 3 prob.= .00009 < .05									

Table 5.26. Frequencies of Dorsal Flake Scar Categories for Biface and Uniface Composite Experimental Assemblages of Patterned Tools (≤25.4 mm).

Composite Assemblages	100% Cortex N %	One Scar N %	Two Scars N %	>Two Scars N %	Total Flakes
Biface	19 8.3	49 21.5	56 24.6	104 45.6	228
Uniface	7 6.0	36 31.0	28 24.1	45 38.8	116
chi-square = 4.202 df = 3 prob.= .240 > .05 V = .1105					

Table 5.27. Frequencies of Platform Types (3) for Biface and Uniface Composite Experimental Assemblages of Patterned Tools (≤25.4 mm).

Composite Assemblages	Cortical N %	Flat N %	Faceted N %	Total Flakes
Biface	59 25.9	56 24.6	113 49.6	228
Uniface	37 31.9	38 32.8	41 51.9	116
chi-square = 6.630 df = 2 prob.= .042 < .05				

Table 5.28. Frequencies of Platform Types/Dorsal Cortex Percentage Categories (9) for Biface and Uniface Composite Experimental Assemblages of Patterned Tools (≤25.4 mm).

Category	Biface % (*n* .)	Uniface % (*n* .)	Category	Biface % (*n* .)	Uniface % (*n* .)
Cortex/0%	14.9 (34)	20.7 (24)	Flat/51-100%	2.2 (5)	10.3 (12)
Cortex/1-50%	5.3 (12)	3.4 (4)	Faceted/0%	36.8 (84)	15.5 (18)
Cortex/51-100%	5.7 (13)	7.4 (9)	Faceted/1-50%	7.9 (18)	12.1 (18)
Flat/0%	18.0 (41)	12.1 (14)	Faceted/51-100%	4.8 (11)	4.3 (5)
Flat/1-50%	4.4 (10)	10.3 (12)	Total Flakes	228	116
chi-square = 34.968 df = 8 prob. = .00003 < .05					

Additionally, dorsal cortex percentage was combined into three categories, with the 51 to 99 percent and 100 percent categories collapsed into a single category, 51 to 100 percent. This variable was also significant for differences in proportions between the two tool types (χ^2 = 15.291, df = 2, .00046 < .05).

Examination of Tables 5.25 and 5.27 and Figures 5.23, 5.24, 5.25, and 5.26 indicates that biface manufacture produced flakes with a greater frequency of zero percent cortex (65.8 percent) than uniface manufacture (46.9 percent), as well as a greater frequency of faceted platforms, 49.6 percent to 35.3 percent. Conversely, uniface manufacture produced a greater frequency of flakes with some dorsal cortex (53.1 percent) and cortical (31.9 percent) and flat platforms (32.8 percent) than biface manufacture (34.2, 25.9, and 24.6 percent respectively). It is not surprising that these differences would be manifest in the combined variable of the attributes of platform types and dorsal cortex percentage categories. Indeed, in the category of Faceted Platform/0 Percent Cortex (Table 5.28 and Figure 5.26) the differences between the tool types were easily discernible (biface = 36.8 percent and uniface = 15.5 percent). However, in larger tables used to compute a chi-square statistic (two by nine in this instance), not every difference is as apparent, as only some of the cells have important differences (Drennan 1996:196). In order to determine which cells or categories provide the greatest amount of differentiation, confidence intervals of 95 and 99.9 percent for each of the nine categories were calculated. The formula for the standard deviation of a proportion is

$$s = \sqrt{pq}$$

where s = the standard deviation of the proportion; p = the proportion expressed as a decimal fraction; and q = 1-p. The standard error expressed as a percentage is calculated with s, the standard deviation of the proportion as

$$SE = \frac{\sigma}{\sqrt{n}}$$

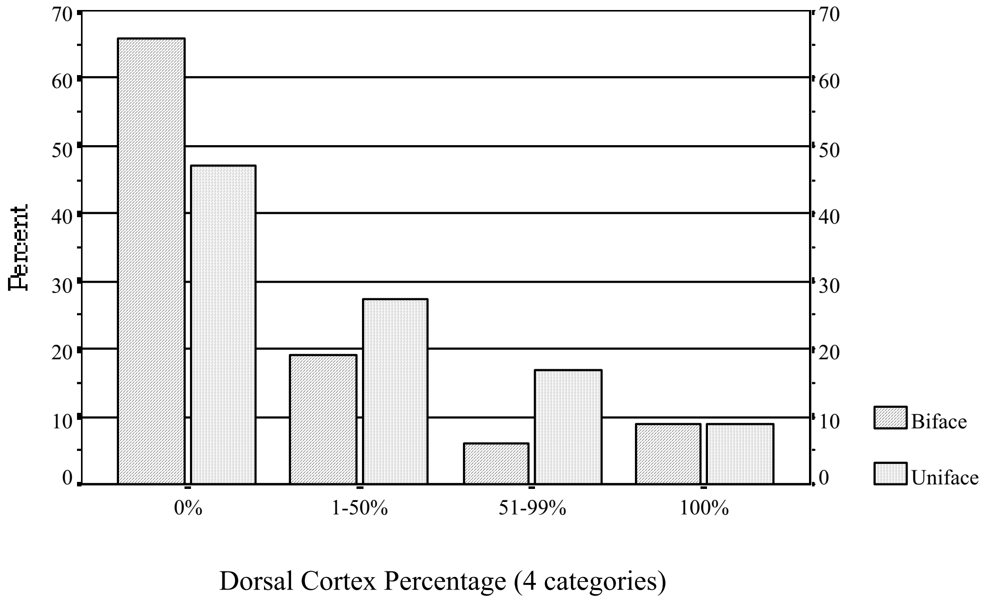


Figure 5.23. Proportions of dorsal cortex percentage categories (4) for composite biface and uniface experimental debitage assemblages (≤25.4 mm).

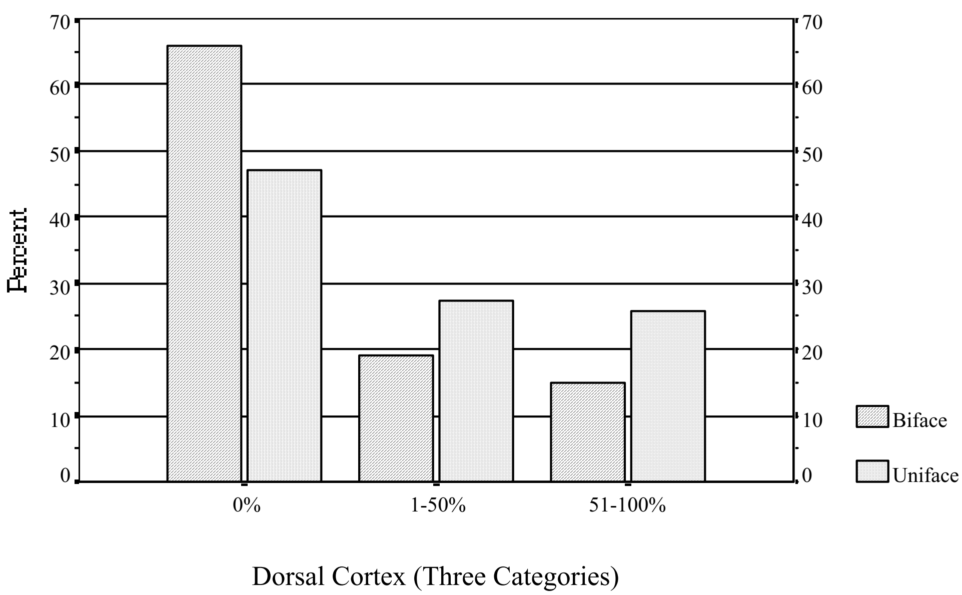


Figure 5.24. Proportions of dorsal cortex percentage categories (3) for composite biface and uniface experimental debitage assemblages (≤25.4 mm).

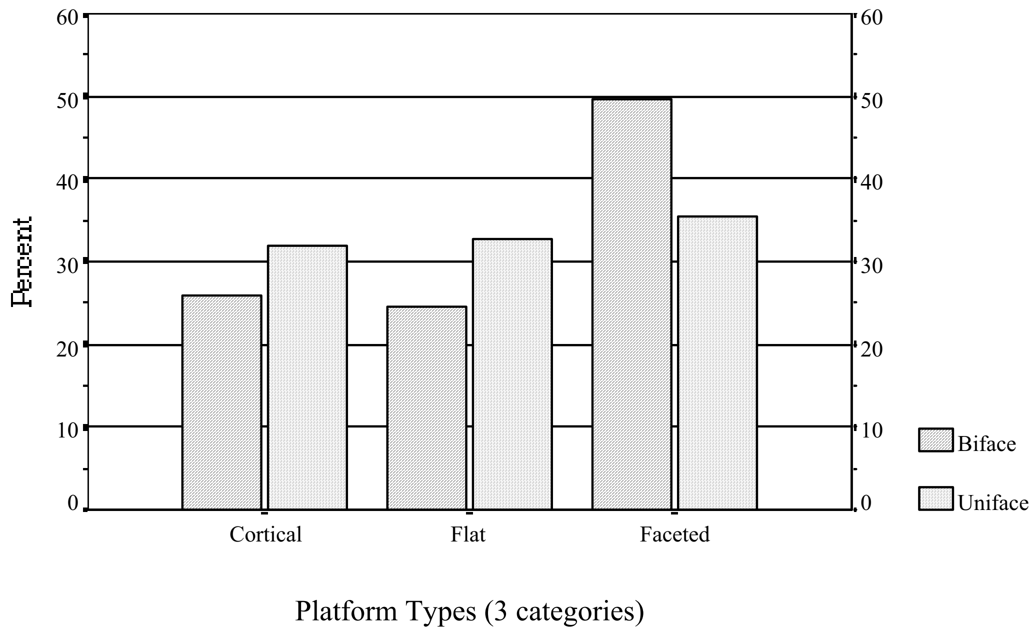


Figure 5.25. Proportions of platform type categories (3) for composite biface and uniface experimental debitage assemblages (≤25.4 mm).

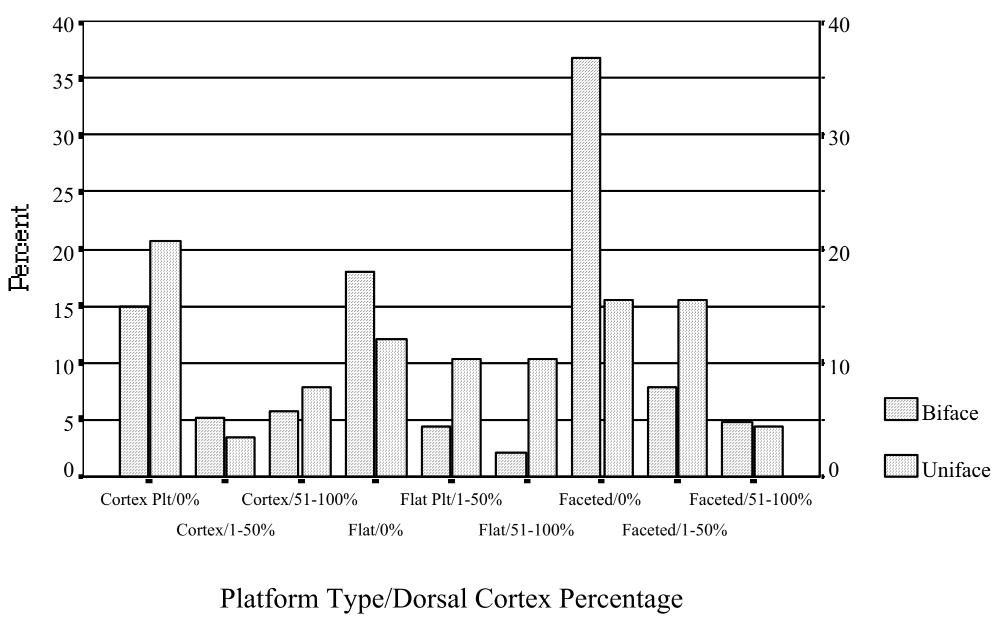


Figure 5.26. Proportions of platform type/dorsal cortex percentage categories for composite biface and uniface experimental debitage assemblages (≤25.4 mm).

Then, the standard error of the proportion is multiplied by a *t* value from the student's *t* distribution table for the level of confidence and the degrees of freedom to obtain the desired confidence error range (Drennan 1996:139-142). The final results contain the standard deviation, standard error, and error ranges (confidence interval) based on the proportion of each category (Table 5.28).

Five categories (Table 5.29) are significant at the 95 percent confidence level and one, faceted/0 percent dorsal cortex, is significant at the 99.9 percent confidence level. This analysis suggests that the category faceted/0 percent dorsal cortex may be the signature attribute of biface manufacture in comparison to uniface manufacture for these experiments. Undoubtedly, extensive thinning, which is recognized as an integral part of biface manufacture and reduction stages (Callahan 1979:90-153; Collins 1975:21-22; Rule and Evans 1981; Stewart 1987a:98-99), is responsible for the majority of these flakes. The value of platform types and dorsal cortex in discriminating bifacial reduction was demonstrated by Magne and Pokotylo (1981:38), and platform facet counts were utilized by Carr and Bradbury (2001:137-139) to aid in the determination of the percentage of biface and uniface manufacture in an assemblage. This category would encompass the bifacial thinning flake, often intuitively identified in flake assemblages (Andrefsky Jr. 1998:112; Crabtree 1972:94 and 96; Magne and Pokotylo 1981:40) as an indicator of biface manufacture (for a critique of this and other flake typologies see Sullivan and Rozen 1985:757-758). The five significant (confidence level .95) categories of platform type/dorsal cortex percentage are plotted for the composite biface and uniface experiments with the calculated proportions (Table 5.29) in Figure 5.27.

The problem of mixed assemblages of biface and uniface manufacture was addressed in the same manner as in the discriminant analysis, patterned tool manufacture was separated from bipolar reduction by creating three simulated mixed composite assemblages with biface to uniface ratios of 75:25, 50:50, and 25:75, respectively

Table 5.29. Confidence Intervals for Platform/Dorsal Cortex% Categories of Biface and Uniface Composite Experimental Flake Assemblages (≤25.4 mm).

Category	Tool	MN %	SD	SE %	Confidence Intervals % 95% +/-	99.9% +/-
Cortex/0%	Bi Uni	14.9 20.7	.3560 .4051	2.4 3.8	4.7 7.5	7.9 12.8
Cortex/1-50%	Bi Uni	5.3 3.4	.2241 .1812	1.5 1.7	2.9 3.4	4.9 5.7
Cortex/51-100%	Bi Uni	5.7 7.8	.2318 .2682	1.5 2.5	2.9 5.0	4.9 8.4
Flat/0% *	Bi Uni	18.0 12.1	.3842 .3261	4.9 3.0	4.9 5.9	8.2 10.1
Flat/1-50% *	Bi Uni	4.4 10.3	.2051 .3040	1.4 2.8	2.7 5.5	4.6 9.4
Flat/51-100% *	Bi Uni	2.2 10.3	.1467 .3040	1.0 2.8	2.0 5.5	3.3 9.4
Faceted/0% **	Bi Uni	36.8 15.5	.4823 .3679	3.2 3.4	6.3 6.7	10.5 11.5
Faceted/1-50% *	Bi Uni	7.9 15.5	.2798 .3679	1.9 3.4	3.7 6.7	6.3 11.5
Faceted/51-100%	Bi Uni	4.8 4.3	.2138 .2029	1.4 1.9	2.7 3.8	4.6 6.4

Biface *n* =228; Uniface *n* = 116.
*significant at 95% confidence level
**significant at 99.9% confidence level

Table 5.30. Proportions of Five Significant (≥.95 CL) Platform/Dorsal Cortex Percentage Categories for Biface, Uniface, and Simulated Mixed Assemblages of Biface and Uniface (75:25, 50:50, 25:75) Manufacture.

Categories	Biface %	Uniface %	75:25 %	50:50 %	25:75 %
Flat/0%	18.0	12.1	16.6	15.0	13.6
Flat/1-50%	4.4	10.3	5.9	7.4	8.8
Flat/51-100%	2.2	10.3	4.2	6.3	8.3
Faceted/0%	36.8	15.5	31.5	26.0	20.8
Faceted/1-50%	7.9	15.5	9.8	11.7	13.6

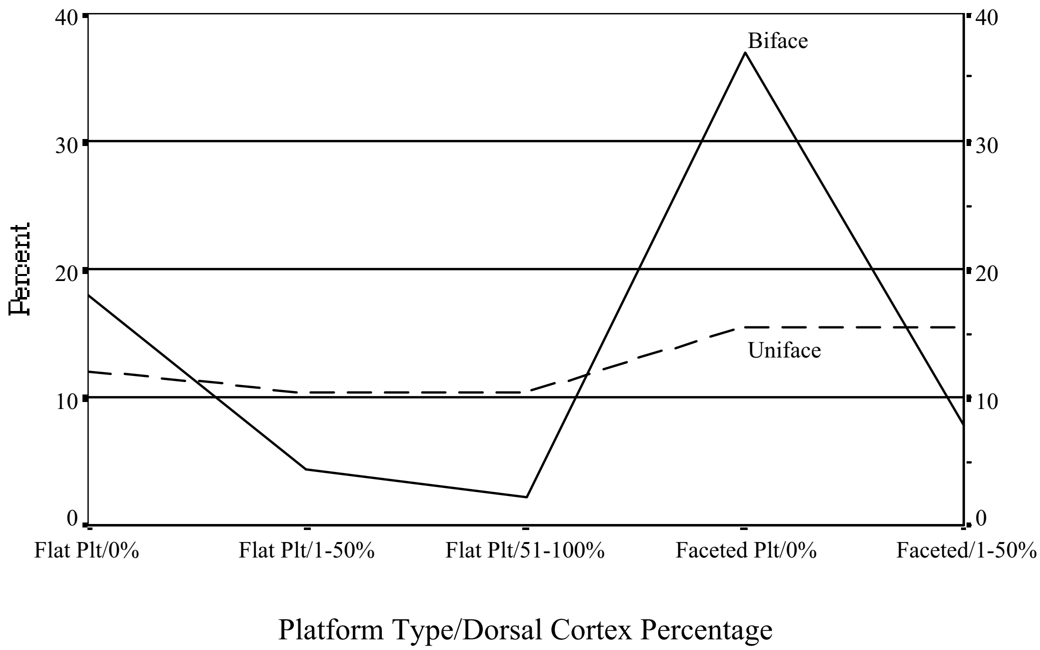


Figure 5.27. Five significant (95% confidence level) categories of Platform/Dorsal Cortex% proportions for biface and uniface composite experimental debitage assemblies (≤25.4 mm).

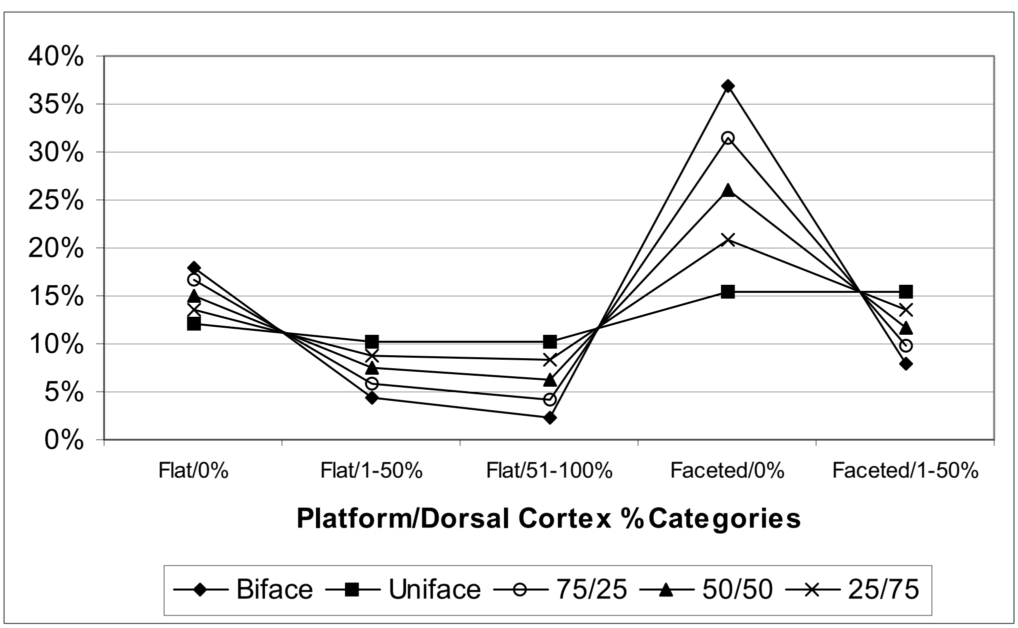


Figure 5.28. Five significant (95% confidence level) categories of Platform/Dorsal

Cortex% proportions for biface and uniface composite experimental debitage assemblies

(Table 5.30). Instead of mixed assemblages of 200 pieces, only the proportions of the five categories for biface/uniface mixtures were calculated. The formula presented on and simulated mixed assemblages of biface and uniface (75:25, 50:50, 25:75) debitage (≤25.4 mm) pages 227-228 was used to develop these mixed assemblages with the assemblage size (n = 200) removed from the equation. Interpolation of these results should provide a relative indication of the percentage of biface and uniface manufacture. The proportions displayed in Table 5.30 are plotted in Figures 5.27 and 5.28. It is apparent that the greatest separation for the mixed assemblages is provided by category Faceted/0 Percent Dorsal Cortex. In smaller assemblages of 100 pieces or less, as in several of the trenches at the BF locus, a few flakes not recovered or removed originally by the knapper could possibly skew the results in the other four categories. In these cases the Faceted/0 Percent Dorsal Cortex alone would alone provide the means to infer the relative percentage of biface and uniface manufacture.

Ratio Attributes. The ratio variables of length, maximum width, maximum thickness, and weight were analyzed to determine if they could separate biface and uniface manufacture. The means, standard deviations, and t test statistics of the debitage

Table 5.31**.** Summary Data and t test Statistics for Maximum Length, Width, and Thickness and Weight for Debitage of Composite Experimental Biface and Uniface Manufacture (≤25.4 mm).

Variables	Tool	N	Mean	S.D.	t -value	df	2-t significance
Length (mm)	Biface	262	12.15	4.70	-1.73	390	.084
	Unifac	130	13.03	4.74	—	—	—
Width (mm)	Biface	276	11.77	4.09	0.72	407	.473
	Unifac	133	11.46	3.93	—	—	—
Thickness (mm)	Biface	313	2.74	1.55	-2.45	458	.015
	Unifac	147	3.15	1.84	—	—	—
Weight (gm)	Biface	327	0.37	0.48	-2.27	474	.024
	Unifac	149	0.53	1.06	—	—	—

for both tool types are presented in Table 5.31. Only maximum thickness and weight meet the two-tailed significance level of .05. Practically, the confounding effect of mixed patterned tool and bipolar reduction assemblages would make it extremely difficult to separate the debitage of the two tool types by these ratio attributes (see Carr and Bradbury (2001 :134-141) for a discussion of determining percentage of reduction types).

Discussion. In practice, separation of the debitage from the two patterned tool classes would only be reliable on a relatively unmixed sample, one in which there is little or no debitage from bipolar reduction present. Practical application at the KBS would require discriminant analysis to classify the excavation unit assemblages, and to ascertain the relative amount of admixture of bipolar reduction and patterned tool manufacture debitage (Table 5.17 and Figure 5.16). Because neither Mohney (2004) or Kuijt et al. (1995) published similar data for the four ordinal and four interval attributes from their experiments, these results could not be compared to bipolar reduction. It is highly problematic to utilize these attributes in any but the relatively unmixed (75:25) patterned tool to bipolar reduction assemblages (Figure 5.16), which can be classified by the discriminant function presented earlier in this study. In addition, the length of the biface reduction trajectory accomplished at the BF locus is an important consideration in this analysis. The BF assemblage represents both complete and partial trajectories from initiation to premature termination and full completion. Some initial processing may have occurred at another location, thus removing this debitage signature from the archaeological assemblage. Larger flakes may have been further reduced, and/or pieces may have been transported for use elsewhere. Limiting the analysis of debitage to pieces equal to or less than 25.4 mm in greatest dimension should lessen the potential impact of these factors. The five platform type/dorsal cortex percentage categories should provide a relative percentage of tool type represented in an identified patterned tool assemblage at KBS.

Experimental Biface Reduction Sequence

The BRS developed for this study consists of three stages: Blank, Preform I, and Preform II. This study uses the terms sequence and stage interchangeably (Andrefsky Jr. 1998 :180). This BRS is essentially a product of shifts in production technology from bipolar reduction in the Blank stage, to produce either a SP or further reduction into a usable FLK to Preform I, to shape, thin, and straighten edges by freehand hard hammer reduction, and Preform II, which is final thinning and sharpening of edges by pressure flaking (see page 133). These stages were developed for purpose of analysis and may or may not have been cognizant goals of the KBS knappers, but simply part of the continuum of manufacture (see Callahan 1979; Sellet 1993; Shott 1994:81-83).

A suite of nominal, ordinal, and ratio variables that have demonstrated utility in stage analysis and in identification of technological signatures in debitage were tested with univariate and multivariate statistical analysis (Ahler and Vannest 1985; Ahler 1989; Amick et al. 1988; Gilreath 1984; Johnson 1989; Magne and Pokotylo 1981; Magne 1989; Morrow 1984; Odell 1989; Sullivan III 1987). These are the nominal variables of platform crushing and lipping; ordinal variables of dorsal cortex percentage, dorsal flake scar count, platform types, size classes, SRT, combined platform types and dorsal cortex percentage; and ratio variables of length, maximum width and thickness, weight, and platform width and thickness. These variables, with the exception of platform crushing, platform lipping, and the SRT, are based on the fundamental truth that knapping is both a reductive and cumulative process. Percentage of dorsal cortex, size class, linear measurements, and mass should diminish as reduction proceeds, while the attributes of dorsal scar count and platform complexity, which reflect the successive removal of flakes, should increase. Crushed platforms and platform lips are seen as indicators of the technological methods, of hard hammer and pressure flaking. The SRT with five flake classes is included for its ability to provide an indication of different force applications, such as bipolar, freehand hard hammer, and pressure flaking.

Only complete biface manufacturing experiments were considered for this portion of the study (see Table 4.3). Although it was broken at Preform I, Experiment 3 was included. Experiment 3a is the continuation of Experiment 3 by reduction of another FLK produced in the Blank stage. Together they complete one sequence from blank production to completed biface. Although there is ample evidence of failures among the CSA's in the KBS archaeological assemblage, there appears to be no discernible method that can accurately assess the proportion of debitage produced by these failures. The inclusion of only complete experiments provides a baseline to measure divergence from this norm. Only debitage equal to or less than 25.4 mm were tested in this portion of study, for reasons previously discussed (see page 220). All SRT flakes were used in the analysis, not just PRB flakes, and consequently the number of pieces in each analysis of individual variables may differ because not all attributes were recorded for each flake type (see Table 4.5). In addition, certain attributes of all debitage equal to or greater than 6.4 mm were tested, to provide an indication of the total biface reduction sequence to assist in determination of the length of the biface reduction trajectory at the KBS. All variables were tested with statistical methods appropriate for their scale or level of measurement (Drennan 1996; Thomas 1986b).

Ordinal Variables. All alluvial gravels are completely covered with cortex. The knapping process removes this cortex with successive blows until no remnant of the original cortex remains on debitage produced in the later stages of reduction. The originally recorded four category variable violated the assumptions of chi-square testing for this analysis. The 51-99 percent and 100 percent categories were combined into a new category, 51-100 percent, to create a three category variable. The proportions of dorsal cortex cover did decrease in the successive BRS stages (Table 5.32 and Figure 5.29). Additionally, a variable of two categories which consisted of zero percent and one to hundred percent cortex, was constructed. It is essentially a no cortex and some cortex

Table 5.32. Frequencies of Dorsal Cortex Percentage Categories for BRS of Composite Experimental Assemblages of Biface Manufacture (≤25.4 mm).

BRS	0%		1-50%		51-100%		Total Flakes	
	N	%	N	%	N	%	N	%
Blank	29	52.7	14	25.5	12	21.8	55	18.8
Preform I	137	68.8	41	20.6	21	10.6	199	68.8
Preform II	35	92.1	2	5.3	1	2.6	38	13.0
Totals	201	68.8	57	19.5	35	11.6	292	100.0
chi-square = 17.875 df = 4 prob.= .0013 < .05 gamma = -.46267								

dichotomy, which is even easier to determine than the three category form. This variable also proved to be significant for differences between stages (χ^2 = 16.244, df = 2, prob. = .0003 < .05, gamma = -.46267). In the Blank stage 47.7 percent of all pieces contain some cortex, compared to 31.2 percent for Preform I, and 7.9 percent for Preform II. The relatively large difference between Blank and Preform II is undoubtedly due to their

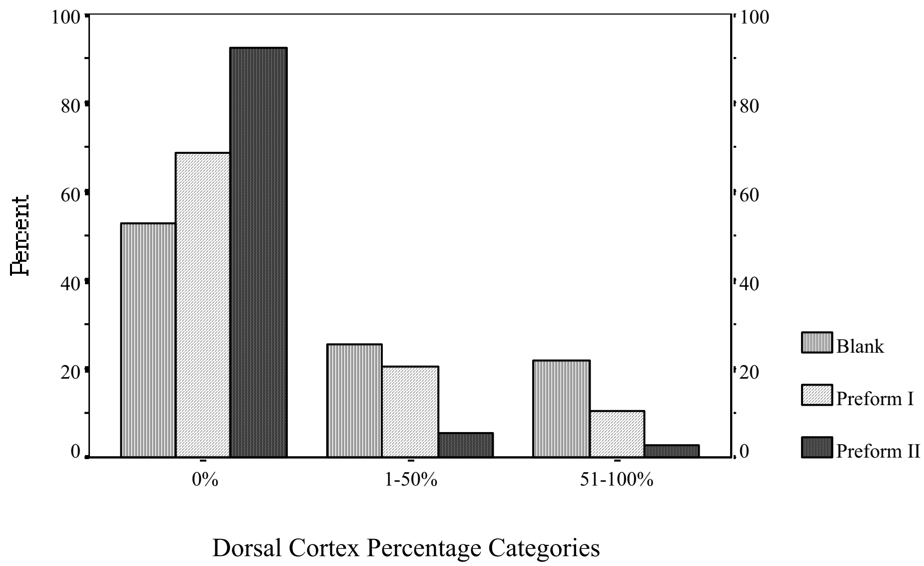


Figure 5.29. Proportions of Dorsal Cortex Percentage categories (3) for BRS stages of composite experimental assemblages of biface manufacture (≤25.4 mm).

Table 5.33. Frequencies of Dorsal Flake Scar Count Categories for BRS of Composite Experimental Assemblages of Biface Manufacture (≤25.4 mm).

BRS	100% Cortex N	%	One Scar N	%	Two Scars N	%	>Two Scars N	%	Total Flakes N	%
Blank	6	20.0	9	30.0	5	16.7	10	33.3	30	13.6
Preform I	9	5.8	36	23.1	41	26.3	70	44.9	156	70.9
Preform II	0	0.0	3	8.8	9	26.5	22	64.7	34	15.5
Totals	15	6.8	48	21.8	55	25.0	102	46.4	220	100.0
chi-square = 18.487 df = 6 prob.= .0051 < .05 gamma= .3891										

respective positions at the beginning and the end of the reduction trajectory. Likewise, dorsal flake scar counts contain significant differences among the BRS stages (Table 5.33). The proportion of flake scar counts increased in each succeeding stage (Figure 5.30). The Blank stage is characterized by a relatively higher proportion (50.0 percent) of flakes with 100 percent cortex and one scar, compared to 28.9 percent for Preform I, and 8.8 percent in Preform II. Conversely, 91.2 percent of flakes produced in Preform II

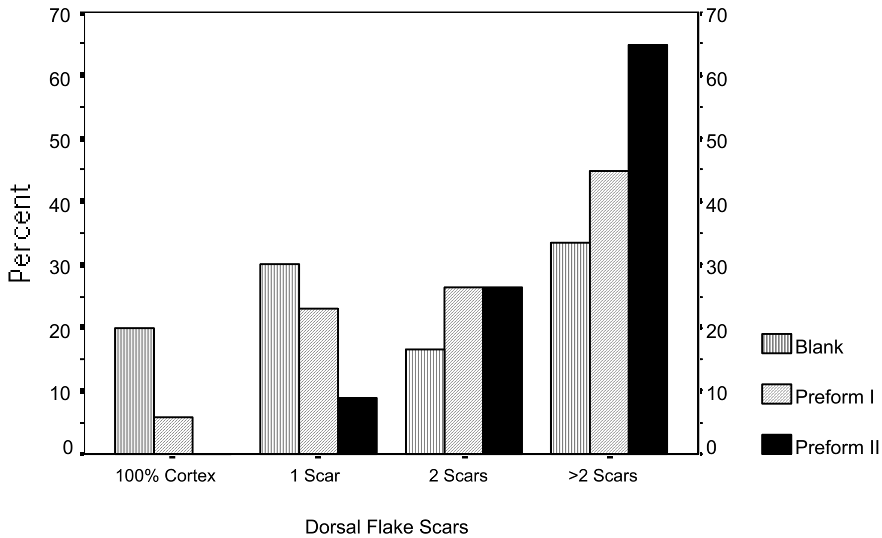


Figure 5.30. Proportions of Dorsal Flake Scar Counts for BRS stages of composite experimental assemblages of biface manufacture (≤25.4 mm).

carried two or more scars, which differentiated it from Blank production at 50.0 percent, but not so greatly from 71.2 percent produced in Preform I.

A three category variable of platform types was constructed (see page 209 for explanation). The four category variable violated the assumptions necessary for the computation of the chi-square statistic. The number of abraded platforms (n = 7) proved too low for consideration. The new variable met all the assumptions. This variable, although significant in the differences in proportions between the BRS stages, gave a gamma statistic that indicates a low-moderate association of this variable to the BRS stages (Table 5.34). This is somewhat surprising, as other researchers found platform types to be useful indicators of reduction stages (Gilreath 1984; Magne and Pokotylo 1981:37; Morrow 1984:26). Examination of Figure 5.31 suggests that this variable distinguishes Preform II from the other two stages, but not between Blank and Preform I.

Table 5.34. Frequencies of Platform Types (3 categories) for BRS Stages of Composite Experimental Assemblages of Biface Manufacture (≤25.4 mm).

BRS	Cortical N	Cortical %	Flat N	Flat %	≥Two Facets N	≥Two Facets %	Total Flakes N	Total Flakes %
Blank	10	33.3	4	13.3	16	53.3	30	13.6
Preform I	45	28.8	39	25.0	72	46.2	156	70.9
Preform II	1	2.9	11	32.4	22	64.7	34	15.5
Totals	56	25.5	54	24.5	110	50.0	220	100.0
chi-square = 12.599 df = 4 prob.= .0134 < .05 gamma = .22648								

The relatively high percentage (53.3) of faceted platforms in the Blank stage was higher than that of the subsequent Preform I.

The results of the platform types tests caused reconsideration of the advantages of testing all flake sizes in the analysis. Platform types were effected more strongly by the removal of flakes greater than 25.4 mm from the analysis than most other variables. To explore this hypothesis, this variable was tested with all size pieces, and the results

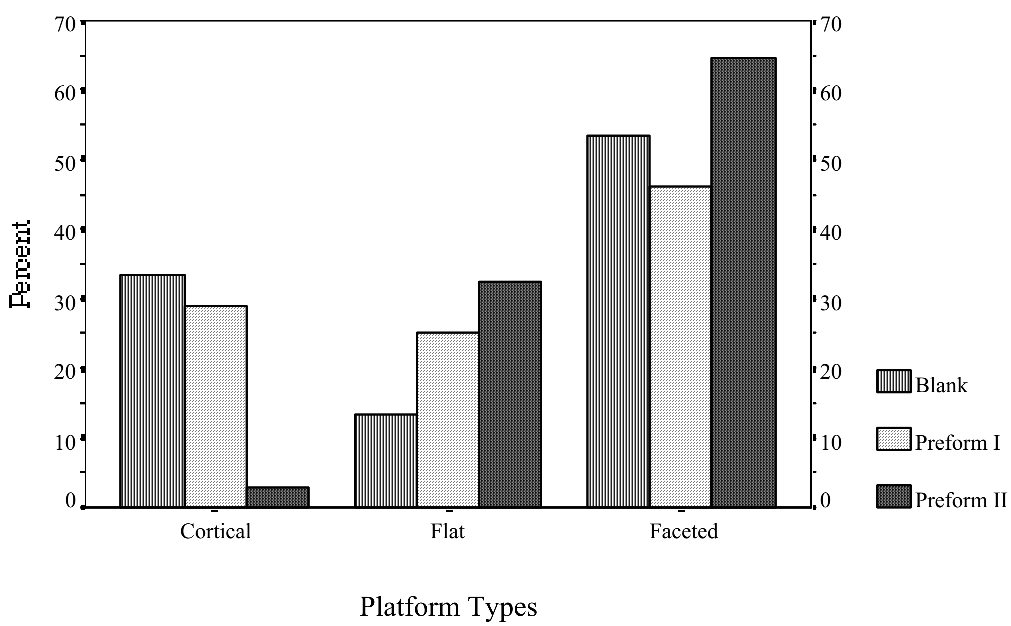


Figure 5.31. Proportions of platform types (3 categories) for BRS of composite experimental assemblages of biface manufacture (≤25.4 mm).

indicated the platform types were significant between BRS stages (χ^2 = 19.93258, df = 4, prob. = .0005 < .05, gamma = .34747). In addition, the gamma statistic suggests a high-moderate association. To further examine this issue the same tests were conducted for all debitage equal to or greater than 6.4 mm for each variable in the analysis. The differences are reported in the *Length of Biface Reduction Trajectory* later in this section.

The variable, which contained the mean of the 5 mm size classes utilized in the log-linear (pages 193-196) portion of this study was tested to determine its usefulness to distinguish BRS stages. It was truncated to four size classes, due to the restriction of the analysis to flakes equal to or less than 25.4 mm. This variable was significant for differences between BRS stages (Table 5.35). The gamma statistic suggests a strong negative association between BRS stages and the size classes, so as reduction proceeds

Table 5.35. Frequencies of Size Class Categories for BRS of Composite Experimental Assemblages of Biface Manufacture (≤25.4 mm).

BRS	6.4-10 mm		10.1-15 mm		15.1-20 mm		20.1-25.4 mm		Total Flakes	
	N	%	N	%	N	%	N	%	N	%
Blank	10	17.2	23	39.7	16	27.6	9	15.5	58	19.3
Preform I	50	24.5	86	42.2	51	25.0	17	8.3	204	67.8
Preform II	31	79.5	8	20.5	0	0.0	0	0.0	39	13.0
Totals	91	30.2	117	38.9	67	22.3	26	8.6	301	100.0
chi-square = 57.378 df = 6 prob.= .00000 < .05 gamma= -.51408										

through the stages the proportions of smaller flakes increase, and the larger flakes decrease (Figure 5.32). In Preform II there are no pieces with a dimension greater than 15 mm, while in Blank and Preform I the proportions of debitage larger than 15 mm in greatest dimension are 43.1 and 33.3 percent respectively.

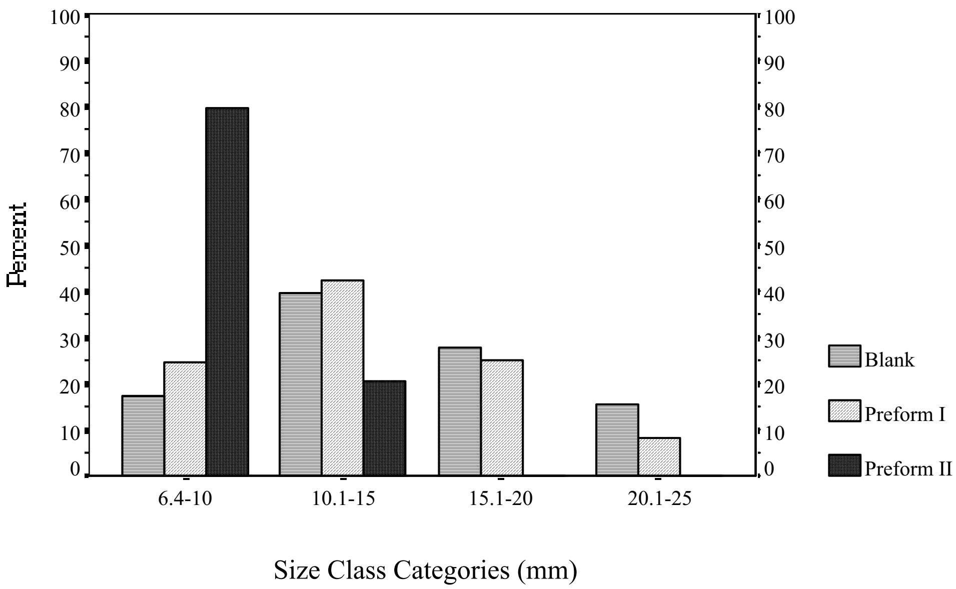


Figure 5.32. Proportions of size class categories for BRS stages of composite experimental assemblages of biface manufacture (≤25.4 mm).

The Sullivan-Rozen flake typology was tested in both variates. The SRT with five categories (addition of split flake) was significant for differences in proportions between BRS stages (Table 5.36). The SRT with four categories (split flakes recorded as flake fragments) was also significant for proportional differences between stages (χ^2 = 20.514, df = 6, prob.=.002 < .05, gamma = -.36324). The five category SRT was selected to gain the addition differentiation provided by the split flake category, especially with the Blank stage that is essentially bipolar reduction (Figure 5.33). Split flakes are thought to occur more frequently as a result of the uncontrolled blows during initial cobble reduction (Sullivan III 1987:46). In fact this was borne out in the relatively higher percentage of split flakes in Blank stage (20.7 percent) compared to Preform I (6.9 percent) and Preform II (0.0 percent). Examination of the relative percentages of flake

Table 5.36. Frequencies of SRT Flake Categories (5) for BRS of Composite Experimental Assemblages of Biface Manufacture (≤25.4 mm).

Stages	Complete N %	Proximal N %	Flk Frag N %	Red Frag N %	Split Flk N %	Total Flks N %
Blank	17 29.3	13 22.4	13 22.4	3 5.2	12 20.7	58 19.3
Preform I	110 53.9	46 22.5	29 14.2	5 2.5	14 6.9	204 67.8
Preform II	23 59.0	11 28.8	4 10.3	1 1.2	0 0.0	39 13.0
Totals	150 49.8	70 23.3	48 15.3	9 3.0	26 8.6	301 100.0
chi-square = 24.451 df = 8 prob. = .0019 < .05 gamma = -.36109						

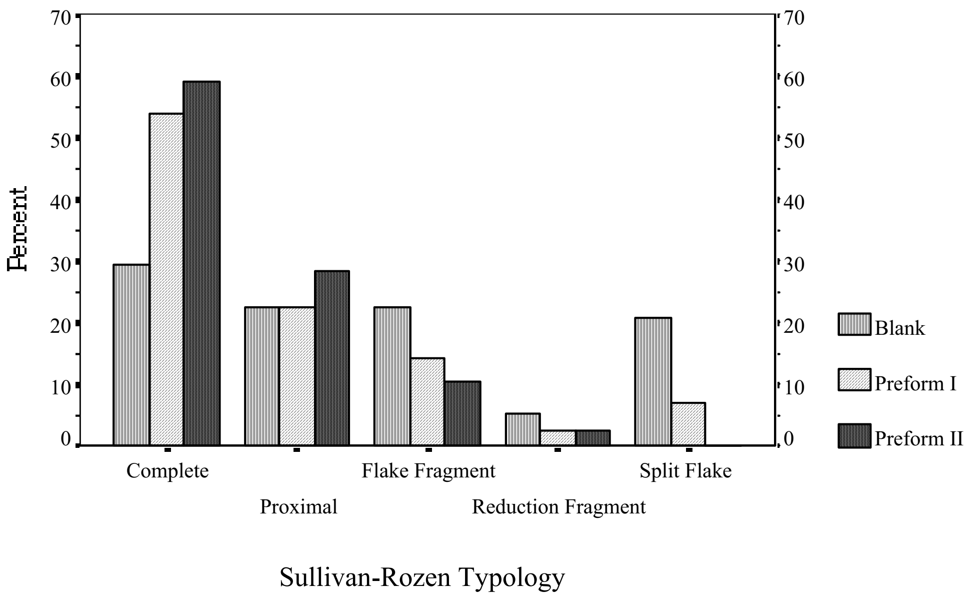


Figure 5.33. Proportions of SRT (5) categories for BRS stages of composite experimental assemblages of biface manufacture (≤25.4 mm).

types suggests that not all of the categories provide equal separation between the three stages. Confidence intervals were computed for each of the categories, and only the split flake was significant for differences between BRS stages at the 95 percent confidence level. This indicates that the percentage of split flakes in an assemblage may assist in determination of the proportion of Blank stage debris present.

The combined variable of platform type and dorsal cortex percentage was tested in both nine and six category variations. Both forms violated the assumptions for computing the chi-square statistic. However, upon examination of the data it appeared as if several of the categories were widely separated (Figure 5.34). Confidence levels computed (see pages 245-246) for all categories indicated that none were significant at

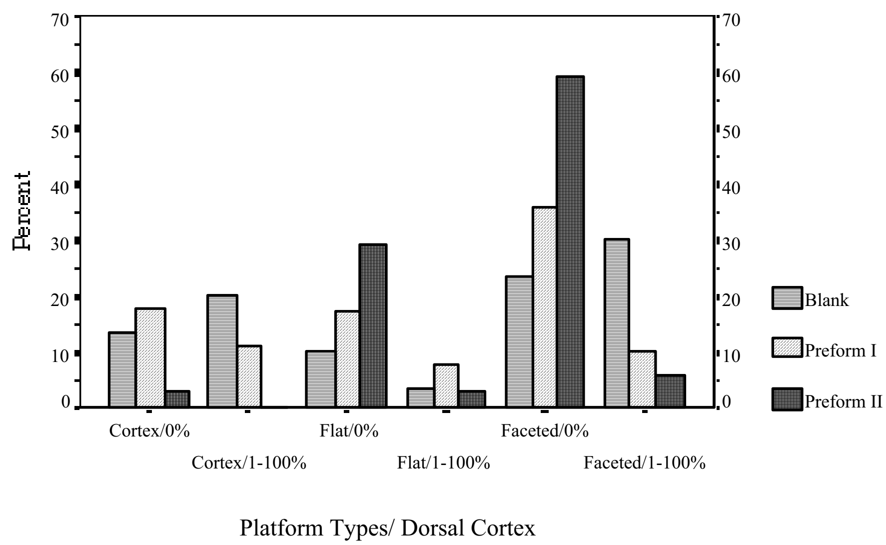


Figure 5.34. Proportions of platform types/dorsal cortex percentage (6 categories) proportions for BRS stages of composite experimental biface manufacture assemblages (≤25.4 mm).

the 95 percent confidence level. At this point this variable eliminated from further consideration, although one of the categories, Faceted/0 Percent, was significant at greater than the 90 percent confidence level.

<u>Ratio Variables</u>. The linear measures of length, maximum width, maximum thickness, weight, and platform width and thickness were each plotted with error bars with the mean plus one standard deviation for each variable (Figures 5.35 through 5.40). The range of these values for each stage is so widely distributed for each measure, that the mean for each stage is overlapped by the range of another stage, therefore a stage

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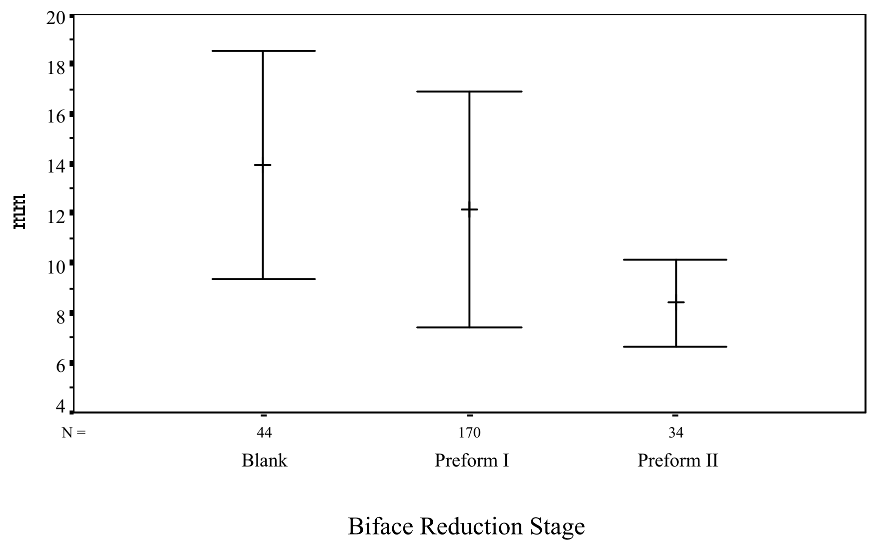

Figure 5.35. Length: mean plus one standard deviation of the debitage from the BRS of the composite experimental assemblage of biface manufacture (≤25.4 mm).

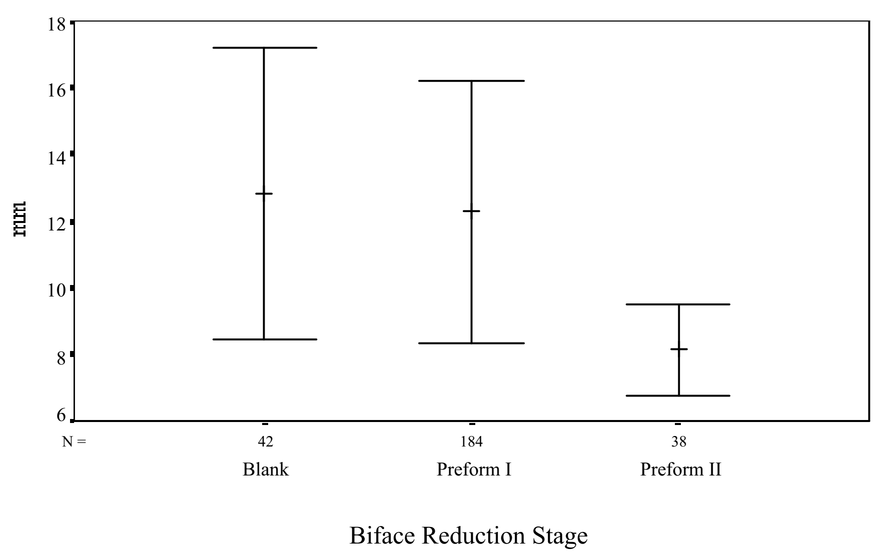

Figure 5.36. Width: mean plus one standard deviation of the debitage from the BRS of the composite experimental assemblage of biface manufacture (≤25.4 mm).

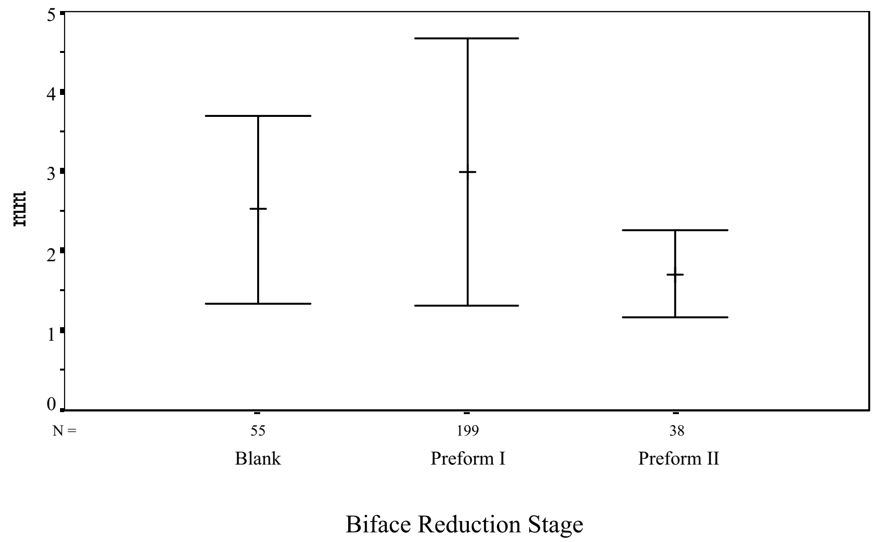

Figure 5.37. Thickness: mean plus one standard deviation of the debitage from the BRS of the composite experimental assemblage of biface manufacture (≤25.4 mm).

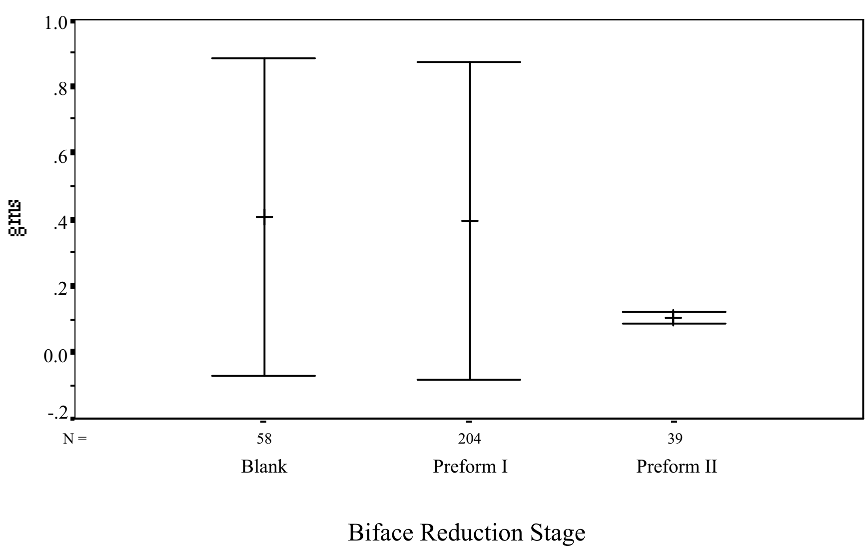

Figure 5.38. Weight: mean plus one standard deviation of the debitage from the BRS of the composite experimental assemblage of biface manufacture (≤25.4 mm).

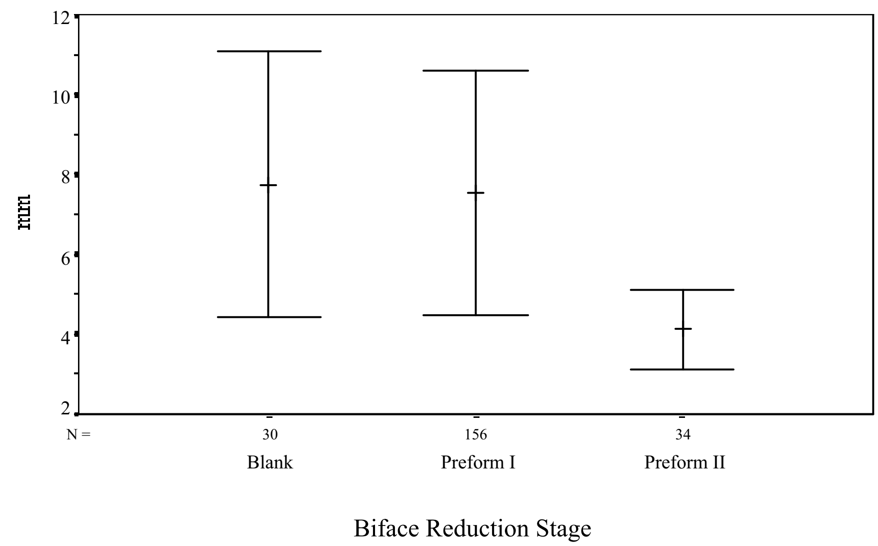

Figure 5.39. Platform Width: mean plus one standard deviation of the debitage from the BRS of the composite experimental assemblage of biface manufacture (≤25.4 mm).

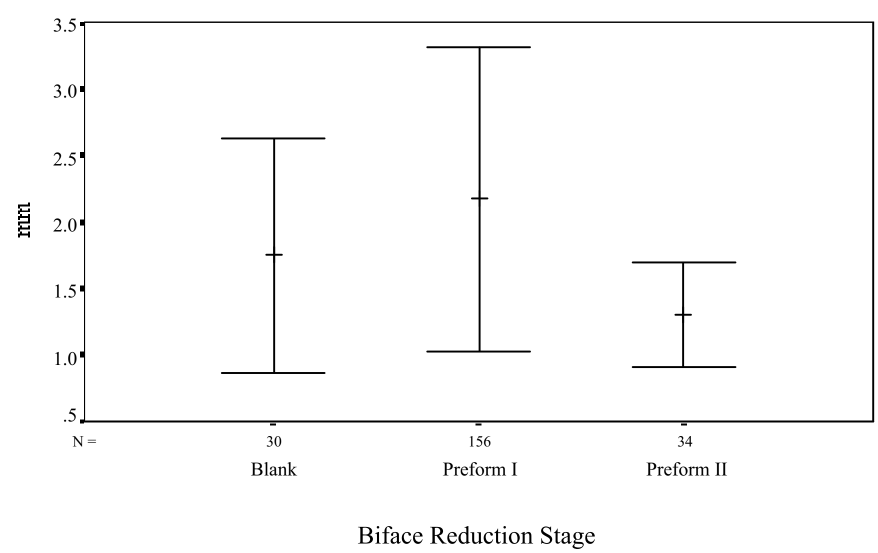

Figure 5.40. Platform Thickness: mean plus one standard deviation of the debitage from the BRS of the composite experimental assemblage of biface manufacture (≤25.4 mm).

cannot be distinguished from the other two by these measures. The conclusion reached was that these six measures would not be useful beyond the descriptive level.

It appeared these measurements could be greatly effected by the removal of flakes greater than 25.4 mm from the analysis, so the distributions with error bars plus one standard deviation were constructed. Although, the means were larger for the Blank and Preform I measurements, the standard deviations were also greater, so the spread for each stage overlapped the means of the others for each attribute as in the size restricted analysis. The population that included all pieces equal to or greater than 6.4 mm in greatest dimension was examined for all measurements. This analysis gave a similar distribution skewed downward toward smaller sizes and weights, as in the analysis of pieces equal to or less than 25.4 mm in greatest dimension. In the delineation of BRS stages for this study, there is no additional information provided by including all of the debitage versus the restricted sample for these ratio variables.

<u>Nominal Variables</u>. Two dichotomous attributes, the presence or absence of platform crushing, and a platform lip, considered useful in separation of hard hammer and pressure flakes, were tested. The first two stages of reduction, Blank and Preform I, are essentially accomplished by hard hammer percussion, with some pressure flaking in Preform I to remove small humps and in platform preparation. These pressure flakes accounted for 3.9 percent (8/204) of the Preform I sample, and 17.0 percent (8/47) of the total pressure flakes. The reduction process in Preform II was exclusively accomplished by pressure flaking. The differences between BRS stages for both these attributes was

significant (Tables 5.37 and 5.38). Platform crushing yielded a lambda of .26168, with crushing as the dependent variable. This statistic indicates that this variable is helpful in

Table 5.37**.** Frequencies of Platform Crushing for BRS Stages of Composite Experimental Assemblages of Biface Manufacture (≤25.4 mm).

Stages	Absent		Present		Total Flakes	
	N	%	N	%	N	%
Blank	5	16.7	25	83.3	30	13.5
Preform I	71	44.9	87	55.1	158	71.2
Preform II	31	91.2	3	8.8	34	15.3
Totals	107	48.2	115	51.8	222	100.0
chi-square = 37.773 df = 2 prob. =.00000 < .05 V = .41249						

Table 5.38**.** Frequencies of Platform Lips for BRS Stages of Composite Experimental Assemblages of Biface Manufacture (≤25.4 mm).

Stages	Absent		Present		Total Flakes	
	N	%	N	%	N	%
Blank	29	96.7	1	3.3	30	13.6
Preform I	134	85.9	22	14.1	156	70.9
Preform II	21	61.8	13	38.6	34	15.5
Totals	184	83.6	36	16.4	220	100.0
chi-square = 16.189 df = 2 prob. =.0003 < .05 V = .27127						

identifying individual flakes (literally 26 percent greater than chance guessing), while platform lip was .0000 as a dependent variable. However, because the greatest proportion of pieces was produced in Preform I, one could predict that an individual flake was from Preform I without the aid of platform lip, although statistically there is a strong association between platform lip and Preform II (Norusis 1995:375). The data suggests these two variables may be helpful in separating flake populations, and to ascertain the length of the biface reduction trajectory present in the assemblage.

Multiple Discriminant Analysis. A series of MDA's were conducted, to determine if the variables previously tested would classify individual flakes correctly as to their membership in a BRS stage. The BRS was entered as the dependent variable and dorsal cortex percentage (two categories), platform crushing, platform lip, dorsal flake scars, platform types (three categories), size classes, SRT (five categories), and the combined platform type/dorsal cortex percentage (six categories) were the independent variables. Three separate analyses were completed: simultaneous entry with all eight variables; stepwise entry to select those variables that are the most significant; and simultaneous entry with the variables selected in the stepwise procedure plus one additional variable (see page 215). Each discriminant analysis assumed equal prior probabilities and used the within group covariance matrix. Both Fisher's and undstandardized coefficients were produced to classify cases.

The simultaneous entry of all variables produced acceptable results with an overall correct classification rate of 62.3 percent (Table 5.39). This MDA produced

Table 5.39. Classification of Flakes within BRS Stages of Composite Experimental Assemblages of Biface Manufacture (≤25.4 mm), Simultaneous Entry, Eight variables.

Predicted Group Membership							
BRS	Number of Cases	Blank		Preform I		Preform II	
		N	%	N	%	N	%
Blank	30	20	66.7	9	30.0	1	3.3
Preform I	156	44	28.2	89	57.1	23	14.7
Preform II	34	1	2.9	5	14.7	28	82.4
Percent of grouped cases correctly classified: 62.3% Total Flakes = 220							

acceptable results of 66.7 percent in the classification of Blank flakes, which is 13.6 percent of the total population, and Preform II, which is 15.5 percent of the total, was correctly classified at 82.4 percent. However, Preform I, the largest portion of the total flake population at 71.0 percent, is only correctly classified at an unsatisfactory 57.1

percent. This is 14 percent less than what could be achieved by simply guessing that all the flakes were from Preform I.

A stepwise procedure with variables entered and removed one at a time produced a lower percentage of correctly classified flakes of 53.2 percent (Table 5.40). However, this was accomplished with just three variables: platform lip, platform crushing, and size classes. Although the overall correct classification rate was diminished, Blank stage flakes were classified correctly at a higher frequency of 76.7 percent, and the Preform II correct classification rate remained the same, 82.4 percent. The flakes in Preform I were even more problematic as the classification rate dropped to 42.3 percent.

Table 5.40. Classification of Flakes within BRS Stages of Composite Experimental Assemblages of Biface Manufacture (≤25.4 mm), Stepwise Entry, Three Variables.

Predicted Group Membership								
BRS	Number of Cases	Blank		Preform I		Preform II		
		N	%	N	%	N	%	
Blank	30	23	76.7	6	20.0	1	3.3	
Preform I	156	62	39.7	66	42.3	28	17.9	
Preform II	34	1	2.9	5	14.7	28	82.4	
Percent of grouped cases correctly classified: 53.2% Total Flakes = 220								

A third MDA, with simultaneous entry, was conducted with the three variables chosen in the stepwise process and a fourth variable, dorsal cortex (two categories). The stepwise process seeks to identity significant variables, but not necessarily the best solution. Dorsal cortex was added, due to its relatively strong correlation in Function 1 of the stepwise MDA, where Function 1 accounted for 99.8 percent of the variation in the two function solution. Secondly, dorsal cortex was added, due to its proposed usefulness in differentiating between biface reduction sequences or stages (Johnson 1989; Magne and Pokotylo 1981; Morrow 1984). The overall correct classification frequency was raised to 60.9 percent (Table 5.41). Compared to the stepwise process, the frequency of correct classification for the Blank stage was lower at 63.3 percent, Preform I was

Table 5.41. Classification of Flakes within BRS Stages of Composite Experimental Assemblages of Biface Manufacture (≤25.4 mm), Simultaneous Entry, Four Variables.

Predicted Group Membership								
BRS	Number of Cases	Blank		Preform I		Preform II		
		N	%	N	%	N	%	
Blank	30	19	63.3	10	33.3	1	3.3	
Preform I	156	42	26.9	87	55.8	27	17.3	
Preform II	34	1	2.9	5	14.7	28	82.4	
Percent of grouped cases correctly classified: 60.9% Total Flakes = 220								

higher at 55.8 percent, and Preform II remained the same. It is obvious that the most problematic groups to discriminate between are Blank and Preform I. In all three analyses, discrimination between the earliest stage, Blank, and the last stage, Preform II, can be accomplished with some degree of accuracy. However, the middle stage, Preform I, remains difficult to separate from the Blank stage, and contains sizable misclassifications (17.3 percent) as Preform II. These results were similar to those of Gilreath (1984), who found that the earliest and last stages were more successfully classified than the middle stages.

The main goal of an MDA is to correctly identify individuals known *a priori* into their respective groups, rather than assess the population characteristics within each stage. However, by selecting certain variables that best identify members of a group, it provides another statistical method to arrive at a set of variables that can best identify population characteristics at each stage.

Discussion. The relative proportions of bifacial reduction by stage may be assessed by comparison of the experimental proportions to those of the archaeological assemblage from the BF locus at the KBS. Although MDA identified four variables that economically identified individual flakes from each stage, the relatively low rate of correct classification for the middle stage, Preform I, led to the conclusion that those variables are best suited to identify the ends of the continuum, while the remaining variables provide more avenues of evidence to support conclusions concerning the BRS and the length of the reduction trajectory for biface manufacture. The variables selected for inclusion in this portion of the study of the archaeological data are the proportions of split flakes, dorsal flake scar counts, dorsal cortex (two categories), size classes, crushed platform, and platform lips. Those not selected are the ratio variables of length, maximum width, maximum thickness, weight, platform width and thickness, the remainder of the SRT categories, platform types, and combined platform types/dorsal cortex. Admittedly, the identification of BRS stages depends on two prior statistical assessments as to the proportion of patterned tool and bipolar reduction in a unit, and if patterned tool, then the proportion of biface and uniface production in that unit. Given the numbers of bipolar and patterned tool CSA's in the assemblage, it is not unreasonable to anticipate highly mixed assemblages. It may be the case that a relatively pure biface manufacture assemblage may not be found in any of the units. This situation was considered before embarking on this portion of the study, but the analysis was undertaken in the hope that the data and the results may prove useful to another researcher who is able to ascertain that an assemblage is primarily the residue of biface manufacture, and has access to a larger experimental sample to develop a stronger classification function. Again, these results would only be applicable to the manufacture of Late Woodland triangular bifaces from alluvial chert and jasper gravels.

Length of Biface Reduction Trajectory

The length of the biface reduction trajectory is determined by which proportions of the total process, from initial bipolar processing to produce blanks in the form of a SP half or a FLK suitable for reduction by freehand hard hammer and pressure flaking to a finished biface, are represented at the site. Examination of the CSA's recovered from the BF locus of the KBS indicates that all BRS stages are represented in the assemblage, but these artifacts are not uniformly distributed throughout the excavated units (see Appendix C). The presence of debitage proportions characteristic of the three stages will provide a second line of evidence to make inferences concerning the technological organization, and the choices made by the Late Woodland inhabitants of KBS in their use of lithic technology.

A complete reduction sequence used for comparison to the archaeological assemblage must consider all debitage equal to or greater than 6.4 mm in greatest dimension to detect deviations from the experimental results. Chipped stone pieces that qualified as one of the categories of non-debitage CSA's were removed from the experimental assemblage, as were similar pieces removed from the archaeological assemblage. See Appendix A, Glossary of Lithic Artifact Types and Appendix B, Lithic Analysis Protocol, for definitions and attributes recorded.

The variables of all debitage equal to or less than 25.4 mm, and those of equal to or greater than 6.4 mm in greatest dimension, were compared to determine if any important differences existed in the differentiation of the BRS stages. A series of chi-square tests were conducted with the unrestricted size classes. These results are presented in Table 5.42. See Tables 5.32, 5.33, 5.34, 5.35, and 5.36 for size restricted variables.

Table 5.42. Results of Chi-Square Tests (X^2), Probability, Gamma, or Cramer's V for Variables Deemed Useful in Determination of the Length of the Biface Reduction Trajectory with Unrestricted Size Classes.

Variables	X^2	DF	Prob.*	Gamma	V
Dorsal Cortex (3 cats.)	35.630	4	.00130	-.5578	—
Dorsal Flake Scars	30.4081	6	.00003	.4123	—
Plt. Types (3 cats.)	19.9326	4	.00050	.3475	—
SRT (5)	22.8502	8	.00360	-.3355	—
Platform Crushing	43.5873	2	.00000	—	.4192
Platform Lip	19.5740	2	.00006	—	.2809

*All tested variables significant at the ≤.05 level.

All variables, except for one, produced similar results in significance, gamma, or Cramer's V compared to the restricted size class analysis. The exception was the combined platform types/dorsal cortex percentage (six categories). This variable, which had violated assumptions with the size restricted debitage population in computing the chi-square statistic, was significant for differences between the BRS stages with the unrestricted population (Table 5.43). As discussed previously in large tables such as this,

Table 5.43. Frequencies of Platform Types/Dorsal Cortex Percentage Categories (6) for BRS Stages of Composite Experimental Assemblages of Biface Manufacture (≥6.4 mm).

Category	Blank % (*n*.)	Preform I % (*n*.)	Preform II % (*n*.)	Totals Row % (*n*.)
Cortex/0%	11.6 (5)	19.3 (33)	2.9 (1)	15.7 (39)
Cortex/1-100%	37.2 (16)	13.5 (23)	0.0 (0)	15.7 (39)
Flat/0%	7.0 (3)	15.8 (27)	29.4 (10)	16.1 (40)
Flat/1-100%	4.7 (2)	7.6 (13)	2.9 (1)	6.5 (16)
Faceted/0%	16.3 (7)	33.9 (58)	58.8 (20)	34.3 (85)
Faceted/1-100%	23.2 (10)	9.9 (17)	5.9 (2)	11.7 (29)
Total Flakes Col.	17.3 (43)	69.0 (171)	13.7 (34)	100.0 (248)
chi-square = 47.485 df = 10 prob. = .00000 < .05 V = .30942				

only some of the categories show important differences. After examination of the table, the proportions of each category were tested at the 95 percent confidence level (see pages 245-246 for the procedure). Indeed, only two of the categories, Cortex/1-100 percent and Faceted/0 Percent, proved significant for differences between all three stages at the 95 percent confidence level (Table 5.44). The expanded assemblage increased the

Table 5.44. Confidence Intervals for Platform/Dorsal Cortex% (6) Categories of BRS Stages of Biface Manufacture of Composite Experimental Flake Assemblages (≥6.4 mm).

Category	BRS	MN %	SD	SE %	95% Confidence Intervals MN ±
Cortex/0%	Blank	11.6	.3196	4.9	9.8
	Preform I	19.3	.3947	3.0	5.1
	Preform II	2.9	.1680	2.9	5.9
Cortex/1-100% *	Blank	37.2	.4833	7.4	14.9
	Preform I	13.5	.3417	2.6	5.1
	Preform II	0.0	.0000	0.0	0.0
Flat/0%	Blank	7.0	.2552	3.9	7.9
	Preform I	15.8	.3647	2.8	5.5
	Preform II	29.4	.4560	7.8	16.0
Flat/1-100%	Blank	4.7	.2116	3.2	6.5
	Preform I	7.6	.2650	2.0	4.0
	Preform II	2.9	.1680	2.9	5.9
Faceted/0% *	Blank	16.3	.3694	5.6	11.4
	Preform I	33.9	.4734	3.6	7.0
	Preform II	58.8	.4920	8.4	17.2
Faceted/1-100%	Blank	23.3	.4227	6.4	13.0
	Preform I	9.9	.3987	3.1	6.0
	Preform II	5.9	.2360	4.0	8.5

Blank n = 43; Preform I n = 171; Preform II n = 34
* significant at 95% confidence level

number of Blank flakes by 43 percent, from 30 pieces to 43 pieces, Preform I from 156 pieces to 171 pieces, though Preform II remained the same. The most profound change was in the proportion of Cortex/1-100 Percent in the Blank stage, which increased from

20.0 percent to 37.2 percent of the pieces in this stage. All of the increase in the Blank stage, save one flake, was in this category. The category of Faceted/0 Percent of Blank pieces was also effected by the increase in the number of flakes. The proportion decreased from 23.3 percent in the size restricted population, to 16.3 percent in the complete population, which increased the difference between Preform I and II for this variable.

Two other variables, size classes and weight, could be modified or added to the tested variables to more accurately portray a complete reduction trajectory. Size classes

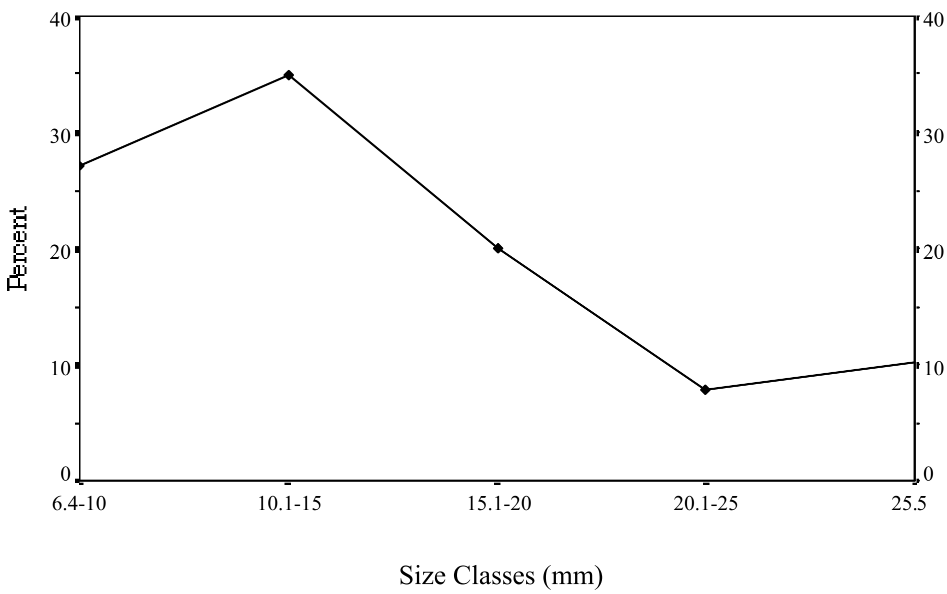

Figure 5.41. Proportions of size classes (≥6.4 mm) with combined ≥25.5 mm category of debitage from composite experimental assemblages of biface manufacture.

were modified by combining all debitage larger than 25.4 mm in greatest dimension into one category, for a total of five categories (Figure 5.41). These modified size classes were significant for differences between BRS stages for all debitage equal to or larger than 6.4 mm in greatest dimension (χ^2 = 83.358, df = 8, prob. = .00000 < .05, gamma = -.56104). The strongly negative gamma indicates that as reduction proceeds through the

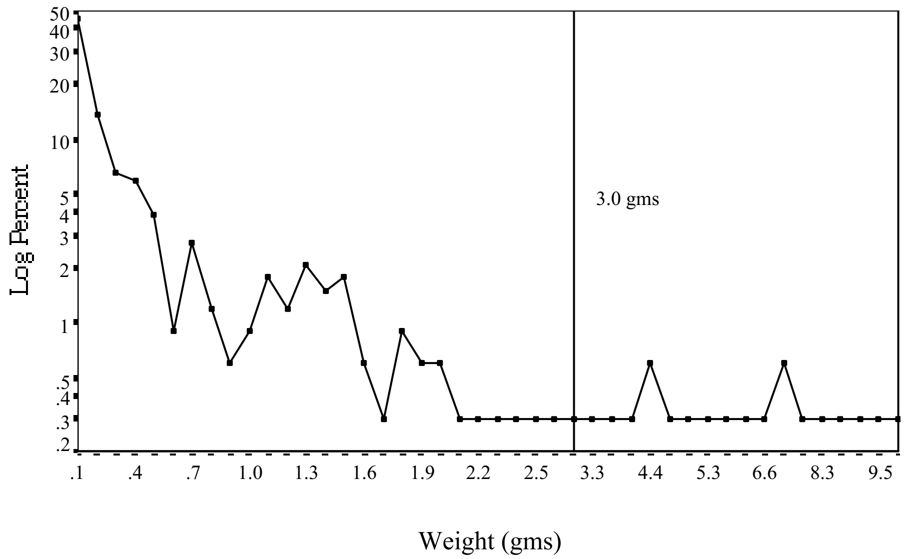

Figure 5.42. Debitage frequency (percentage) distribution of weights with log scale for reduction trajectory of composite experimental assemblage of biface manufacture with 3.0 g line (≥6.4 mm).

stages the size of the detached pieces decreases. However, many of the pieces of debitage in this composite size class of larger pieces are likely candidates for reduction into a biface or uniface tool, which may result in their absence from the archaeological record at the BF locus.

The last variable to be considered is that of weight. Weight has been shown to covary with linear dimensions (Amick et al. 1988:Table 5; Magne and Pokotylo 1981:38) so it would seem redundant to use both. However, examination of weight frequencies by size classes indicate that flakes equal to or greater than 3.0 g occur only in the size class containing the larger pieces. These weights equal to or greater than 3.0 g comprise just 6.0 percent of the complete assemblage (*n* = 20/335), but account for 50 percent (129.5 g) of the total weight of debitage (259.4 g). The proportion of pieces of debitage equal to or greater than 3.0 g should provide a relative indication of the length of the trajectory, or suggest the degree of reduction of the alluvial gravels when considered with other data (Figure 5.42).

The consideration of these additional three variables, platform/cortex (six categories), unrestricted size classes, and weight, in concert with those used in delineating BRS stages, should provide an indication of the relative length of the reduction trajectory at the BF locus of the KBS.

Hard Hammer and Pressure Flakes

To determine if they could differentiate the product of these two knapping techniques, attributes of debitage from hard hammer percussion and pressure flaking in the lithic experiments to manufacture bifaces were analyzed statistically. The variables tested in this portion of the study were the nominal categories of platform crushing, platform lip, and platform type/dorsal cortex (six categories); ordinal variables of dorsal cortex percentage, dorsal flake scar count, platform types (three categories), and SRT (four categories); and ratio variables of length, maximum width, maximum thickness, weight, and platform width and thickness. Univariate and multivariate (discriminant analysis) statistical methods were employed. Only debitage equal to or less than 25.4 mm in greatest dimension were considered in the analysis. The two goals for this portion of the study were to develop a population description of hard hammer and pressure flakes based on the variables in the analysis, and to identify differences attributable to the two load applications in biface manufacture within standardized size classes. A population of 301 pieces of debitage derived from the complete biface manufacture experiments was analyzed (Table 5.45).

Table 5.45. Frequencies of Hard Hammer and Pressure Flakes (≤25.4 mm) Derived from Experimental Biface Manufacture.

Manufacturing Technique	Biface N	%
Hard Hammer	254	84.4
Pressure Flaking	47	15.6
Totals	301	100.0

Univariate Statistical Analysis. The differences in the proportions of hard hammer and pressure flakes for the nominal attributes of platform crushing and platform lipping are significant at the .05 level (Table 5.46). The computed Cramer's V statistic for platform

Table 5.46. Chi-square Statistics (χ^2) for Platform Crushing and Platform Lip on Hard Hammer and Pressure Flakes Derived from Experimental Biface Manufacture (≤25.4 mm).

Variable		HH % (n)	PF % (n)	d.f.	χ^2	Sig.	V
Platform Crushed	Yes	61.8 (110)	7.1 (3)	1	40.634	.00000	.4298
	No	38.2 (68)	92.9 (39)				
Platform Lip	Yes	12.4 (22)	33.3 (14)	1	10.923	.00095	.2228
	No	87.6 (156)	66.7 (28)				

crushing indicate a moderate association, and for platform lipping a low to moderate association between the attribute and knapping technique (Drennan 1996 193-194). Crushing is more prevalent in hard hammer percussion, and platform lips are found more frequently on pressure flakes. However, a platform lip is only present on one-third of all pressure flakes, and crushed platforms are present on somewhat less than two-thirds of hard hammer flakes. Conversely, two-thirds of pressure flakes do not possess a lip, and more than one-third of hard hammer flakes do not exhibit crushing. Additionally, a platform lip is found on 12.4 percent of hard hammer flakes, while crushing is present on 7.1 percent of pressure flakes, further confounding identification. It is apparent, (see pages 179-180) that these attributes cannot be used to directly identify individual flakes, but they may be useful to aid in the categorization of debitage populations or assemblages in conjunction with other attributes.

Among the ordinal variables, only dorsal cortex (two categories) and platform types are significantly different in proportions between hard hammer and pressure flakes at the .05 level (Table 5.47). Although, the significance for SRT is just marginally

Table 5.47. Chi-square Statistics (χ^2) for Selected Ordinal Variables of Experimental Hard Hammer (HH) and Pressure (PF) Flakes (≤25.4 mm).

Variables	Number of Flakes HH	PF	d.f.	χ^2	Sig.	V
Dorsal Cortex (2 cats.)	246	46	1	6.473	.01095 *	.1489
Dorsal Flake Scars	178	42	3	5.225	.15603	—
Platform Types (3 cats.)	178	42	2	15.682	.00039*	.2670
SRT (4)	254	47	3	7.706	.05249	—
*significant at the ≤.05 level.						

greater than the .05 significance level, it could be utilized at this level. However, it is problematic for this portion of study for the same reason as indicated previously in the BRS section: the incomplete recovery of the smaller flake fragments and reduction fragments associated with pressure flaking. These results, and those of the BRS study, led to the testing of the combined platform types/dorsal cortex (six categories) variable. The chi-square statistic for this variable indicated that there is a significant difference in the proportions between hard hammer and pressure flakes at the .05 level (Table 5.48). The Cramer's V statistic indicated low-moderate association between this combined variable and the indenter type, which is an improvement over the two attributes considered separately (Table 5.47).

Table 5.48. Frequencies of Platform Types/Dorsal Cortex Percentage (6 categories) for Hard Hammer (HH) and Pressure lakes (PF) of Composite Experimental Assemblages of Biface Manufacture (≤25.4 mm).

Category	HH % (*n*.)	PF % (*n*.)	Totals Row % (*n*.)
Cortex/0%	18.0 (32)	2.4 (1)	15.0 (33)
Cortex/1-100%	12.9 (23)	0.0 (0)	10.5 (23)
Flat/0%	15.7 (28)	28.6 (12)	18.2 (40)
Flat/1-100%	5.6 (10)	9.5 (4)	6.4 (14)
Faceted/0%	34.3 (61)	52.4 (22)	37.7 (83)
Faceted/1-100%	13.5 (24)	7.1 (3)	12.3 (27)
Total Flakes Col.	80.9 (178)	19.1 (42)	100.0 (220)
chi-square = 18.902 d.f. = 5 prob. = .002 < .05 V = .2931			

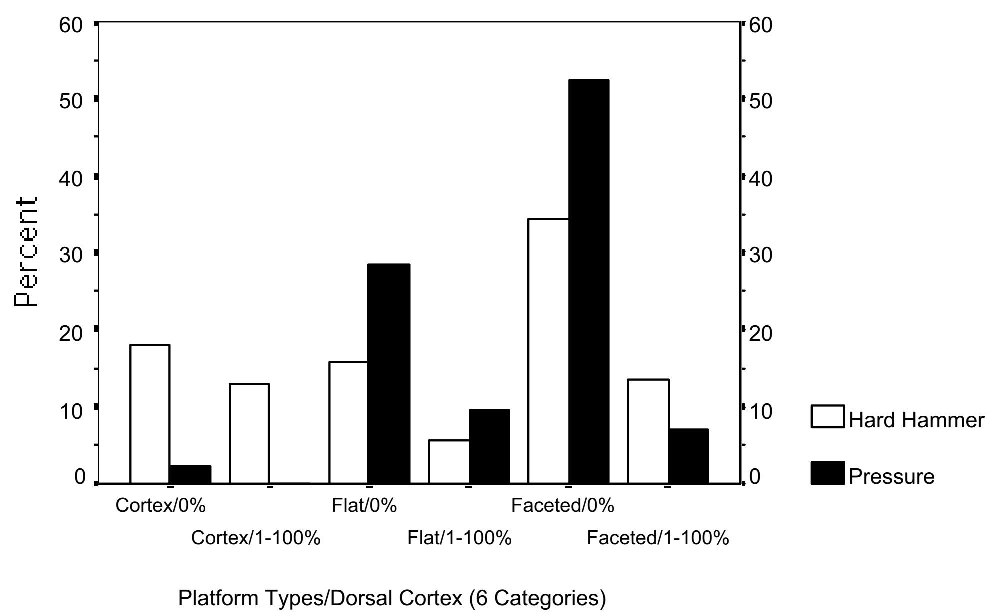

Figure 5.43. Proportions of platform types/dorsal cortex (6 categories) for hard hammer and pressure flakes of composite experimental assemblages of biface manufacture (≤25.4 mm).

Because the pressure flakes are all derived from biface manufacture, they exhibited a nearly identical pattern of platform types/dorsal cortex categories as in the BRS study

(Figure 5.35). The signature category of this variable for pressure flakes is Faceted/Zero Percent Dorsal Cortex along with a relatively higher frequency of Flat/Zero Percent Dorsal Cortex (Figure 5.43). Cortex platforms with either zero percent or one to 100 percent cortex likewise distinguishes hard hammer flakes.

The ratio measurements of length, maximum width, maximum thickness, weight, and platform width and thickness (Table 5.49) and their associated *t* tests (Table 5.50) indicate that differences in these measurements between hard hammer and pressure flakes

Table 5.49. Summary Statistics for the Six Ratio Variables* for Hard Hammer and Pressure Flakes of Composite Assemblages of Experimental Biface Manufacture (≤25.4 mm).

HH	N	Mean	S.D.	PF	N	Mean	S.D.
Length	206	12.74	4.71	—	42	8.14	1.88
Max. Width	218	12.47	4.01	—	46	8.37	1.57
Max. Thick.	246	2.90	1.61	—	46	1.78	0.58
Weight	254	0.41	0.48	—	47	0.10	0.02
Plt. Width	178	7.67	3.10	—	42	4.44	1.51
Plt. Thick.	178	2.13	1.12	—	42	1.35	0.47

*Note: Linear measures are in mm and weight in g.

are significant at the .05 level. These findings are actually unremarkable, and simply reaffirm the findings of other researchers of this topic (Chandler and Ware 1976; Henry et al. 1975:59-60; Odell 1989:Table 2; Patterson and Sollberger 1978:Tables 1 and 2). The standard deviation for the weight of hard hammer flakes is greater than the mean for these flakes, which is due to the range (.1-2.6 g) of values for these pieces and the large number (105) of smaller pieces weighing .1 g. The median of .2 g, which is less than half of the mean, supports this observation. The variable of weight is further discussed later in this section.

Table 5.50. The Results of *t* tests for Six Ratio Variables for Hard Hammer and Pressure Flakes of Composite Assemblages of Experimental Biface Manufacture (≤25.4 mm).

Variable	*t* -value	df*	2-tailed significance
Length	6.23	246	.000
Max. Width	6.83	262	.000
Max. Thick.	4.70	290	.000
Weight	4.29	299	.000
Plt. Width	6.56	218	.000
Plt. Thick.	4.41	218	.000

*Note: Variances for each variable are considered equal (Levene's Test).

<u>Multivariate Analysis</u>. A two group discriminant analysis of all debitage in complete biface manufacture experiments, with debitage equal to or less than 25.4 mm in greatest dimension, was employed to determine if individual pieces could be correctly classified as resulting from either hard hammer percussion or percussion flaking. The variables input into these analyses were chosen based on the results of the univariate analysis. These variables were length, maximum width, maximum thickness, weight, platform crushing, platform lipping, dorsal cortex (yes/no), platform types, platform width, platform thickness, platform type/dorsal cortex, and size classes. The variables were entered in a stepwise process with equal probabilities, and a within group covariance matrix was used to classify individual pieces. To adjust for the large difference in the number of cases in the two groups (HH = 178 and PF = 42), the "sample procedure" in SPSS was utilized to draw a random sample of hard hammer pieces approximately equal to the number of pressure flaked pieces. Discriminant analysis considers only those cases without missing values for any of the attributes, so in essence only PRB flakes were considered, and flake fragments and reduction fragments were eliminated by the SPSS program.

Each stepwise analysis with different samples of hard hammer flakes selected a somewhat different set of variables for the classification function. A fourth discriminant analysis was conducted with simultaneous entry with all of the variables selected in the stepwise process. These variables were crushed platforms, length, maximum width, platform width, weight, and platform lip. This discriminant analysis produced an overall successful classification rate of 91.86 percent (Table 5.51). The SPSS program randomly selected 71 hard hammer percussion pieces of debitage, 44 of which were PRB flakes which were used in this analysis.

Table 5.51. Discriminant Classification of Hard Hammer and Percussion Flakes of Composite Assemblages of Experimental Biface Manufacture (≤25.4 mm), Simultaneous Entry, Six Variables.

Predicted Group Membership					
Flake Type	Number of Cases	HH N	HH %	PF N	PF %
Hard Hammer*	44	38	86.4	6	13.6
Pressure	42	1	2.4	41	97.6
Percent of grouped cases correctly classified: 91.86% Total Flakes = 86					

*Note: Hard hammer cases are a random sample.

The selected variables make intuitive sense, because hard hammer flakes as a group are significantly larger in the four ratio measures than pressure flakes (See Table 5.50). Crushed platforms are much more likely to be associated with hard hammer percussion and platform lips with pressure flakes. Finally, the combined variable of platform type/dorsal cortex is a strong indicator of Preform II in the BRS, from which all of the pressure flakes are derived.

The *unstandardized canonical discriminant function coefficients* used to directly classify individual flakes are presented in Table 5.52. Individual flake data are multiplied by these coefficients, the results are summed, and then added to the constant to produce a score. The score is then compared to the cutting score of -.03385, which is the average of the two group centroids. All flakes with discriminant *Z* scores greater than

Table 5.52. The *Unstandardized Canonical Discriminant Function Coefficients* from Stepwise Discriminant Analysis of Hard Hammer and Pressure Flakes from Composite Experimental Biface Manufacture (≤25.4 mm).

Variable	Function 1
Crushed Plt.	1.4296466
Length	.2754673
Max. Width	.2674050
Plt/Cortex	-.3497526
Plt. Width	.1757940
Weight	-2.9710792
Plt. Lip	-.6845616
(Constant)	-4.8140091

.

```
                        Canonical Discriminant Function 1
     8 +                          2                                       +
       |                          2                                       |
       |                          2                                       |
F      |                          2                                       |
r    6 +                       2  2   2     1      1                      +
e      |                       2  2   2     1      1                      |
q      |                       2  2   2     1      1                      |
u      |                       2  2   2     1      1                      |
e    4 +                      22  2   2     11  1  1    1                 +
n      |                      22  2   2     11  1  1    1                 |
c      |                 2   222222   2 2   11  1  1    1                 |
y      |                 2   222222   2 2   11  1  1    1                 |
     2 +                 2  2222222 21122 2 11 1111111  1                 +
       |                 2  2222222 21122 2 11 1111111  1                 |
       |                22  2222221 21111 1 1111111111 11                 |
       |                22  2222221 21111 1 1111111111 11                 |
       X ----------+----------+----------+----------+----------+----------X
      out      -4.0      -2.0        .0       2.0       4.0        out
  Class   222222222222222222222222222222211111111111111111111111111111
Centroids                       2             1
                           (-1.48928)     (1.42158)

Key: 1=Hard Hammer; 2=Pressure Flake. Each case is represented by two
vertical numbers. The rows of 1's and 2's below the X axis indicate
the group to which the scores are assigned. Cutting score is -.03385.
```

Figure 5.44. Histogram of classification scores for two group discriminant analysis of hard hammer and pressure flakes from experimental biface manufacture (≤25.4 mm). Hard hammer flakes sampled (n = 44).

-.03385 are classified as hard hammer percussion flakes, and those less than -.03385 are classified as pressure flakes (Figure 5.44). To ensure that these results were not the product of chance in the random selection of hard hammer flakes, a second discriminant analysis with the same parameters and another equalized random sample of debitage was conducted. The classification results were almost identical, and the *unstandardized canonical discriminant function coefficients* were of the same magnitude and sign as in the first test. These results reaffirm the first set of classification results.

Population Characteristics. On a population level, pressure flakes may be distinguished from hard hammer flakes by a relatively lower percentage of crushed platforms, a relatively higher percentage of platform lips, and a relatively higher percentage of flat and faceted platforms with zero percent dorsal cortex. All of the pressure flakes conducted. The classification results were almost identical, and the *unstandardized canonical discriminant function coefficients* were of the same magnitude and sign as in the first test. These results reaffirm the first set of classification results. produced in these experiments were found in the two smallest size classes, 6.4-10 mm and 10.1-15 mm, suggesting that small size is a key indicator, although flakes as long as two inches (5.08 cm) may be produced by this method (Crabtree 1972:15). However, 64.3 percent of the hard hammer flakes equal to or less than 25.4 mm in greatest dimension were also found in these two size classes. Pressure flakes in the experimental biface assemblages are smaller in all linear dimensions and weight, but also overlap the range of hard hammer flakes for these attributes (Table 5.49). The nominal variables of platform crushing and lipping, and the combined variable of platform type/dorsal cortex, appear to be more reliable as indicators of differences between the two populations, although the latter is a function of when the techniques are employed in the BRS. The results of the discriminant analysis are promising, but separating hard hammer and pressure flakes in an assemblage where the bipolar and freehand techniques are intermixed is somewhat problematic, and overall a larger sample of pressure flakes is needed to validate the effectiveness of this classification function. In addition to the preceding caveats, these results are only applicable to the reduction of alluvial chert and jasper gravels; further experimentation will be required with other raw materials and forms to ascertain the validity of these attributes to separate pressure and hard hammer percussion flakes.

Attribute Differences Within Size Grade. Hard hammer and pressure debitage were standardized by size grade to determine if the two load applications produced discernible differences in the attributes of platform width, platform thickness, and maximum thickness. Pressure flakes were produced in two size grades, 6.4-10 mm and 10.1-15 mm. The number (11) of pressure flakes in size grade 10.1-15 mm were too few for statistical analysis, but the size grade 6.4-10 mm contained 36 flakes, which exceeded the minimum number of cases (30) required for analysis (Drennan 1996:135). The standardization of debitage to size classes allows for the explanation of differences due to load factor characteristics of hard hammer percussion and pressure flaking, other than simply size and number of pieces (Henry et al. 1975:59). In addition to maximum thickness, which was identified by Henry et al. (1975:Tables 2 and 3), platform width and thickness were included. It appears logical that the larger area of contact between a hard hammer and the objective piece should produce wider platforms than the correspondingly smaller contact area of the indentor, a tine of a deer antler, used to pressure flake an objective piece. In pressure flaking, force is normally applied to the bifacial edge of an objective piece, rather than behind it as in hard hammer percussion (Whittaker 1994:133). As a result pressure flakes should then be thinner than hard hammer flakes within the same size grade. Weight was not included in this analysis, because the scale employed was only sensitive to .1 g. Debitage less than .1 g registered as zero on the scale, but were recorded to the nearest weight of .1 g. Within the population of pressure flakes, 94.4 percent weighed less than .1 g (34/36), while 67.3 percent (37/55) of the hard hammer flakes were also in this category. To test weight as a variable for this portion of study, the debitage should be weighed to the nearest .01 g. Given the moderately-strong correlation (.69030) between weight and thickness shown in the discriminant analysis discussed earlier in this section, and the conclusion of Henry et al. (1975: 60 and Figure 2) that the two attributes were strongly correlated, the three variables were included in the analysis.

The variables of maximum thickness, platform width, and platform thickness demonstrated that pressure flakes were thinner with narrower platforms than the hard hammer flakes within the size category 6.4-10 mm. Pressure flakes also varied less around the mean for the three measures than hard hammer flakes (Table 5.53). The results of *t* tests indicated that the differences in the maximum thickness, platform width,

Table 5.53. The Summary Statistics for Maximum Thickness, Platform Width, and Platform Thickness for Hard Hammer (HH) and Pressure Flakes (PF) of Composite Experimental Biface Assemblages (6.4-10 mm). All measurements are in mm.

HH	N	mean	SD	Varianc e	PF	n	mean	SD	Varianc e
Max. Thick.	5	2.12	1.18	.63	—	3	1.63	.49	.24
Plt. Width	3	6.24	1.97	3.89	—	3	4.30	1.24	1.53
Plt. Thick.	3	1.74	.79	.63	—	3	1.25	.40	.16

and platform thickness of hard hammer and pressure flakes, standardized to size grade, are significant at the .05 level (Table 5.54). Platform width, platform thickness, and weight were shown to have a strong-moderate correlation by Amick et al. (1988:Table 5) among hard hammer and soft hammer percussion flakes. Henry et al. (1975:60)

Table 5.54. The Results of *t* tests for Maximum Thickness, Platform Width, and Platform Thickness for Hard Hammer and Pressure Flakes of Composite Experimental Assemblages of Patterned Tools (6.4-10 mm).

Variable	*t* -value	df*	2-tailed significance
Max. Thick.	3.22	118.68	.002
Plt. Width	5.24	88.43	.000
Plt. Thick.	3.57	89.87	.001

*Note: Variances for each variable are considered unequal (Levene's Test).

concluded weight and maximum thickness are strongly correlated and one may be inferred from the other. Given the differences in platform width, platform thickness, and maximum thickness between hard hammer and pressure flakes and their moderate to strong correlation, it is reasonable to infer that weight recorded from a scale sensitive to .01 g would also exhibit significant differences.

The results obtained in this portion of the study confirm the findings of Henry et al. (1975), that significant differences exist between hard hammer and pressure flakes standardized to the same size grade. These differences are most likely due to the differential load applications inherent in the two knapping techniques.

Experimental Production Rates

In this portion of the study, data is provided to estimate the number of knapping episodes of patterned tool manufacture and gravels reduced by the bipolar technique from the recovered debitage in the archaeological assemblage. This estimate is based on the mean counts of the debitage from the knapping experiments for patterned tools and bipolar reduction. To apply these results to the archaeological recovered debitage, the percent of patterned tool manufacture and bipolar reduction must be determined by comparison of their proportions of SRT categories to the experimental results (Figure 5.17).

The problem of estimating the number of knapping episodes or cores reduced has been approached by researchers using counts, weights, types of flakes, and flake attributes derived from experimental assemblages. Ahler (1989:213-216) multiplied the actual count of tools and cores in the archaeological assemblage by the experimental rates for a specific type of reduction episode with a specific raw material type. Both weight and debitage counts were used to calculate this estimate. Magne (1989:19-22 and Figure 1) employed the percentage of late stage flakes (finishing and resharpening of tools) and tool/debitage ratio to develop an assemblage formation model in the contexts of raw material abundance and scarcity. Carr and Bradbury (2001:133-145), utilizing PRB flakes only, employed platform facet counts, dorsal scar counts, and weights within the quarter-inch size grade to determine the relative percentages of tool (biface/uniface) and core reduction. They further developed "analytical core units" derived from weights and platform facet counts to estimate the amount of production in terms of cores reduced represented at an archaeological site.

The approach used here is to count all the debitage 6.4-25.4 mm in greatest dimension in a unit or the total assemblage, partition it into relative percentages of pattern tool manufacture and bipolar reduction as previously discussed in this chapter

(*SRT Results*), and divide this result by the mean figures for each reduction strategy derived from the experimental knapping to estimate the number of knapping episodes represented by this debitage. The size of the gravels reduced in the knapping experiments approximate the range of local alluvial gravels available to the indigenous knappers of Kimble's Beach. Based on the experimental manufacture of pattern tools, it is reasonable to assume that a relatively skillful knapper could produce two FLK's or two SP halves from each of the alluvial gravels. Bipolar reduction episodes are assumed to continue until usable flakes could no longer be produced by this technique (Mohney 2004). No attempt is made to infer efficiency rates in the production of usable flakes. The results of biface experiments 3 and 3a were combined to form one complete experiment. Experiments 10, 15, and 16 to produce uniface scrapers were included, although they had to be terminated due to raw material flaws, because the number of

Table 5.55. Data Based on Counts of Debitage (6.4-25.4 mm) for Experimental Patterned Tool Manufacture Episodes.

Experiment #	Goal	Starting Form	Result	Count	Mean	Standard Deviation
3/3a	biface	Flk	complete	26	33.44	15.90
4	biface	SP	complete	36	—	—
6	biface	Flk	complete	19	—	—
7	biface	SP	complete	73	—	—
9	biface	Flk	complete	32	—	—
17	biface	SP	complete	32	—	—
20	biface	Flk	complete	35	—	—
21	biface	Flk	complete	23	—	—
23	biface	Flk	complete	25	—	—
10	uniface	Flk	terminated	28	24.83	15.73
11	uniface	Flk	complete	46	—	—
13	uniface	SP	complete	10	—	—
14	uniface	SP	complete	9	—	—
15	uniface	SP	terminated	16	—	—
16	uniface	SP	terminated	40	—	—

pieces produced by these experiments fell within the range (nine to forty six pieces) of complete experiments (Table 5.55).

Examination of the data presented in Table 5.55 indicates that it is fairly likely that there are no significant differences between the mean count of debitage for episodes of biface and uniface manufacture ($t = 1.019$, df = 13, $p = .3233 > .05$). Additionally, counts for SP and FLK as starting forms were also compared. The difference between the mean counts of debitage for SP and FLK starting forms in patterned tool manufacture is very likely not significant ($t = .561$, df = 13, p = .631 > .05). Consequently, the mean count for the biface and uniface experiments were combined into one class, patterned tools. The mean for the pattern tool episodes of manufacture was calculated as 30 pieces of debitage per episode, with a standard deviation of 15.87. The count data of debitage (6.4-25.4 mm) for the 12 bipolar reduction experiments (Mohney 2004) is presented in Table 5.56. The mean count for the experimental bipolar reduction of alluvial chert gravels is rounded to 23.1 pieces of debitage per episode.

Table 5.56. Data Based on Counts of Debitage (≤25.4 mm) for Experimental Bipolar Reduction Episodes.

Experiment	Count	Experiment #	Count
1c	16	17c	13
9c	22	18c	10
10c	7	19c	27
11c	13	21c	29
14c	33	22c	14
15c	40	25c	53
Mean = 23.083 S.D. = 13.807			

To estimate the numbers of patterned tools manufactured, and gravels reduced by the bipolar technique from the archaeological debitage (6.4-25.4 mm) assemblage, the actual debitage count is divided by the mean count for each category after it is partitioned into the relative percentages of each category. The formula for computation of the numbers of episodes of pattern tool manufacture is as follows:

$$\text{Number of patterned tools} = \frac{\text{(Total Debitage } (\leq 25.4 \text{ mm) x \% PT)}}{30}$$

An estimate of the number of gravels reduced for patterned tool manufacture may be calculated by dividing the number of patterned tool manufacture episodes by two, which is the number of FLK's or SP's a relatively experienced knapper could derive from a single suitable size alluvial gravel.

The formula to calculate an estimate of the number of gravels reduced by the bipolar technique is as follows:

$$\text{Number of BP episodes} = \frac{\text{(Total Debitage } (\leq 25.4 \text{ mm) x \% BP)}}{23.1}$$

Because all gravels are considered to be reduced by the bipolar technique until no more usable flakes may be detached, each episode is the equivalent of one gravel reduced. In both set of calculations the resulting estimate is somewhat imprecise, since the partitioned percentages will be computed with the nearest 25 percent interval, e.g. 25:75, 50:50, 75:25.

This methodology should make possible inferences concerning the amount of effort expended in the production of patterned tools and bipolar reduction of gravels to obtain usable flakes. These results, along with tool and core counts, will provide additional insights into the behavior and the lithic technology of the Late Woodland inhabitants of Kimble's Beach.

1. Size class ranges are shown as used by Paterson (1990). Size classes in later sections are shown with the first number in the range as “10.1, 15.1, 20.1.....” . They are essentially the same size classes, except they provide a cutoff of +.1 mm for inclusion in the class.

2. Row percentages in all tables may sum to .1 above or below 100 percent. SPSS reports percentages to only one decimal place (0.1%) and the program’s internal rules round up or down without regard to the final sum of 100%. These truncated percentages are for comparison only and are not used in actual statistical procedures.

3. Drennan (1996:160-163) argues that in significance testing evaluating the likelihood that a null hypothesis is true based on the probability assigned may be used in place of simply accepting or rejecting it. I will employ either system depending on the statistical analysis and the nature of the data evaluated. The approach chosen will be used consistently within each particular analysis. The desriptions used are as follows: p=.80-Extremely Likely, p=.50-Very Likely, p=.20-Fairly Likely, p=.10-Not Very Likely, p=.06-Fairly Unlikely, p=.05-Fairly Unlikely, p=.01-Very Unlikely, and p=.001 Extremely Unlikely.

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CHAPTER 6

ANALYSIS OF BEACH FACE LITHIC ARTIFACTS

General

In this chapter the results of the analysis of the lithic artifacts recovered from the BF locus of the KBS are presented. A total of 2,588 lithic artifacts were recovered from the BF locus of the KBS in the four weeks of excavation in the period 1995-1998. These recovered specimens consisted of 105 CSA's, such as bifaces, scrapers, and cores; 95 specimens of other lithics (OL), such as hammerstones, unmodified gravels, and FCR; and the most numerous category, debitage, with 2,389 pieces (Table 6.1). When discussed as a single group, all CSA and OL are referred to as nondebitage lithics (NDL).

This analysis was conducted in accordance with the goals and methodology discussed in Chapter 4, *Stone Tool Analysis*. A glossary of operant definitions and a complete list of lithic classes, types, and attributes recorded for each type used in this study are found, respectively, in Appendices A and B. The analysis of these lithic artifacts was undertaken to provide data to answer the questions posed in the *Methodology*, Chapter 4. The CSA, OL, and a 20 percent sample of the BF debitage were initially examined prior to the development of the research plan and the formulation of questions to be answered through the lithic experiments and debitage analysis.

The first section presents descriptive statistics and the analysis of the CSA and OL. The attributes measured and recorded for each lithic type are found in Appendix B. Some rudimentary interpretation of use-wear is also presented where appropriate.

The second section contains a complete characterization of the BF debitage through descriptive statistics for the attributes recorded. The product of the BF debitage study, including interpretation, utilizing the results obtained through the experimental debitage analysis presented in Chapter 5, is also included in this section.

Table 6.1. Frequency of Non-Debitage Lithic Artifact Classes and Types.

Artifact Class	Artifact Type	Number	Percent of Class	Percent of Non-Debitage Lithics
CSA	Bipolar Core	9	8.6	4.5
—	Biface	22	21.0	11.1
—	Bipolar Citrus	4	3.8	2.0
—	Bifacial Wedge	1	1.0	.5
—	Core	4	3.8	2.0
—	Core Red. Frag.	25	23.8	12.6
—	Core Tool	3	2.9	1.5
—	Drill	1	1.0	.5
—	Flaked Cobble	3	2.9	1.5
—	Flaked Pebble	8	7.6	4.0
—	Projectile Point	4	3.8	2.0
—	Scraper	7	6.7	3.5
—	Split Pebble	12	11.4	6.0
—	Uniface Tool	2	1.9	1.0
Total CSA	—	105	100.0	52.8
OL	Abrader	3	3.2	1.5
—	FCR	56	59.6	28.1
—	Hammerstone	4	4.3	2.0
—	Pecked Pebble	5	5.3	2.5
—	Reutilized Raw Material	17	18.1	8.5
—	Unmodified Pebble	9	9.6	4.5
Total OL	—	94	100.0	47.2

Non-Debitage Lithic Analysis

In this section, the CSA and OL are characterized through the use of descriptive univariate statistics. Raw material types are identified for all artifacts and selected individual specimens are described, including any use-wear visible with 10X magnification. Potential tool uses and functions are inferred from observed use-wear patterns where possible.

Raw Materials

Seven lithic raw material types were identified in the NDL assemblage from the BF locus at Kimble's Beach. The type and frequency of raw materials for the CSA and OL classes are shown in Figure 6.1. The CSA specimens are manufactured mostly from

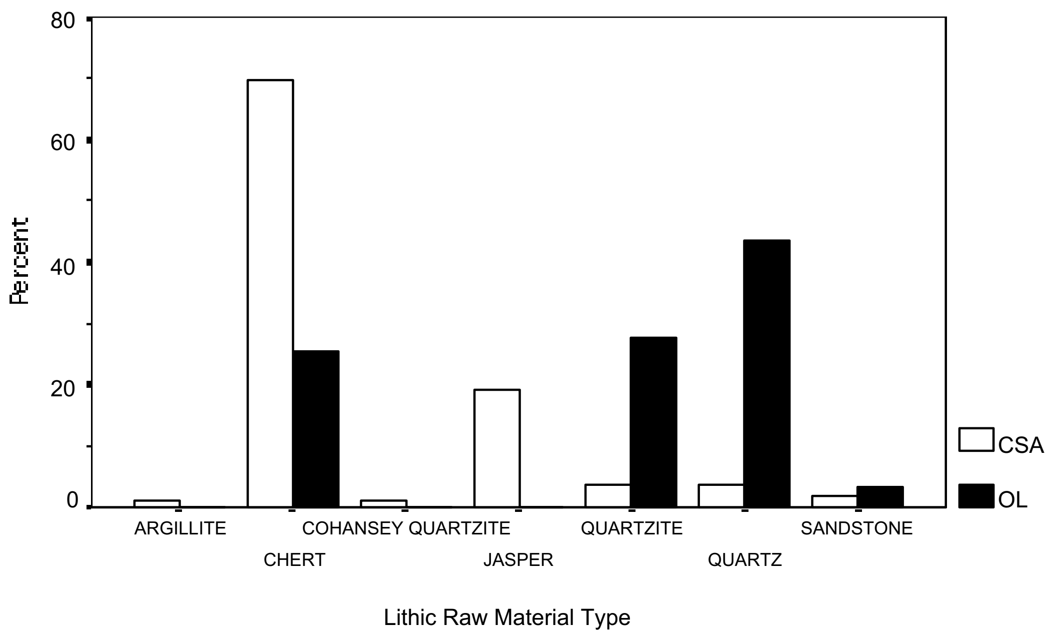

Figure 6.1. Proportions of lithic raw material types for NDL classes.

chert and jasper (88.5 percent; $n = 93$). Reutilized material (RUM) and unmodified pebbles (UP), which were likely brought to the BF locus to serve as raw material for tool manufacture, are also overwhelmingly of chert or jasper (92.3 percent; $n = 24$). This decided preference for high quality cryptocrystalline raw materials is seen elsewhere in the Late Woodland period on the Coastal Plain in New Jersey (Cross 1941; Mounier 1997a; Mounier 1972; Mounier 1981; Mounier 1997b; Pagoulatos 1992; Stewart 1998b; Wall et al. 1996). The OL class, which includes RUM and UP, is mostly quartz, quartzite, and sandstone (74.5 percent; $n = 70$).

The remnant waterworn cortex and the relatively small size of the CSA specimens indicate a gravel origin for the raw materials utilized by the indigenous knappers of Kimble's Beach. The gravels collected for the lithic experiment ranged from 34-86 mm in greatest dimension. Only two of the CSA specimens recovered from the BF locus were larger than 86 mm, at 91.2 and 138.5 mm. However, these two specimens of flaked cobbles (FC) were obviously alluvial gravels. Ninety-eight percent of the artifacts were 71.2 mm or less in greatest dimension, and could be easily manufactured from the gravels found today along the margins of the Delaware Bay. Waterworn cortex, indicative of alluvial gravels, was retained by 84.6 percent (*n* = 89) of the CSA specimens. The amount of remnant cortex was recorded in nine categories from 1-10 to 90-99 percent. Of the 22 bifaces, which can be placed within the BRS from Kimble's Beach, 63.5 percent (*n* = 15) retained some amount of waterworn cortex. It is readily apparent, upon examination of the CSA specimens, that the source of the raw material was the alluvial gravels that can be found along the margins of the Delaware Bay in the vicinity of the BF locus which, at the time of the site occupation, was most likely 400-500 m distant.

The frequency of raw material types and the number thermally altered for CSA, RUM, and UP is presented in Table 6.2. The total number of specimens represented among these artifact types is 128, 33 of which are thermally altered (25.8%). The only lithic raw materials exhibiting signs of thermal alteration are chert and jasper (*n* = 114; 29.0 percent). Forty-four percent of the biface specimens made of chert were thermally altered, as were 83.3 percent of the jasper specimens. Two-thirds of the jasper specimens for all artifact types exhibited signs of thermal alteration, while only slightly more than 20 percent of the chert specimens did so. Although it is a relatively small sample, the data suggests that jasper was preferentially heat treated at the BF locus of the KBS.

Table 6.2. Frequency of Raw Material Types and Specimens Thermally Altered for CSA, Reutilized Material, and Unmodified Pebbles.*

Artifact Type	Argillite	Chert	Cohansey Quartzite	Jasper	Quartz	Quartzite	Sandstone
BC	—	8/2	—	1/0	—	—	—
BI	—	16/7	—	6/5	—	—	—
BPC	—	3/0	—	1/0	—	—	—
BW	—	—	—	—	—	1/0	—
CO	—	2/0	—	1/0	—	1/1	—
CRF	—	18/6	—	2/1	3/0	1/0	2/0
CT	—	1/0	—	—	—	—	—
DR	—	1/0	—	—	—	—	—
FC	—	—	—	—	—	1/0	—
FP	—	10/3	—	—	—	—	—
PP	1/0	2/0	1/0	—	—	—	—
RUM	—	16/0	—	—	—	1/0	—
SCR	—	2/1	—	5/4	—	—	—
SP	—	8/1	—	2/0	1/0	—	—
UN	—	2/0	—	2/2	—	—	—
UP	—	7/1	—	—	2/0	—	—
N	1	96	1	18	5	5	2
TA	0	21	0	12	0	0	0
% TA	0.0	21.9	0.0	66.6	0.0	0.0	0.0

*Note: Abbreviations for artifact types are found in Appendix B. Cells for artifact types and raw material types contain the number of specimens and the number thermally altered (N/TA).

Bifaces

Bifaces, in various stages of manufacture, comprised 22.8 percent of the CSA specimens in the assemblage, which is the second largest artifact type after core reduction fragments. These numbers suggest that the production of Late Woodland triangular projectile points was the major emphasis in chipped stone tool manufacture at the BF Locus of the KBS. All of the stages of the BRS are represented, so it appears that a complete biface reduction trajectory was accomplished at the BF locus for at least some of the episodes of biface manufacture.

Table 6.3. Frequencies of Raw Material and TA for BRS Stages at the BF Locus of the KBS..

BRS	N	Raw Mat.	TA	TA %
Blank	6	Chert	0	0.0
P I	2	Chert	2	100.0
—	2	Jasper	1	50.0
P II	8	Chert	4	50.0
—	4	Jasper	4	100.0
Finished Triangle*	2	Chert	1	50.0
Totals	24	Chert = 18 Jasper = 6	7 5	38.9 83.3

*Note: Projectile point of Cohansey quartzite omitted

The biface specimens (*n* = 24), with two exceptions (discussed later in the section), can be placed within the BRS shown in Figure 4.2 and described on pages 231-234. The frequencies of raw materials and TA for each BRS stage are contained in Table 6.4. All of the specimens were manufactured from high quality chert and jasper. None of the specimens in the Blank stage were heat treated, while 66.6 percent (12/18 specimens) of Preform I-II and finished bifaces exhibited signs of thermal alteration. Heat treatment for these specimens began in Preform I, most likely after the SP was partially thinned and shaped, or as a FLK starting form. Five of the six the jasper specimens were heat treated. This comports with the overall high percentage of TA for jasper among CSA.

Statistics for whole or reconstructed specimens in the BRS are contained in Table 6.4. As biface manufacture proceeds from the earliest stages to finished biface, the edge angles decrease and the width-thickness ratio increases (Callahan 1979:Tables 7 and 10; Walker 1994:201-203). This pattern is borne out in the limited sample of specimens in the BRS stages recovered from the BF locus. The differences in width-thickness ratios between stages are less pronounced at the BF locus than expected from works of Callahan (1979) and Walker (1994). The width-thickness ratio of the nine experimentally manufactured triangles was also rather low, with a mean of 3.67 (S.D. = .47) and a range

Table 6.4. Summary Data for BRS Stages, BF Locus of the KBS.

Blank	N*	Mean	SD	Range
Length (mm)	5	45.58	7.85	38.8-56.2
Width (mm)	6	30.68	4.86	22.3-37.3
Thickness (mm)	6	14.82	4.72	6.9-19.8
Weight (g)	5	24.18	13.84	5.8-43.1
WT Ratio	6	2.23	.62	1.74-3.23
Preform I	N	Mean	SD	Range
Length (mm)	2	35.45	1.77	34.2-36.7
Width (mm)	2	33.55	5.73	29.5-37.6
Thickness (mm)	5	12.7	1.96	9.6-14.5
Weight (g)	2	15.7	3.25	13.4-18.0
WT Ratio	2	2.39	.29	2.19-2.59
Preform II	N	Mean	SD	Range
Length (mm)	5	27.38	5.66	18.2-32.5
Width (mm)	6	22.9	5.02	16.6-28.6
Thickness (mm)	12	6.67	2.28	4.0-11.5
Weight (g)	5	3.52	1.53	2.0-6.0
WT Ratio	6	2.97	.83	2.0-4.38

*Note: The number varies within a stage. Only specimens that could be reliably measured or weighed for an attribute were included in that computation.

of 3.09-4.48. This is most likely due to the initial small size of the gravels used as raw material to manufacture both sets of bifaces. These small preforms are relatively difficult to grasp in the hand, which leads to difficulty in thinning with a hard hammer. As a result, larger width-thickness ratios are not easily obtained even in Preform II and Finished Triangles.

Edge angle ranges for Preform I and II and finished triangles are found in Table 6.5. Table 6.6 contains the edge angle data for all individual finished bifaces. In this relatively small sample, the trend is for the edge angle to decrease from Preform I to Finished Triangle, although edge angle ranges overlap for Preform I and II and Preform II

Table 6.5. Summary Data for Edge Angles in BRS Stages in Degrees.

BRS	N	Mean	S.D.	Range
Preform I	4	64.0	8.68	54-75
Preform II	12	49.0	8.72	38-61
Finished Triangle	2*	45.5	71	45-46

*Note: Includes only the two specimens deemed to be representative of the BRS at Kimble's Beach

and finished triangular bifaces. Edge angles generally decrease as biface manufacture progresses from earlier to later stages. The nine finished experimental triangles measured between 30-39 degrees for three specimens, 40-49 degrees for three specimens, 50-59 degrees for two specimens, and one specimen was 60-69 degrees. This is within the range of the three Late Woodland triangles, including the one of Cohansey quartzite (see Table 6.6).

Examination of the specimens in Preform I and II indicate that 12 of the 16 pieces in these stages were broken in manufacture due to raw material flaws, or fractured due to hard hammer percussion. According to Callahan (1979:84 and 87), this is a fairly common occurrence in biface manufacture. The remaining four specimens were most

Table 6.6. Summary Data for Projectile Points from BF Locus, KBS.

PP	Catalog #	Condition	Raw Mat.	Weight (g)	Length (mm)	Width (mm)	Thickness (mm)	WT Ratio
isosceles triangle	33	broken	COH	2.7	31.5	31.6	4.8	4.05
isosceles triangle	223	broken	CHT	3.3	30.5	25.0	7.2	3.47
LW triangle	334	broken	CHT	.2	13.2	7.6	3.3	—
Fox Creek?	245	broken	ARG	10.7	45.9	33.2	7.7	4.31
—	Catalog #	Blade Length (mm)	Blade Width (mm)	Edge Angle (deg)	Basal Depth (mm)	—	—	—
—	33	33.5 32.7	31.6	50-59	4.7	—	—	—
—	223	31.5 29.7	25.0	40-49	—	—	—	—
—	334	—	—	40-49	—	—	—	—
—	245	—	—	30-39	—	—	—	—

likely abandoned due to large humps of material on one face that defied efforts of the knapper to remove them. The humps may have rendered the bifaces unfit for hafting.

Two relatively whole Late Woodland triangles were recovered from the BF locus. The four projectile point specimens are shown in Figure 6.2, and the summary data is presented in Table 6.6. One of these is a projectile point manufactured from Cohansey quartzite (Munsell 5YR 6/1). This specimen is whole, except for a small portion broken off the tip of one shoulder, similar to the impact fractures shown in Odell and Cowan (1986:Figure 2, E) and Cox and Smith (1989:Figure 2,C, H, I, J, and K), which resulted from striking prey animals. The margins and the base are both incurvate. This raw material was not represented among the debitage in the BF assemblage. It was recovered from a shovel test pit and was associated with one ceramic sherd and two pieces of debitage. It is most likely that this point was manufactured elsewhere, as previously discussed (page 131). The second Late Woodland triangle is manufactured from black chert (Munsell N-1). The tip is broken transversely, with a small step fracture scar parallel to the long axis that emanates from the tip. This breakage is most likely the result of impact (Dockall 1997:Figure 1,C,D; Odell and Cowan 1986:Figure 2). One shoulder is broken obliquely at approximately a 30 degree angle from the margin to the base. This fracture is typical of those sustained when projectile points are utilized in cutting or scraping tasks (Woods 1988:Figure 1,E,J,L and Figure 2,A,B). The edges were pressure flaked on both margins and faces. The edges feel sharp to the touch, although there is use-wear in the form of micro-flakes and striations evident on both margins. The margins are slightly excurvate, and the base (reconstructed) appears to be either straight or incurvate. This specimen may have served as a projectile point, a hafted tool, or in both functions during its lifetime. This specimen is a strong candidate to represent the end of the biface

Figure 6.2. Completed projectile points recovered from the BF locus. Catalog 245, argillite, possible Fox Creek type; Catalog 33, Cohansey quartzite, Late Woodland isosceles triangle; Catalog 334, chert, shoulder of Late Woodland triangle; and Catalog 223, chert, Late Woodland isosceles triangle.

manufacturing process at the KBS. A third specimen, manufactured from a high quality chert (Munsell 5YR 8/1), is a portion of a margin and a shoulder of a Late Woodland triangle. The margin is finely pressure flaked on both faces. It is likely that it had broken off in a prey animal, and it was presumably deposited after the animal was cooked (Jack Cresson, personal communication 2004).

The remaining projectile point is manufactured from argillite (Munsell 5YR 4/1), with numerous inclusions of an unidentified mineral material. It is lanceolate in shape, with excurvate margins, and it is broken transversely. There is use-wear evident on one margin. This specimen resembles a Fox Creek biface as shown and described in Custer (2001:32), which is dated to the Middle Woodland period. Argillite occurs in outcrops in Central New Jersey (Figure 2. 4). This biface, the Late Woodland triangle of Cohansey quartzite, and an early stage biface, discussed under reutilized material, are not representative of the predominate BRS at the BF locus.

Examination of the specimens that comprise BRS stages Blank through Preform II, with 10 X magnification, showed evidence of use-wear (striations, rounding, micro-flakes, and edge damage) in six of the 22 specimens. As an example, the split cobble shown in Figure 4.2 contained evidence of use-wear (micro-flakes and edge damage) on the flakednmargin. This damage suggests it was used as a tool for cutting or scraping activities. It is likely that these specimens served a utilitarian function as tools after they dropped out of the biface reduction trajectory.

Scrapers, Core Tools, and Unifacial Tools

Scrapers are the second most abundant chipped stone tool type, next to bifaces, in the assemblage from the BF locus. Among the seven specimens classified as scrapers

(Figure 6.3), four are morphologically distinct types: core type scraper (n = 3), endscraper or end tools (n = 2), double ended scraper (n = 1), and a thumbnail scraper (n = 1). Data for linear measurements, raw material, TA, use-wear, and edge angles are presented in Table 6.7.

The core tool type is made on a gravel which is split transversely. One specimen, catalog 156, was made on a medial portion of a cobble, ovoid in shape, with two relatively flat surfaces where the ends were detached. One edge was flaked to form a working edge, leaving the unflaked margins covered with waterworn cortex. Two specimens, catalog 130 and 276, were made on cobbles split medially, with one margin

Table 6.7. Data for Scrapers from the BF Locus at the KBS.

Catalog Number	Raw Material	TA	Length, Width, Thickness (mm)	Weight (g)	Edge Angl e	Use-wear Present	Note
130	Jasper	No	29.7x27.5x21.7	21.4	46	Yes	Core Tool Type
178	Jasper	Yes	20.6x21.4x9.3	4.4	60	Yes	Endtool
156	Chert	Yes	34.2x26.4x15.7	13.3	80	Yes	Core Tool Type
239	Jasper	Yes	39.6x11.6x10.1	6.3	70	Yes	Double-Ended
276	Chert	No	35.7x39.0x27.1	46.8	79	Yes	Core Tool Type
405	Jasper	Yes	9.3x15.7x5.2	.7	50	Yes	Working Edge
122	Jasper	Yes	15.1x9.6x3.0	.4	30	Yes	Thumbnail

flaked from the ventral surface to remove a portion of the dorsal surface, and form a working edge perpendicular to the long axis of the piece. Catalog 130 has five flakes removed and catalog 276 four removed. All three specimens can be held comfortably between the thumb and the first two fingers, which is most probably how they were held during use.

The double-ended scraper, catalog 239, possesses working edges on both ends of a rather thick flake. The flakes removed to form the working edges are on the opposite

Figure 6.3. Scrapers recovered from BF locus at the KBS: Endtool, 178; Double-Ended, 239; Thumbnail, 122; Working Edge (broken), 405; Core Tool Type, 156, 130, and 276.

faces of the flake from each other. This piece was most likely not hafted, and can be held between the thumb and the index finger easily.

The two endtools were made on flakes. The working edges appear to have been made by pressure flaking. One tool, catalog 178, is broken transversely, and the proximal end is missing. This tool was most probably hafted. The other endtool, catalog 405, is the working edge that was broken off transversely, most likely in use.

The last type is a thumbnail scraper, catalog 122, manufactured on a flake. The proximal end shows signs of smoothing on the arrises, suggesting it may have been hafted. Fowler (1991:37) suggests that the proximal end of these small scrapers may have been inserted under the thumbnail to provide a grip, hence the name.

All of the specimens were manufactured from high quality chert ($n = 2$) or jasper ($n = 5$). Four of the jasper specimens and one of the chert were thermally altered. The three core type scrapers possessed remnant waterworn cortex. The edge angles ranged from 30-80 degrees with a mean of 59.3 (S.D. = 18.5). Use-wear was observed on the working edges of all specimens to a varying degree with macroscopic examination (10 X magnification). The use-wear was in the form of micro-flaking, polish, and striations. These signs have been shown to be indications of cutting, chopping, and scraping activities on wood, hides, or vegetable matter (Ahler 1979:305-314). Polish or smoothing on the proximal, nonworking surfaces are seen as indications of hafting.

Three specimens in the assemblage were classified specifically as core tools, based on the minimal amount of effort invested in their manufacture, and the poorer quality of the stone material (Figure 6.4). Ratio measurements, raw material type, TA, and use-wear are contained in Table 6.8. The specimen designated as catalog 205 is similar in overall

Figure 6.4. Chipped stone tools recovered from the BF locus at Kimble's Beach. Catalog 105, 205, and 412, core tools; Catalog 410, working edge of a uniface tool; Catalog 238, thumbnail type of a uniface tool; Catalog 354, bifacial wedge; and Catalog 107, drill (reamer).

morphology to the core tool type scraper, in that flakes are struck from the ventral or interior surface and removed from the dorsal surface. However, the ventral

Table 6.8. Data for Core Tools and Uniface Tools from the BF Locus at the KBS.

Tool Type	Catalog Number	Raw Material	TA	Length, Width, Thickness (mm)	Edge Angle (deg)	Use-wear Observed	Weight (g)
Core Tool	205	Chert	No	25.0x30.4x16.0	74	No	12.2
Core Tool	412	Chert	No	35.3x25.5x26.8	77	No	25.3
Core Tool	105	Chert	No	36.5x35.5x10.2	64	Yes	11.1
Uniface	410	Jasper	Yes	15.3x3.9x20.5	38	Yes	1.2
Uniface	238	Jasper	Yes	14.3x12.8x4.3	45	Yes	.6

surface is irregular as opposed to being relatively flat, and only three flakes are removed to create a working edge. The chert is of relatively poor quality with no signs of thermal alteration. Use-wear could not be observed under 10 X magnification. This core tool may have been manufactured and then discarded prior to use. The specimen catalog 412 is a pebble split longitudinally by the bipolar method. There are flake removals perpendicular to the irregular ventral surface. Again, there are no visible signs of use-wear. The last core tool, catalog 120, is a squarish flat pebble split longitudinally. Two flakes were removed on one margin perpendicular to the ventral surface. Use-wear, in the form of micro-flakes, is evident on the flaked margin. The three core tools are manufactured from a relatively lower quality of chert than the scrapers, with no signs of being heat treated. The edge angles ranged from 64-77 degrees with a mean of 72 degrees (S.D. = 6.81).

The two unifacial tools were made on flakes (Figure 6.4). Ratio measurements, raw material type, TA, and use-wear are contained in Table 6.8. Both specimens were made from high quality thermally altered jasper. One specimen, catalog 410, is broken medially. The working edge has micro-flake scars visible. The other specimen, catalog 196, resembles a thumbnail scraper, with use-wear evident on the distal and proximal ends. There is smoothing or rounding on the arrises of the dorsal surface on the proximal end, suggesting it may been hafted. The working edge on both specimens appear to have been created by pressure flaking.

Other Chipped Stone Tools

Among the chipped stone tools are two specimens classified as a bifacial wedge and a drill. They are shown in Figure 6.4 above.

The bifacial wedge was manufactured from an oblate/disk shaped quartzite pebble. The length, width, and thickness of this specimen is 22.5 x 25.2 x 11.6 mm, respectively, with a weight of 6.9 g. One large flake has been removed from one face, and three smaller flakes removed from the opposite face, to form a bifacial edge of 75 degrees. The working edge shows evidence of use-wear in the form of micro-flakes and smoothing of the working edge. Approximately 40 percent of the surface is covered with remnant waterworn cortex. Although only one specimen was recovered from the BF locus, this chipped stone tool type was fairly common in the assemblages of the excavated inland portions of the KBS, enough so that the undergraduates who worked on the site gave it the nickname of "wedgie."

Binford and Quimby (1963:289) and Shott (1989:17) classify a similar artifact type as bipolar cores, while LeBlanc (1992:11) and Ranere (1975:190) maintain that artifacts of this type are used as wedges or pièces esquillés. There is no visible evidence of battering on the margin opposite the working edge, which if found would suggest bipolar reduction or use as a wedge. However, the overall small size of this specimen would make it very awkward to have removed flakes by freehand percussion. The damage on the working edge suggests it was used as a tool.

The other tool in this category is classified as a drill. It is made on a non-heat treated chert flake, which is triangular in cross-section. The proximal end contains a visible flake platform and the distal end the working bit. Fifty to 60 percent of the dorsal surface is covered by waterworn cortex. The specimen's length, width, and thickness is 21.0 x 9.2 x 5.9 mm, respectively, and it weighs .8 g. The edges of the working or distal portion are smoothed/rounded. There is no smoothing or polish on the proximal end to suggest that is was hafted. The piece can be held easily between the thumb and index fingerand twisted in either direction as with a modern key. The relatively thick and blunt bit is similar to a type of drill classified as a "reamer" by Fowler (1991:29 and Plate 5) which he concluded was used to ream out holes in woody material.

Cores, Flaked Gravels, and Split Pebbles

Two types of cores were classified in the KBS BF assemblage: bipolar and freehand. The core specimens are shown in Figure 6.5. Summary data for chert and jasper the cores are presented in Table 6.9.

The bipolar cores consist of one jasper and eight chert specimens. Two of the chert cores are heat treated. Each of the bipolar cores contained some remnant waterworn cortex indicating their origin in alluvial gravels. These cores are similar to the types illustrated and described by Binford and Quimby (1963:289-296 and Figures 128-132), which occurred in deposits from the Middle Archaic to the Late Woodland periods in the Upper Peninsula of Michigan. These bipolar cores appear to have been used to produce flakes for use as expedient tools, rather than the production of bifacial preforms or flake blanks. Bipolar reduction is generally thought to be used to take

Figure 6.5. Bipolar and freehand cores recovered from the BF locus at Kimble's Beach. Catalog 130, 370, 195, 386, and 265, bipolar cores; and Catalog 336 and 253, freehand cores.

advantage of lithic material otherwise too small to be reduced efficiently by freehand (Cresson 1977; Knudson 1978).

In addition to the three chert and jasper freehand cores summarized in Table 6.9, there was a fourth core of quartzite. The length, width, and thickness of this core is 53.5 x 45.8 x 37.8 mm respectively and it weighs 114.2 g. The maximum circumference was 175 mm, and the Wt*MLD was 6109.70. The core retained 20-29 percent of its original

Table 6.9. Summary Data for Chert and Jasper Bipolar and Freehand Cores.

Bipolar Cores*					
Attribute	N	Mean	S.D.	Range Min	Range Max
Length (mm)	9	33.79	6.82	23.3	46.7
Width (mm)	9	25.39	2.83	20.9	30.5
Thickness (mm)	9	15.43	3.49	11.2	20.5
Weight (g)	9	13.56	6.69	4.9	25.9
Max. Circ. (mm)	9	101.33	17.36	76	131
MLD	9	34.06	6.39	25.6	46.7
Wt*MLD	9	486.65	297.12	125.44	1041.41
Cortex %	9	—	—	10-19	60-69
Freehand Cores*					
Length (mm)	3	47.47	5.80	41.8	53.4
Width (mm)	3	32.37	4.57	27.6	36.7
Thickness (mm)	3	26.57	6.87	22.5	34.5
Weight (g)	3	56.60	33.94	27.1	93.7
Max. Circ. (mm)	3	144.67	13.65	130	157
MLD	3	47.47	5.80	41.8	53.4
Wt*MLD	3	2724.01	1647.56	1132.78	4422.64
Cortex %	3	—	—	<10	60-69

*Combined for chert and jasper cores.

waterworn cortex. The three freehand cores of chert and jasper were amorphous in shape with flakes removed in multiple directions. The quartzite core was blocky with flakes removed from either end. This specimen was also reddened, suggesting it may have been used as FCR or heat treated either before or after the flake removals. All four of the specimens retained some amount of waterworn cortex. Unlike the fine grained materials used in biface manufacture, the one jasper and two chert specimens are of coarse material.

Although the number is small, this suggests a deliberate choice to use poorer quality cryptocrystalline material to produce flakes. No prepared cores were found in this assemblage or in the assemblages from the inland portions of the site. None of these cores possessed a useable bifacial edge; therefore it appears that the detached flakes were the desired outcome of the reduction process.

The category of flaked gravels is divided into flaked pebbles and cobbles based on the greatest linear dimension of less than or more than 64 mm, respectively (Waters 1996:Table 2.1). Although, initially defined as artifact types for this study, the distinction appears to be without merit because it looks as if the specimens were flaked in the same manner for the same purpose. Therefore, the summary data for chert flaked pebbles and cobbles is combined and presented in Table 6.10. Ten of the 11 specimens are of chert and one of quartzite. Two of the chert specimens show signs of thermal

Table 6.10. Summary Data for Flaked Gravels* of Chert.

Attribute	N	Mean	S.D.	Range	
				Min	Max
Length (mm)	10	51.23	17.65	35.5	91.2
Width (mm)	10	35.35	7.48	25.2	50.6
Thickness (mm)	10	18.26	8.76	4.6	30.4
Weight (g)	10	40.37	25.76	9.1	81.9
Max. Circ. (mm)	10	147.10	34.79	102	222
MLD	10	51.23	17.65	35.5	91.2
Wt*MLD	10	2280.90	2107.76	368.55	7469.28
Cortex %	10	—	—	40-49	80-89

*Combined data for flaked pebbles and cobbles.

Table 6.11. Summary of Shapes for All Flaked Gravels.

Shape	Number of Specimens
Oblate	4
Bladed	4
Equant	1
Prolate	2

alteration. The quartzite specimen is 138.5 mm in length, 110.9 mm in width, 47.6 mm thick, weighs 160.0 g with a WT*MLD of 22,160, a maximum circumference of 386 mm, and 60-69 percent remnant cortex. A summary of shapes represented by the flaked gravels is contained in Table 6.11.

Four of the specimens appear to have been tested (Mounier 2003) to determine the quality of the material beneath the cortex by removing one or two flakes (Figure 6.6). Two of the specimens were of poor quality chert, so it is unlikely they were tested at the prehistoric beach face. The 11 gravels have between one and four flakes removed. All of the flake scars are less than one cm in length.

One of the specimens is an elongated flat pebble shaped like a spoon. The narrow end has one small flake removed from either face to form a rough edge. Micro-flakes on the edge suggest its use as an expedient tool. Another of the specimens is reutilized material from an earlier time. It is split in half transversely and edges resulting from this action are surf rounded. However, fresh flake scars are in evidence. This piece may have been initially split naturally or by human action. Stone in the sizes of the flaked gravels from the BF assemblage do not occur naturally in the soils of Cape May, but are easily found along the margins of the Delaware Bay.

Table 6.12. Summary Data for Split Pebbles.

Attribute	N	Mean	S.D.	Range	
				Min	Max
Length (mm)	10	31.55	10.71	17.3	57.4
Width (mm)	10	26.30	9.82	15.7	40.8
Thickness (mm)	10	11.8	4.65	6.8	21.8
Weight (g)	11	10.88	10.66	3.7	39.6

Twelve of the CSA's from the BF assemblage are classified as split pebbles (See Appendix A). Summary data for these artifacts is contained in Table 6.12 with combined

Figure 6.6. Flaked pebbles recovered from the BF locus at Kimble’s Beach.

data for chert (n = 9) and jasper (n = 2). One of the chert specimens displayed evidence of thermal alteration. The other specimen of quartz is 71.7 mm in length, 40.2 mm in width, 21.1 mm thick, and weighs 78.3 g. The WT*MLD is 5614 and the maximum circumference is 187 mm. All specimens retained some percentage of waterworn cortex on the dorsal surface.

These artifacts may have been initially split to produce tool blanks, as opposed to generalized bipolar reduction to produce useable flakes as expedient tools. However, they are relatively small to be used to manufacture triangular bifaces, as only two of the specimens are larger than 40 mm in greatest dimension.

Core Reduction Fragments, Bipolar Citrus, Unmodified Pebbles, and Reutilized Material

Core reduction fragments (CRF) (Appendix A) comprise 13.1 percent (n = 25) of the chipped stone artifacts. The summary data for weight by raw material is provided in Table 6.13. Six of the chert and one of the jasper specimens are thermally altered. All of the specimens have some percentage of waterworn cortex on their dorsal surfaces. These pieces are considered the residue of bipolar reduction of gravels for tool blanks or useable flakes.

Table 6.13. Summary Data for Weight (g) of CRF.

Raw Material	N	Mean	S.D.	Range	
				Min	Max
Chert (n = 17 Jasper (n = 2)	19	4.67	2.31	1.6	10.1
Quartz	3	4.33	2.91	2.1	7.6
Sandstone	2	3.50	—	1.9	5.1
Quartzite	1	5.7	—	—	—

One of the types of chipped stone artifacts in the BF assemblage was characterized as bipolar citrus (BPC). See discussion of this type on pages 231-234 in *Starting Forms* . Chapter 5 and Figure 5.18 for an illustration. Four specimens in this assemblage are classified as BPC. Summary data for the one jasper and three chert specimens are presented in Table 6.14. None of these specimens appears to have been thermally altered.

Table 6.14. Summary Data for Bipolar Citrus Artifacts*.

Attribute	N	Mean	S.D.	Range	
				Min	Max
Length (mm)	4	27.78	6.33	21.8	36.7
Width (mm)	4	14.30	3.16	11.2	17.5
Thickness (mm)	4	11.25	3.16	8.0	16.1
Weight (g)	4	3.98	3.08	2.4	8.6

* Note: Combined chert and jasper specimens.

In the present study, the BPC is considered to be the by-product of bipolar reduction, which, if large enough, could be used as a tool blank. An alternate explanation is provided by Stafford (1977:27-28), in which the BPC is the object of bipolar reduction of small pebbles (40 mm or less). This form (alternately labeled as an Orange Peel Flake) is valued as a tool in which the functional working edge is formed by the intersection of the two scarred or ventral surfaces, and the dorsal or cortical surface provides a grip. It is suggested that these forms were used in cutting and scraping activities. This interpretation was based on Stafford's (1977:27-28) work in the Escalante Ruin Group, Classic Hohokum sites in south-central Arizona. However, under 10 X magnification, no evidence of use-wear was discerned in the four specimens from the BF locus. This does not rule out their use as tools, but neither does it provide evidence to support that interpretation.

Unmodified pebbles (UP) and reutilized material (RUM) are classified as Other Lithics in Appendix B. They are discussed in the CSA portion of this study, because it is most probable that they were brought from the prehistoric beach face for use as raw material for manufacturing chipped stone tools (notably the chert specimens).

Table 6.15. Summary Data for Unflaked Pebbles by Raw Material.

Attribute	N	Mean	S.D.	Range Min	Max
Chert					
Length (mm)	7	45.03	10.06	30.7	54.8
Width (mm)	7	30.97	4.99	25.8	36.5
Thickness (mm)	7	20.53	9.47	9.7	35.7
Weight (g)	7	36.44	24.31	10.0	69.4
Max. Circ. (mm)	7	128.1	17.45	107	150
WT*MLD	7	1748	1436	344	3699
Quartz					
Length (mm)	2	53.95	—	46.7	61.2
Width (mm)	2	26.65	—	23.1	30.2
Thickness (mm)	2	13.85	—	11.7	16.0
Weight (g)	2	32.15	—	30.6	33.7
Max. Circ. (mm)	2	140	—	130	150
WT*MLD	2	1746	—	1429	2062

Table 6.16. Number of Specimens of UP in Each Shape Category.

Shape	Chert	Quartz
Oblate	4	0
Bladed	2	0
Equant	1	2
Prolate	0	0

Nine UP, seven of chert and two of quartz, were recovered from the BF Locus. Summary data for the two raw materials is presented in Table 6.15, and the shape classification in Table 6.16.

All but one of the unmodified or unflaked pebbles are within the size range of the gravels collected from the current beach face for use in the knapping experiments (34-86 mm in greatest linear dimension). By size alone, they are likely candidates for bipolar reduction into tool blanks or to obtain useable flakes for expedient tools. The waterworn cortex encasing these specimens indicate their origin in the alluvial gravels of the bay margin. Small cracks in the surface of the stone made possible the identification of the chert specimens, but experience has shown that when these gravels are split, other raw materials than those observed may predominate in the body of the specimen. All seven of the chert specimens were pockmarked with U-shaped incipient cones, which generally indicate knappable material. As discussed previously in this section, gravels of this size do not occur naturally in these soils, so they were likely brought to the site from the prehistoric beach face.

The last artifact type discussed in chipped stone artifacts is RUM (See Appendix A). This is lithic material flaked in an earlier time. The edges and arrises are surf rounded, and cortex has begun to form on flake scar surfaces. It is possible that natural forces (wave action) may be responsible for some damage to these pieces, but the pattern and number of flake scars suggest that they were flaked or tested in an earlier time, abandoned, buried, eroded out of sediments as the bay transgressed on to formerly dry land, deposited on the beach face, and then selected by the Kimble’s Beach knappers and brought to the upland site (Figure 6.7). The quality of this stone is easily determined by visual inspection, and it is suggested here that they formed a portion of the supply of lithic raw materials. Five chipped stone artifacts in the assemblage were derived from RUM: one biface, two split pebbles, and two CRF’s.

The RUM artifacts consisted of 16 chert and one quartzite specimen. Summary data for chert specimens is presented in Table 6.17. The quartzite specimen is described later in the discussion.

Table 6.17. Summary Data for Reutilized Material from the BF Assemblage.

Attribute	N	Mean	S.D.	Range	
				Min	Max
Length (mm)	16	28.19	6.33	19.2	39.3
Width (mm)	16	20.3	5.84	10.9	36.0
Thickness (mm)	16	10.94	3.80	6.6	19.7
Weight (g)	16	7.07	5.90	1.7	26.4

The RUM is noteworthy in two aspects when compared to other stone materials found at the BF Locus; the stone is of uniformly high quality, and the pieces are of relatively small size. The quality of the stone is easily assessed, as the flake scars provide a window into the interior. The formation of cortex clouds this window, but it is obvious that it is high-quality cryptocrystalline material. Compared to the chert UP's in Table 6.15, the mean of the RUM specimens are lesser in length by 17 mm, in width by 11 mm, in thickness by 10 mm, and in weight by 28 g. The relatively smaller size is due to the original removal of material from the unmodified gravel. Most likely, larger pieces brought to the site were reduced first and the smaller pieces left unused to become part of the CSA assemblage.

The most unique specimen of RUM is an early-stage quartzite biface of an unknown earlier period, catalog number 113 (Figure 6.7). It appears to have been abandoned due to humps of material on both faces that could not be removed. All of the arrises are rounded and the formation of cortex on the flake scars gives a cloudy appearance to the stone. The specimen's length, width, and thickness are 47.9 x 25.7 x 13.9 mm, respectively, with a weight of 16.7 g. There are no fresh scars on this piece or on the other specimens.

Figure 6.7. Reutilized material recovered from the BF locus at Kimble's Beach. Catalog 113, quartzite, early stage biface.

It appears that RUM was an easily obtainable and high-quality cryptocrystalline material that could be reduced to obtain flakes for expedient tools or to manufacture chipped stone tools. Indeed, walking along the current beach face at low tide, one can find such materials with relative ease among the gravels.

Other Lithics

The class of "Other Lithics" described here contains cobble based specimens such as abraders, hammerstones, pecked stones, and FCR (Appendices A and B). These artifacts are unmodified, and are used in chipped stone tool manufacture, processing plant materials, and food preparation.

Among the lithic artifacts recovered from the BF Locus were three specimens classified as abraders (Figure 6.8). Data on individual specimens are given in Table 6.18.

Table 6.18. Data for Individual Specimens of Abraders from the BF Locus.

Catalog Number	Raw Material	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Cortex Percentage
363.a	Quartzite	42.1	16.2	10.7	11.1	90-99
335	Quartzite	58.7	39.7	11.7	47.0	100
185	Sandstone	47.8	41.1	7.2	14.2	80-89

The first specimen, catalog 363.a, retains its waterworn cortex with striations and luster or polish on the concave face as an indication of use-wear. There are rusty or reddened spots on the surface, suggesting it may have been subjected to heat either before or after its use as an abrader. The second specimen, catalog 335, is a flatish, ovoid pebble covered with waterworn cortex. There is use-wear in the form of striations on both surfaces, with one surface showing more pronounced wear than the other. The third specimen, catalog 185, is an irregular disk shape with rounding on the margins from use.

Figure 6.8. Examples of Other Lithics recovered from the BF locus at Kimble’s Beach. Catalog 335 and 363.a, abraders; and Catalog 363.b, 362, and 417, hammerstones.

All three specimens fit comfortably in the hand or between the thumb, index, and middle fingers. Based on the use-wear observed under 10 X magnification, it appears that the specimens catalog 363 and 335 were used in the chipped stone tool manufacturing process. The specimen catalog 185 appears to have been used on softer substances, such as vegetative material.

Four of the artifacts from the BF assemblage are classified as hammerstones, based on their morphology, raw material, and damage observable on their surfaces. Data

Table 6.19. Data for Individual Specimens of Hammerstones from the BF Locus.

Catalog Number	Raw Material	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Cortex Percentage
363.a.1	Quartz	82.5	35.1	31.9	150.0	70-79
363.b	Quartzite	74.7	38.2	28.3	112.2	80-89
362	Quartz	65.7	37.1	32.9	106.9	88-89
417	Quartzite	87.7	55.4	39.0	235.0	80-89

on linear measurements, weight, percentage of remnant cortex, and raw material for individual specimens is contained in Table 6.19. The hammerstones consist of two quartz and two quartzite specimens of alluvial cobbles with remnant waterworn cortex. All four specimens were classified as prolate in shape (Figure 6.8).

The first specimen, identified as catalog 363.a.1, possesses a flake scar three-quarters of the length from the proximal end, with a step termination approximately one-third of the length of the scar from initiation. The scar then continues toward the distal end. This may be the result of either one or two detachment events. Crushing is evident on the distal portion, with small scars on the proximal end indicating either evidence of use or the initiation of the flaking events. The second specimen, catalog 363.b, has damage in the form of crushing on the distal end, and on one face approximately 10 mm from edge of the margin, as if it was used as a baton. There are no striations visible. The damage may be the result of use as a percussor or another purpose not involved in lithic production. Both of these specimens were recovered from the same unit and level, so it is possible they were part of an individual's toolkit. The third specimen, catalog 362, exhibits crushing on both ends of this elongated cobble. This item fits easily and comfortably in the hand to use as a percussor (Whittaker 1994:93 and Figure 6.10). The fourth specimen, catalog 417, is pitted and crushed on one end with some damage on the face just below the margin. Damage in the form of crushing and pitting is on one face near the opposite end. It appears that this specimen may have been held at either end and used as a baton to strike an object with a blow perpendicular to the long axis of the hammerstone. The damage suggests its use as a percussor in lithic reduction with the possibility of use in processing other materials.

Data for the artifact type pecked stone is contained in Table 6.20. The specimens of pecked stone are either quartz or quartzite, which are covered with waterworn cortex (Figure 6.9). The greatest linear dimension ranges between 39.0-77.8 mm. All specimens exhibit damage on margins, one surface, and/or the ends. Catalog numbers 324.a, 324.b, 325, and 326 were recovered from Trench 9, while catalog 420 was recovered from Trench 20.

The first specimen, catalog 324.a, is damaged on one surface 7 mm from the end of the piece. The second specimen, catalog 324.b, exhibits pitting and striations on one of the rounded margins. This suggests use as a grinding stone. The piece fits in the hand comfortably for this purpose. The third specimen, catalog 325, has a flake scar on the widest end of the piece, and is pitted on the other end along the margin. The fourth

Figure 6.9. Other Lithics recovered from the BF locus at Kimble's Beach. All specimens pecked stone.

Table 6.20. Data for Individual Specimens of Pecked Stone from the BF Locus.

Catalog Number	Raw Material	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Cortex Percentage	Shape
324.a	Quartz	73.2	37.3	26.1	99.5	90-99	Prolate
324.b	Quartz	44.7	37.7	21.9	51.8	70-79	Oblate
325	Quartzite	53.8	39.0	21.2	69.0	80-89	Oblate
336	Quartzite	39.0	22.3	11.9	12.6	60-69	Broken
420	Quartzite	77.8	74.7	14.2	119.4	80-89	Oblate

specimen, catalog 336, is blade shaped with rounded margins, and is broken parallel to the "A" axis with a flake scar on one end. One margin is pitted approximately 13 mm from the break. The fifth specimen, catalog 420, is a circular disk shape that is lightly pitted for 22 mm along one margin. The damage suggests use in lithic reduction activities, abrading chipped stone artifacts, or processing of other resources.

Fire cracked rock is the most abundant artifact type of the NDL recovered from the BF locus in both frequency (28.1 percent) and weight (53.2 percent). The frequency Fire cracked rock is the most abundant artifact type of the NDL recovered from the BF locus in both frequency (28.1 percent) and weight (53.2 percent). The frequency of raw material types and summary data for weight for the FCR is presented in Tables 6.21 and 6.22. Quartz and quartzite account for 94.6 percent of the FCR in the assemblage. All specimens exhibit some reddening and many show cleavage fracture common with heat damage. As noted in Chapter 3, *Project History*, the principal investigator for the KBS, Dr. John Cavallo (Cavallo et al. 1996), expressed surprise at the relatively small amount of FCR that was recovered in the excavations. Considering Cavallo's (1987:Table 24) experience in the excavations at the Abbott Farm site complex, especially 28 Me 1-B or Area B, where literally tons of FCR were found, his surprise is understandable. However in Area B, the large amount of FCR was found in

Table 6.21. Frequency of FCR by Raw Material Type.

Raw Material	Frequency	Percent
Chert	1	1.8
Quartzite	18	32.1
Quartz	35	62.5
Sandstone	2	3.6
Totals	56	100.0

Table 6.22. Summary Data for Weight (g) of FCR from the BF Assemblage.

N	Mean (g)	S.D.	Range		Sum (kg)
			Min	Max	
56	63.88	103.64	.2	459	3.577

contexts dated to the Terminal Archaic to Early Woodland times when processing of anadromous fish through stone boiling was hypothesized to be an important subsistence activity in the Middle and Lower Delaware Valley (Stewart 1998a).

The FCR is distributed rather thinly, with Trench 2 producing the highest frequency of specimens at 16.1 percent (n = 9), with a weight of 1352.4 g or 37.8 percent of the total FCR weight (Table 6.22). In Trench 2, five of the pieces were recovered in or near the feature, while the other four are noted as general provenience within the trench. The remainder of the specimens are distributed among 11 excavation units (n = 47; 2224.8 g). Examination of the distribution of FCR in the BF locus does not suggest any discernible pattern or associations with other lithic artifacts. Perhaps the distance to the prehistoric beach face from this upland site (see Chapter 3, *Site Background*) precluded the use of this relatively heavy stone material in any great amount for cooking or the lining of hearths. If the large deposits of FCR at Abbot Farm are associated with the processing of anadromous fish through stone boiling, as suggested by Cavallo (1987:181), perhaps Stewart's (1998d) impression that the importance of fishing declined from the

Middle Woodland period to Late Woodland period, or at least the activities used to exploit this resource had changed, may provide an explanation. This change and the distance from the prehistoric beach face may explain in part the relatively small amount of FCR recovered from the BF locus at the KBS. Of course, the location of Kimble's Beach near the wide mouth of the Delaware Bay would make the use of weirs and netting to capture large numbers of these fish problematic, though both were used with effectiveness in the narrower reaches of the Delaware River and its tributaries further north (Kraft 1982:151).

Summary: Non-Debitage Lithics. The types of raw materials (*n* = 7) represented by the NDL recovered from the BF locus are the "usual suspects" found in OCP archaeological sites. The overwhelming proportion of the CSA specimens (NDL) consists of high quality chert and jasper specimens (88.5 percent). Nonlocal lithic materials, such as argillite and Cohansey quartzite, are represented by only one specimen of each type. The remainder of the local materials consist of quartz, quartzite, and sandstone. The Other Lithics (*n* = 66), excluding RUM and UP, are almost exclusively of quartz, quartzite, and sandstone. All of these lithic materials are easily found along the Delaware Bay margins in the vicinity of the KBS.

The relatively small size of the CSA and the presence of waterworn cortex suggest that alluvial gravels found along the bay margins was the source of the lithic raw materials at the BF locus. The relatively small size of the CSA (98 percent 71.2 mm or smaller in greatest dimension) could easily be manufactured from these alluvial gravels. Approximately 85 percent of the CSA specimens retained some percentage of waterworn cortex similar to that found on the local alluvial gravels.

Signs of TA were present in more than a quarter of all chert and jasper CSA specimens. Approximately 55 percent of all chert and jasper biface specimens were heat treated. All of the biface specimens that were heat treated were found in Preform I and II and Finished Triangles of the BRS. This suggests that heat treatment was applied after the gravels were initially split or a suitable flake blank was produced. Biface specimens of jasper showed signs of TA at nearly double the proportion of chert specimens. Since the flaking qualities of both materials may be improved by heat treatment (Luedtke 1992:91-96), this difference in the proportions of TA suggests that jasper may have been preferentially heat treated for nontechnological reasons (Snow 1980:132).

Bifaces, in their various stages of manufacture, represent the largest artifact type in the CSA class. The BRS, as described and shown in Chapter 4, is represented by all four stages at the BF locus. This suggests that the manufacture of small triangular bifaces (assumed to be arrow points) was a major object of lithic reduction at the BF locus. The presence of all four stages of the BRS suggests that the complete biface reduction trajectory was accomplished for at least some of the biface manufacturing episodes. All of the biface specimens were manufactured from high quality chert or jasper gravels. Seventy-five percent of the biface specimens of incomplete triangles were either broken in manufacture or contained lumps of material on one face that could not be removed through knapping. However, these materials were not totally wasted, because 27 percent (n = 6) of the 22 specimens displayed various forms of use-wear.

A stone artifact type, RUM, was defined for this project (Appendix A). Specimens of this previously flaked material were transported from the Late Woodland beach face to the upland site, which is found at the current beach face at Kimble's Beach. This material has the advantage of being easily identified as high quality cryptocrystalline material without testing. These specimens along with UP were unflaked raw materials recovered from the BF locus.

The chipped stone tools consisted of stages of triangular biface manufacture, scrapers of several types, unifacial tools, core tools, a bifacial wedge, and a drill. Tools in the OL class were abraders, hammerstones, and pecked stone. The BF locus at the KBS yielded a seemingly small variety of artifact types, although it is similar in overall composition to the Middle/Late Woodland deposits at the Gropp's Lake site (28 Me 100G), a portion of the Abbott Farm Complex (Stewart 1987:79-130).

Fire cracked rock, present in comparatively small numbers, was the most numerous artifact type in the assemblage. Considering that the site may have been 400-500 m from the prehistoric beach face, which is the source of this stone (see Chapter 3, *Landward Transgression of the Delaware Bay*), the relatively small amount of FCR is more understandable considering the costs of time and effort for transport. It would seem more economical for the processing of foods that required the use of FCR to be accomplished in proximity to the beach face. Hence, it seems reasonable this artifact type would not be greatly represented at an upland site the OCP.

The relatively large numbers of BP cores, CRF's, and SP found at the BF locus indicate that bipolar reduction was employed to produce useable flakes for expedient tools and initial processing of gravels to obtain a SP or FLK starting form for biface manufacture. Only a few freehand cores were recovered suggesting the small size of the gravels did not lend themselves to this mode of reduction.

The CSA and OL artifact types are rather spottily distributed across the BF locus (see Chapter 7 for further discussion). As would be expected, Trenches 2 and 17, which yielded the largest amount of debitage, also produced the greatest proportions of CSA and OL. Examination of the distribution of the NDL, in the absence of debitage, produced no easily discernible patterns or indications of specialized activities. Stewart (1998d) hypothesizes that evidence of tool production should be widely distributed within a Late Woodland settlement and/or associated with individual households, rather than in specific areas. He further suggests that the formal staged biface industry and the knapping specialist of the Middle Woodland period has largely given way, by Late Woodland times, to the relatively simple core and flake strategy of bipolar flake production, one biface type (triangular projectile points), and a few easily produced stone tools. Literally, it was a simple technology that could be easily mastered by a wide swath of the population.

Analysis of Beach Face Debitage

Attributes Recorded and General Procedures

Debitage recovered from the BF locus of the KBS totaled 2,389 pieces. The entire suite of variables, originally tested with the experimental debitage, was retained for use in analysis of the archaeological assemblage. Normally, in an experimental study such as this, attributes are only retained if they demonstrate some usefulness in answering specific research questions. However, at present there is no published study of the lithic materials recovered from any of the excavated areas at KBS. In light of these circumstances, a complete characterization of the debitage in terms of the study attributes of at least one area of the site would provide a baseline for any future studies or categorization of the site. Although length, maximum width, and thickness provided little insight into the posed research problems, they are commonly recorded attributes, and consequently are retained (Andrefsky 1998:85-88). Categories of flake terminations and flake fragments were included for the same reason (see pages 171-174). In addition to the debitage attributes, the catalog number, unit, quad, level, and feature numbers were recorded. The data, as in the experimental study, were recorded on forms and entered into an SPSS database. This SPSS database was cross-checked against the data forms to eliminate any entry errors or omissions. This entire procedure was time intensive, with an average of 10 hours per each 100 pieces of debitage needed to analyze, measure, record, enter, and verify. The hope is that a future study will utilize these results with a package of attributes that best answers their own particular research questions regarding artifact samples from other loci at the KBS, or Delaware Bay sites whose lithic technology focused on alluvial gravels as the primary source of raw material.

The recorded attributes are raw material, thermal alteration (yes/no), SRT (five categories), flake termination type, platform type (four categories), crushed platform (absent/present), platform lip (absent/present), platform width and thickness, dorsal cortex percentage (four categories), dorsal flake scar count (four categories), weight (nearest .1g), length, maximum width and thickness, and size class recorded in five mm increments. All attributes were identified or measured in accordance with the procedures discussed in pages 160-190 and Appendix B. In the initial portion of this section, attributes for the composite debitage of all raw materials types and size classes are presented, but only chert and jasper pieces are considered when exploring the stated research problems. These two raw materials comprise 96.1 percent of the debitage at the beach face. In addition, most of the analyses were size restricted to debitage in the 6.4-25.4 mm range, but the full range of size classes (6.4-50 mm) were employed to determine the reduction type and the biface reduction trajectory length at the BF locus. To avoid confusion, in the beginning of each segment it is clearly stated which range of debitage sizes are considered in the particular analysis. This is a study of populations of debitage, except for the classification of individual hard hammer (HH) and pressure flakes (PF).

Description of Complete Debitage Assemblage from the Beach Face Locus

In this portion of the study the beach face debitage, including all raw materials and size classes, are presented and discussed for the recorded attributes.

A total of 27 excavation units, including trenches 1 x 4 m or larger, 1 x 1 m test units, and shovel tests, yielded debitage at the BF locus. Two units, trenches 2 and 17, yielded 22.1 percent (n = 529) and 23.1 percent (n = 553) respectively of the total debitage recovered. The other units ranged between 1-165 pieces (Table 6.23).

Table 6.23. Frequencies of Debitage for Beach Face Units.*

Excavation unit	N	%	Excavation unit	N	%
Trench 1	165	6.9	Trench 17	553	23.1
Trench 2	529	22.1	Trench 18	51	2.1
Trench 3	141	5.9	Trench 19	79	3.3
Trench 4	132	5.5	Test Unit 1	19	0.8
Trench 5	35	1.5	Test Unit 2	68	2.8
Trench 7	89	3.7	Test Unit 3	34	1.4
Trench 8	5	0.2	Test Unit 4	9	0.4
Trench 9	67	2.8	Test Unit 5	12	0.5
Trench 9A	3	0.1	Test Unit 7	54	2.3
Trench 10	102	4.3	Test Unit 8	41	1.8
Trench 11	30	1.3	Shovel Test 11	2	0.1
Trench 12	1	0.04	Shovel Test 21	1	0.04
Trench 13	8	0.3	Total	2389	100.0

*Note: All raw materials and size classes.

Five features were excavated within units. They yielded 77 pieces of debitage; or 3.2 percent of the total recovered (Table 6.24). The results of the analysis of the feature

Table 6.24. Frequencies of Debitage in Features as a Percentage of the Total Assemblage.

Excavation Unit	Feature	N	%
Trench 2	1	30	1.3
Trench 2	2	14	0.5
Trench 4	1	2	0.08
Trench 9A	1	3	0.13
Trench 17	1	28	1.2
	Total	77	3.2

debitage for the studied attributes were unremarkable when compared to the total assemblage, with a few exceptions. These exceptions were in raw materials, proportions of dorsal flake scars, thermal alteration, and large pieces (>25.4 mm). The raw materials consisted entirely of chert, jasper, and a few pieces of chalcedony. The percentage of pieces with two or more dorsal flake scars in Trenches 2 (67.6) and 17 (73.7) was greater than the mean (57.6 percent) for the entire assemblage. The three large pieces (>25.4

mm) recovered were all in the size class 25.4-30 mm. The proportion (42.9) of debitage recovered from Trench 17 with thermal alteration was nearly twice (22.8) that of the entire assemblage. Only a few small pieces of charcoal were recovered from this feature and no reddening of the soil was noted, so it cannot be determined if this was a hearth feature. None of the debitage recovered from this feature exhibited signs of having been burnt in a fire and many of the pieces showed signs of luster[1], as well as color change, although thermal alteration of the debitage by a hearth fire cannot be completely ruled out. The small numbers of debitage recovered from the features did not allow for any meaningful statistical inferences regarding differences in lithic reduction activities as compared to the total assemblage.

The lithic raw materials represented in the BF debitage assemblage were overwhelmingly of chert and jasper. They comprised 96.1 percent (*n* = 2296) of the total assemblage. The small size (97.9 percent equal to or less than 25.4 mm in greatest dimension) of the debitage often made identification somewhat difficult. In addition, the gravels used as raw material were covered with cortex, which ranged from one to eight mm in thickness. Debitage from this layer were generally coarse, and often bore little resemblance to the encased chert and jasper. These pieces were identified generically as chert, based on the experience gained from the lithic experiment and the testing of hundreds of gravels gathered from the margins of the Delaware Bay at Kimble's Beach. Jasper was primarily differentiated from chert by color. All brown, mustard colored, and red cherts were classified as jasper, in accordance with archaeological practice in the lower Delaware River and Bay (Cross 1941:41-51; Mounier 1972; Wall et al. 1996:3). This was done with full knowledge of Luedtke's (1992:6) admonition to archaeologists that jasper is simply a form of chert, unless chemically identified as to a specific type.

Table 6.25. Frequency of Raw Material Types Represented in the BF Debitage Assemblage.

Raw Material	N	%	Cumulative %
Chert	1784	74.7	74.7
Jasper	512	21.4	96.1
Quartz	39	1.6	97.7
Chalcedony	19	0.8	98.5
Quartzite	15	0.6	99.1
Sandstone	11	0.5	99.6
Metasediments	3	0.1	99.7
Cohansey Quartzite	2	0.1	99.8
Felsite	2	0.1	99.9
Unknown	2	0.1	100.0
Total Number	2389	100.0	100.0

This researcher's personal observation, not based on any rigorous methodology, such as the one proposed by Shelley (1993), is that quartz is the dominant lithic material found along the bay margin. However, quartz is only 1.6 percent of the total debitage recovered. There can be no doubt that the indigenous knappers of the BF locus chose the higher quality cryptocrystalline materials represented by chert and jasper to manufacture their tools and produce expedient flakes (Table 6.25).

The frequency of SRT flake types is contained in Table 6.26 for five categories (includes split flake) and four categories with the split flakes counted as flake fragments (see page 208-209 for explanation). Platform remnant bearing flakes are 79.9 percent (n = 1910) of the total debitage assemblage. This combined with the relatively lower number of flake fragments, reduction fragments, and split flakes, suggests more patterned tool production than bipolar reduction, based on the experimental results (Figure 5.12). Quartz (n = 39) exhibited a different pattern with flake fragments (33.3 percent) and reduction fragments (17.9 percent) together, greater than complete flakes (33.3 percent)

Table 6.26. Frequencies of Sullivan-Rozen Flake Types (5 and 4 categories).

	SRT (5)		SRT (4)	
Category	N	%	N	%
Complete	1401	58.6	1401	58.6
Proximal	509	21.3	509	21.3
Flake Fragment	409	17.1	426	17.8
Red. Fragment	53	2.2	53	2.2
Split Flake	17	0.2	-----	------
Totals	2389	100.0	2389	100.0

and proximal flakes (15.4 percent) combined, suggesting bipolar reduction was the principal technique used to reduce these gravels. Types of flake fragments and flake terminations are contained in Tables 6.27 and 6.28. The extent of any postdepositional breakage caused by trampling is unknown.

Table 6.27. Frequencies of Flake Fragment Types.

Category	N	% of FF
Medial	120	29.3
Distal	289	70.7
Total	409	100.0

Table 6.28. Frequencies of Flake Termination Types.

Category	N	%
Feathered	1604	69.2
Stepped	629	27.1
Hinged	85	3.7
Plunging	1	0.0
Total	2319	100.0

The measurements of length, maximum width and thickness, platform thickness and width, and weight are summarized in Table 6.29. Not surprisingly, the means of length and maximum width are both less than 15 mm for the entire debitage assemblage.

The standard deviation of weight is .62 g, which is greater than the mean of .4 g and the median of .2 g. Debitage weighing .1 g or less comprised 40.9 percent (*n* = 977) of the

Table 6.29. Summary Data of Debitage Measurements for All Debitage.

Variable	Mean	SD	Minimum	Maximum	Valid N
Length (mm)	12.71	4.88	.85	46.45	1927
Max.Width (mm)	11.36	3.82	.4	35.75	2319
Max. Thick. (mm)	2.74	1.52	.4	12.25	2336
Plt. Width (mm)	5.96	2.52	1.35	30.9	1910
Plt. Thick. (mm)	2.02	1.16	.4	11.65	1910
Weight (g)	.41	.62	.1	7.2	2389

total assemblage, while pieces weighing less than .1 g were 24.4 percent (*n* = 582) . The left skewing (skew = 4.711) of the population to the lower weights is shown in Figure 6.10. The total weight of debitage recovered from the beach face is .989 kg.

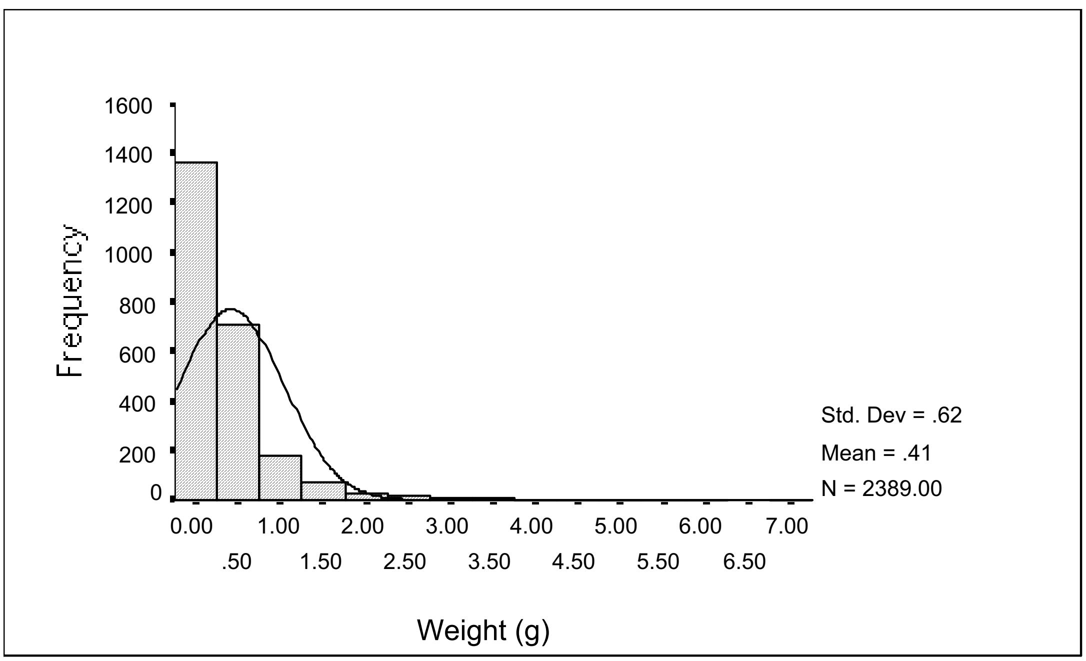

Figure 6.10. Histogram of weight frequencies for BF debitage with normal curve.

The frequencies of debitage in size classes of five mm increments contained in Table 6.30 reinforce the conclusions from the length and maximum width data concerning the relatively small size of the majority of the debitage. Size class 10.1-15 mm contains

Table 6.30. Frequencies of Size Classes (5 mm increments) of all BF Debitage.

Size Class (mm)	N	%	Cum.%
<6.4	5	0.2	0.2
6.4-10	565	23.7	23.9
10.1-15	1119	46.8	70.7
15.1-20	495	20.7	91.4
20.1-25.4	155	6.5	97.9
25.5-30	35	1.5	99.4
30.1-35	10	0.4	99.8
35.1-40	2	0.1	99.9
40.1-45	2	0.1	100.0
45.1-50	1	0.0	100.0
Totals	2389	100.0	100.0

the largest number of pieces (n = 1119; 46.8 percent). Only 2.1 percent (n = 50) of the debitage is larger than 25.4 mm, while the experimental assemblage yielded almost 500 percent more of these larger pieces. This indicates that the larger pieces generated in the earlier stages of core reduction were further reduced, selected to be used beyond the limits of the BF, initial core reduction took place beyond the limits of the tested portions of the BF locus, and/or a combination of these behaviors.

The frequencies of dorsal cortex percentage categories and dorsal flake scar categories are presented in Tables 6.31 and 6.32, respectively. Pieces with zero percent

Table 6.31. Frequencies of Dorsal Cortex Percentage Categories of all BF Debitage.

Category	N	%
0%	1324	56.7
1-50%	555	23.2
51-99%	292	12.5
100%	165	7.1
Total	2336	100.0

Table 6.32. Frequencies of Dorsal Flake Scar Categories of all BF Debitage.

Category	N	%
100% Cortex	118	6.2
1 Scar	303	15.9
2 Scars	389	20.4
>2 Scars	1100	57.6
Total	1910	100.0

dorsal cortex are 56.7 percent of the total pieces for which this attribute was recorded (all SRT flakes except reduction fragments), while 43.3 percent of the debitage retained some cortex. This proportion of debitage with some cortex is within the range of Ranere and Ressler's (1981:Table 1) experimental reduction of chert gravels from the margins of the Great Egg Harbor River on the Atlantic coast of New Jersey. Their reduction of chert gravels produced a mean percentage of 32.1 and a range of 15.2-57.1 percent for six experiments. This reinforces the conclusion that alluvial gravels were the lithic raw material at the BF locus of the KBS. Debitage with more than two flake scars accounted for 56.6 percent of all PRB flakes for which this attribute was recorded. Multiple flake scars are considered to be indicative of later stage biface manufacture (Gilreath 1984; Magne 1989).

Platform types with four and three categories recorded for the PRB flakes are contained in Table 6.33. Faceted platforms are 44.4 percent of the debitage for which

Table 6.33. Frequencies of Platform Types of Four and Three Categories of all BF Debitage.

Category (4)	N	%	Category (3)	N	%
Cortical	306	16.0	Cortical	306	16.0
Flat	733	38.4	Flat	733	38.4
Faceted	848	44.4	Faceted	871	45.6
Abraded	23	1.2	—	—	—
Totals	1910	100.0	Totals	1910	100.0

this attribute was recorded. Faceted platforms are thought to be indicative of later stage biface manufacture (Gilreath 1984; Johnson 1989:127). Flat platforms are essentially those with no cortex present, and one scar, regardless of the platform shape.

The frequencies of the presence or absence of platform crushing and platform lipping are contained in Table 6.34. Although a relatively small sample (*n* = 19), quartz PRB's exhibited a greater proportion of crushed platforms (73.7 percent) than the percentage (41.9) for the total assemblage. This is suggestive of the more violent and uncontrolled percussion inherent in BP reduction (Cotterell and Kaminga 1987:685).

Table 6.34. Frequencies of Crushed Platforms and Platform Lips of all BF Debitage.

Crushed Plt	N	%	Platform Lip	N	%
Present	801	41.9	Present	274	14.3
Absent	1109	58.1	Absent	1636	85.7
Totals	1910	100.0	Totals	1910	100.0

Debitage that exhibited high gloss and/or reddening were recorded as thermally altered pieces. Approximately one quarter (22.6 percent) of the debitage was judged to have undergone heat treatment (Table 6.35). A number of pieces of debitage appeared to have been burned (blackened) in a fire, rather than heat treated. These pieces were not recorded as thermally altered. Thermal alteration examined by raw material type suggests that jasper was heat treated more often than chert. Nearly one-half (49.4 percent; 253/512 pieces) of the jasper debitage were heat treated, while only 15.9 percent of the chert pieces (284/1784) were so treated. Jasper contains a higher percentage of

Table 6.35. Frequency of Thermal Alteration for the Total BF Debitage Assemblage.

Thermal Alteration	N	%
Yes	541	22.6
No	1848	77.4
Totals	2389	100.0

iron, thus reddens more noticeably and may be easier to identify as heat treated (Luedtke 1992:6). The difference in proportions in thermal alteration of chert and jasper may be due to the color preferences of the Kimble's Beach knappers, analyst bias, or a combination of both. However, similar patterns of thermal alteration of jasper and chert appear to be common in archaeological sites within the OCP of New Jersey (Jack Cresson, personal communication 2008).

In summary, chert and jasper are the primary lithic raw materials represented in the beach face assemblage of debitage at KBS. These two raw materials account for 96 percent of the total assemblage. The next largest component is quartz at 1.6 percent, with the other types comprising less than one percent of the assemblage. There is an obvious preference for these relatively high-quality cryptocrystalline materials, considering the preponderance of quartz among the gravels along the margins of the Delaware Bay.

The relatively high proportion (43.3 percent) of pieces with some dorsal cortex strongly suggests a gravel source for these lithic materials. This relatively high percentage exceeded the mean (32 percent) reported by Ranere and Ressler (1981:Table 1) for their reduction experiments with alluvial chert gravels. The margin of the Delaware Bay at or near KBS is the logical source for these gravels. The waterworn or smoothed appearance of the cortex greatly resembles that of the gravels collected from this source for the lithic experiment. The large proportion (97.9 percent) of small-sized debitage (equal to or less than 25.4 mm in greatest dimension) also argues for the small-sized raw material (Wenzel 2001:Table 7.4) represented by the alluvial gravels (range of 34-86 mm in gravels collected for reduction experiments) as the lithic raw material for the knappers of the BF locus at the KBS.

The relatively large proportion (79.9 percent) of PRB flakes, and the conversely smaller proportion of flake fragments and reduction fragments, suggest that pattern tool manufacture was the primary lithic activity at the BF locus. The relatively larger proportion of flake fragments, reduction fragments, and PRB flakes with crushed platforms found among the quartz debitage suggests that bipolar reduction was used to reduce this lithic material.

Heat treatment of lithic raw materials was practiced at the BF locus at some point in the reduction trajectory (see following section). Comparison by raw material type indicated that the jasper debitage exhibited signs of thermal alteration for nearly half of all recovered pieces, which is 300 percent more than the chert debitage.

The domination of the assemblage by small-sized debitage (equal to or less than 25.4 mm in greatest dimension), and the relatively low percentage of pieces larger than 25.4 mm, suggest that either early reduction took place off site, larger pieces were reduced to a greater extent than in the lithic experiments, pieces were removed to another area, and/or some combination of these behaviors.

Chert and Jasper Debitage Analysis and Research Questions

In this portion of the study, the results of the experimental knapping were applied to the chert and jasper debitage to answer the research questions posed for the BF locus of the KBS. Chert and jasper were analyzed to correspond with the experimental work with these lithic materials. In some aspects of this study, all size classes were employed (type of reduction and length of reduction trajectory), in the others, only debitage 6.4-25.4 mm in greatest dimension were utilized.

Patterned Tool Manufacture or Bipolar Reduction. A major goal of the debitage experiment is to determine if the archaeological assembly of debitage from the BF locus of the KBS represents the residue of patterned tool manufacture or bipolar reduction to obtain usable flakes, or some combination of both. In patterned tool manufacture, with the small alluvial gravels, a certain proportion of the debitage is derived from the initial use of the bipolar method to produce either a split pebble or flake blanks for tool manufacture. The debitage from this initial BP process is accounted for in the discriminant function and the proportions of SRT flakes in the patterned tool experimental assemblage. This assumes a complete manufacture trajectory at the BF locus.

In order to make this determination of reduction strategy, the beach face debitage was compared to the proportions of SRT flakes of four categories derived from the lithic experiments for patterned tool manufacture and bipolar reduction (see Chapter 5, *SRT Results*). Further, the *unstandardized canonical discriminant function coefficients*, obtained from the discriminant analysis, was used to calculate a discriminant score for the entire assemblage and all excavation units with 30 or more pieces of debitage. To determine if the debitage represented patterned tool manufacture, bipolar reduction, or some combination, these discriminant scores were then compared to the cutting score of the discriminant analysis for the experimental episodes of reduction. See page 221 for a more complete description of the procedure. This initial classification of reduction types determined if further problems could be explored with the experimental results.

The proportions of SRT (four) flakes were calculated for all chert and jasper debitage as one group for the BF debitage assemblage. The differences in SRT (four) flake proportions for chert and jasper from the BF assemblage were highly unlikely to be significant (X^2 = .9228, p = .81992 >.05); therefore, they were treated as one group as in the experimental study. Any reference to BF debitage from this point on refers to the composite chert and jasper assemblage, unless otherwise stated.

The proportions of the SRT (four categories) flakes for the archaeological assemblage of debitage from the BF compared to those for patterned tool manufacture, and BP reduction are presented in Table 6.36. The proportions of the flake categories for

Table 6.36. Frequencies of Sullivan-Rozen Flake Categories (4) of BF Debitage and Experimental Patterned Tools and Bipolar Reduction.

	KBS BF		PT		BP	
Category	N	%	N	%	N	%
Complete	1358	59.1	273	50.9	36	12.3
Proximal	490	21.3	121	22.6	11	3.8
Flake Fragment	407	17.7	121	22.6	164	62.8
Red. Fragment	41	1.8	21	3.9	62	21.2
Totals	2296	100.0	536	100.0	293	100.0

the BF are very similar to those of the patterned tool experimental assemblage (Table 5.9), with somewhat higher proportions of complete flakes and proximal fragments, and a slightly lower proportion of flake fragments and reduction fragments. Examination of the 3D chart in Figure 6.11 suggests that the configuration of the line representing the BF archaeological assemblage of debitage closely approximates that of the composite patterned tool experimental assemblage for the four category SRT. This indicates that the BF locus assemblage of debitage was the result of patterned tool manufacture not bipolar reduction.

The *unstandardized canonical discriminant function coefficients* (Table 5.14), derived from the discriminant analysis of the experimental debitage, were used to calculate discriminant *z* scores for the BF debitage assemblage and for excavation units which contained 30 or more pieces. Data for each SRT (four categories) flake category was multiplied by its coefficient, with the products added together with the constant. The

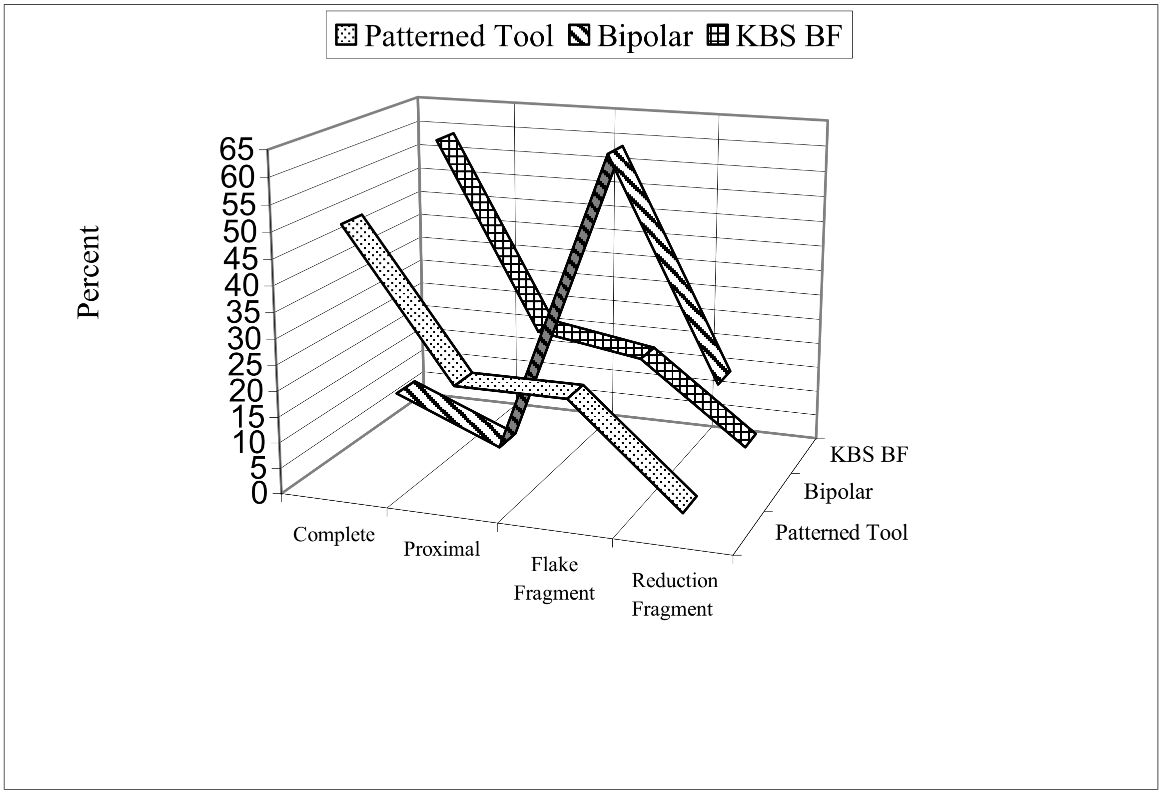

Figure 6.11. Proportions of SRT flake categories (4) for experimental patterned tool (biface and uniface), experimental bipolar reduction (Mohney 2004), and KBS beach face debitage assemblages (chert and jasper).

results of these calculations are presented in Table 6.37. Each discriminant *z* score was compared to the cutting score of .3575. Scores less than cutting score are classified as patterned tool manufacture, and those greater are classified as bipolar reduction. All individual units, and the BF debitage assemblage as a whole, were classified as the residue of patterned tool manufacture.

The results of the multivariate classification with discriminant analysis, and the similar proportions of the SRT (four) flake categories to those of the experimental patterned tool manufacture, strongly suggest that the manufacture of patterned tool (bifaces and unifacial scrapers) was the primary lithic activity at the BF locus of the KBS.

Table 6.37. Frequencies and Discriminant *Z* Scores for BF Debitage Assemblage and Excavation Units (≥30 pieces).

Assemblage	Complete N %	Proximal N %	Flk Frag N %	Red Frag N %	Totals	Discriminant *Z* Score
KBS BF	1358 59.1	490 21.3	407 17.7	41 1.8	2296	-79.9002
TR 1	89 56.0	34 21.4	33 20.8	3 1.9	159	-4.8955
TR 2	285 56.4	118 23.4	96 19.0	6 1.2	505	-17.23940
TR 3	79 59.0	31 23.1	23 17.2	1 0.7	134	-5.30070
TR 4	61 47.3	32 24.8	32 24.8	4 3.1	129	-2.99500
TR 5	20 57.1	10 28.6	5 14.3	0 0.0	35	-1.86200
TR 7	48 57.8	17 20.5	17 20.5	1 1.2	83	-2.78100
TR 9	34 54.0	19 30.2	8 12.7	2 3.2	63	-3.09470
TR 10	60 63.2	19 20.0	15 15.8	1 1.1	95	-3.96640
TR 11	19 63.3	9 30.0	2 6.7	0 0.0	30	-2.06820
TR 17	375 70.2	68 12.7	75 14.0	16 3.0	534	-20.41250
TR 18	27 55.1	11 22.4	11 22.4	0 0.0	49	-1.67770
TR 19	45 58.4	20 26.0	10 13.0	2 2.6	77	-3.64560
TR 20	28 56.0	12 24.0	10 20.0	0 0.0	50	-1.95150
TR 21	56 54.9	21 20.6	23 22.5	2 2.0	102	-2.87540
TU 2	33 48.5	20 29.4	15 22.1	0 0.0	68	-2.39310
TU 3	24 75.0	6 18.8	2 6.3	0 0.0	32	-2.11550
TU 7	27 50.0	15 27.8	12 22.2	0 0.0	54	-1.91920
TU 8	16 41.0	15 38.5	7 17.9	1 2.6	39	-1.76280

This does not preclude the fact that BP reduction may have taken place at the BF locus. Products of this reduction may have been removed from the site for use as expedient tools, further reduced, or simply accounted for less than 25 percent of the debitage (see page 198, *SRT Results*).

Biface and Uniface Manufacture. The strong indication of patterned tool manufacture derived from the proportions of SRT (four) flake categories, and the results of the discriminant classification of the BF debitage assemblage, permit further analysis to determine the proportions of biface and uniface manufacture. In this portion of the study, only chert and jasper debitage in the range of 6.4-25.4 mm in greatest dimension were analyzed.

The proportions of Platform Types/Dorsal Cortex Percentage (nine categories) are contained in Table 6.38. These proportions compared to those of the experimental biface

Table 6.38. Frequency of Platform Types/Dorsal Cortex % (9 categories) for BF Debitage.

Category	KBS BF N %
Cortex/0%	67 3.7
Cortex/1-50%	114 6.3
Cortex/51-100%	99 5.5
Flat/0% *	348 19.3
Flat/1-50% *	184 8.2
Flat/51-100% *	160 8.9
Faceted/0% *	602 33.3
Faceted/1-50% *	158 8.7
Faceted/51-100%	74 4.1
Totals	1806 100.0

* sig. at .95 CL for exp.bifaces and unifaces

and uniface manufacture (Table 5.28) present a somewhat confounding picture. The proportions for the archaeological assemblage are within the range of confidence intervals (Table 5.29) that suggest biface manufacture for three categories: Flat/0%, Faceted/0%, and Faceted/1-50%. However, in two of the categories, Flat/1-50% and Flat/51-100%, they are within the confidence intervals that suggest uniface manufacture. These results suggest no significant (.95 CL) differences between the KBS BF proportions for these categories and the tool types indicated. The proportions for the five significant categories of platform types/dorsal cortex percent for the debitage of the experimental tool types and the KBS BF are portrayed in Figure 6.12. The overall configuration of the line representing the archaeological assemblage is most similar to the line representing biface manufacture.

The excavation units that produced 100 or more pieces of debitage are studied to determine if there are intrasite differences in the tool production types. The proportions of Platform Types/Dorsal Cortex percentage categories are contained in Table 6.39.

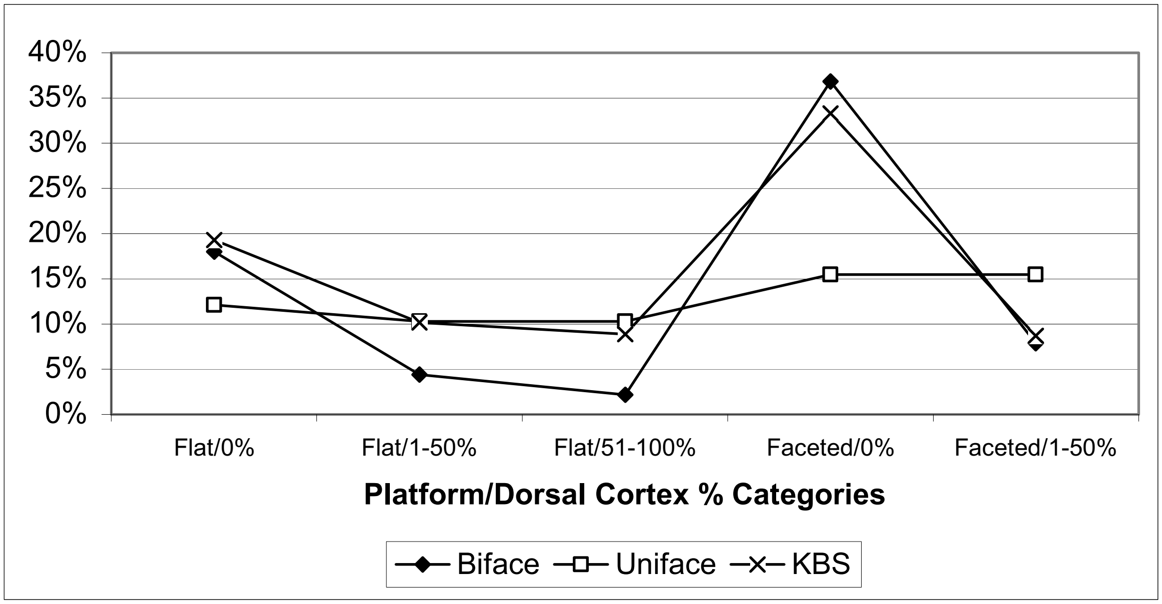

Figure 6.12. Proportions of platform/dorsal cortex% categories significant at the ≥ .95 CL for composite experimental biface and uniface and KBS debitage assemblages.

Table 6.39. Frequencies of Platform Types/Dorsal Cortex % (9 categories) for Debitage from Trenches 1, 2, 3, and 17 (≥100 pieces).

Category	Trench 1 N %	Trench 2 N %	Trench 3 N %	Trench 17 N %
Cortex/0%	3 2.5	12 3.0	1 1.0	19 4.4
Cortex/1-50%	8 6.6	19 4.8	5 4.9	35 8.0
Cortex/51-100%	11 9.0	13 3.3	5 4.9	26 6.0
Flat/0% *	17 13.9	69 17.3	19 18.4	101 23.2
Flat/1-50% *	17 13.9	31 7.8	12 11.7	42 9.6
Flat/51-100% *	15 12.3	30 7.5	10 9.7	35 8.0
Faceted/0% *	31 25.4	176 44.2	33 32.0	133 30.5
Faceted/1-50% *	13 10.7	33 8.3	13 12.6	31 7.1
Faceted/51-100%	7 5.7	15 3.8	5 4.9	14 3.2
Totals	122 100.0	398 100.0	103 100.0	436 100.0
* sig. at .95 CL for exp.bifaces and unifaces				

These proportions are shown with composite experimental biface and uniface assemblages and simulated biface/uniface assemblages proportions of 75:25, 50:50, and 25:75 (Table 5.30) in Figures 6.13, 6.14, 6.15, and 6.16. Examination of these figures for each of the units suggests an overall pattern similar to the total assemblage, with some differences.

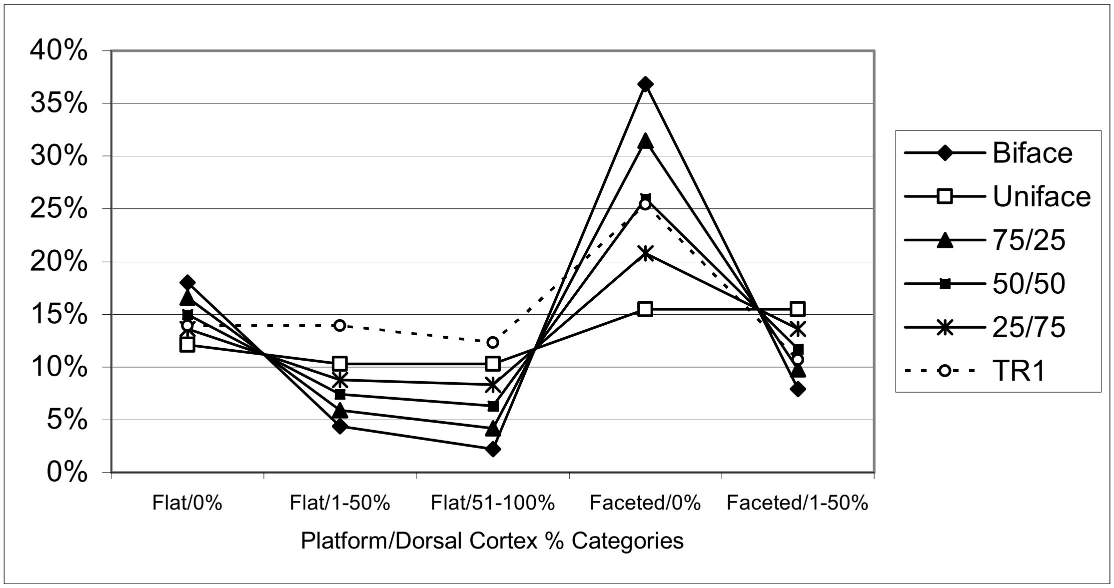

Figure 6.13. Proportions of platform/dorsal cortex % categories significant at .95 CL for debitage from Trench 1, experimental biface, uniface, and simulated mixed assemblages of biface and uniface.

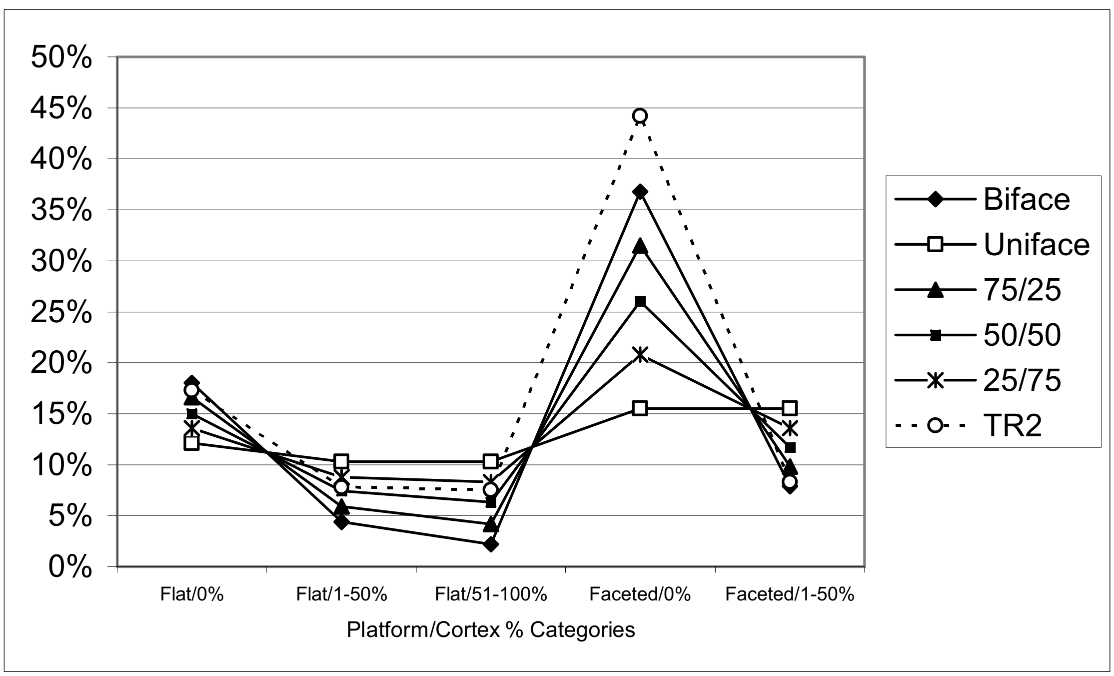

Figure 6.14. Proportions of platform/dorsal cortex % categories significant at .95 CL for debitage from Trench 2, experimental biface, uniface, and simulated mixed assemblages of biface and uniface.

The line for Trench 1 (Figure 6.13) is similar to proportions of the categories in the 50:50 simulated assemblage, suggesting equal amounts of debitage from both tool types. Trench 2 (Figure 6.14) appears to reflect mostly biface manufacture with a small percentage of uniface debitage (less than 25 percent). The configuration of the line (Figure 6.15) representing Trench 3 best approximates the proportions of the 75:25 simulated mixture of biface to uniface debitage. The proportions of Trench 17 (Figure 6.16) suggest primarily biface manufacture, with a lesser percentage of uniface manufacture, which is closest to the 75:25 ratio of simulated mixed assemblages. Individually, these four excavation units suggest that biface manufacture was the primary lithic activity, similar to the total assemblage pattern, with uniface manufacture representing lesser proportions. There exists the distinct possibility that flakes, especially those larger than 25.4 mm in greatest dimension, were removed from the BF locus to be utilized in another location, or further reduced to manufacture patterned tools. The morphology of the gravels utilized by the knappers of the BF locus is unknown. Although the experimental gravels were classified into four shapes, the experiment did not attempt to calculate any differences in chipped stone debris derived from these different shapes. Lastly, the BF debitage assemblage reflects many knapping episodes that were terminated for various reasons (see pages 302-303). Thus, the reduction of different gravel shapes, the removal of larger flakes, terminated knapping episodes, and initial processing at another area may be responsible for the proportions of platform/dorsal cortex percentage categories that strongly resemble both biface and uniface manufacture. It also must be considered that proportions derived from the experimental patterned tool manufacturing episodes may not accurately reflect real differences between the two tool types. Further experimentation may be required

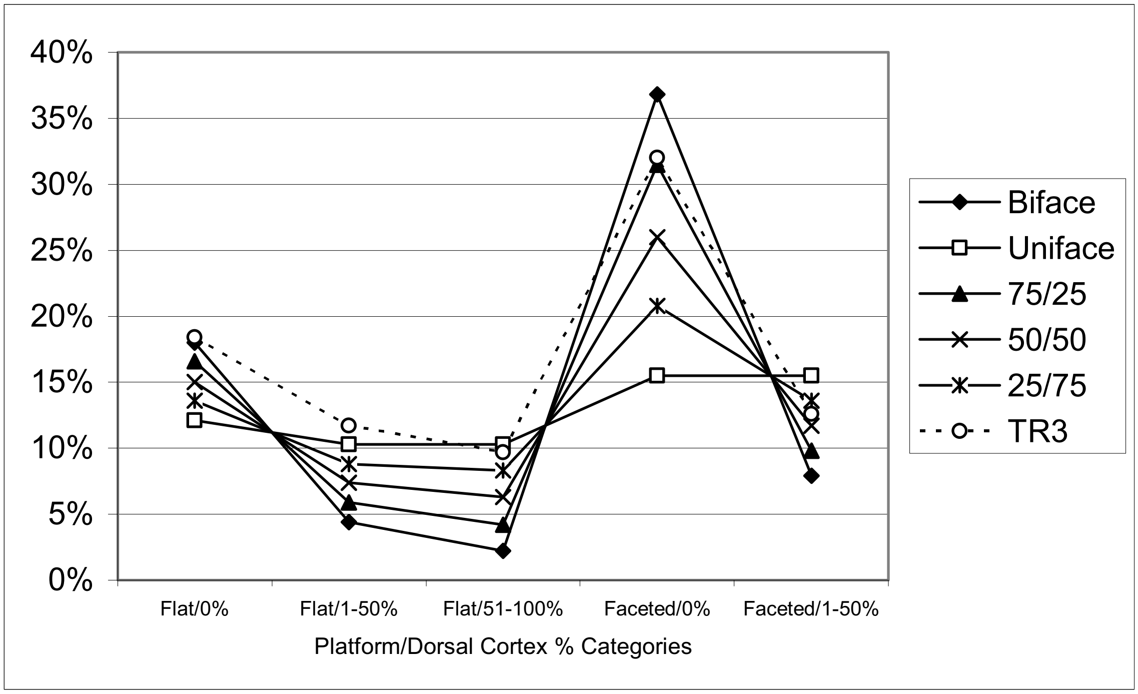

Figure 6.15. Proportions of platform/dorsal cortex % categories significant at .95 CL for debitage from Trench 3, experimental biface, uniface, and simulated mixed assemblages of biface and uniface.

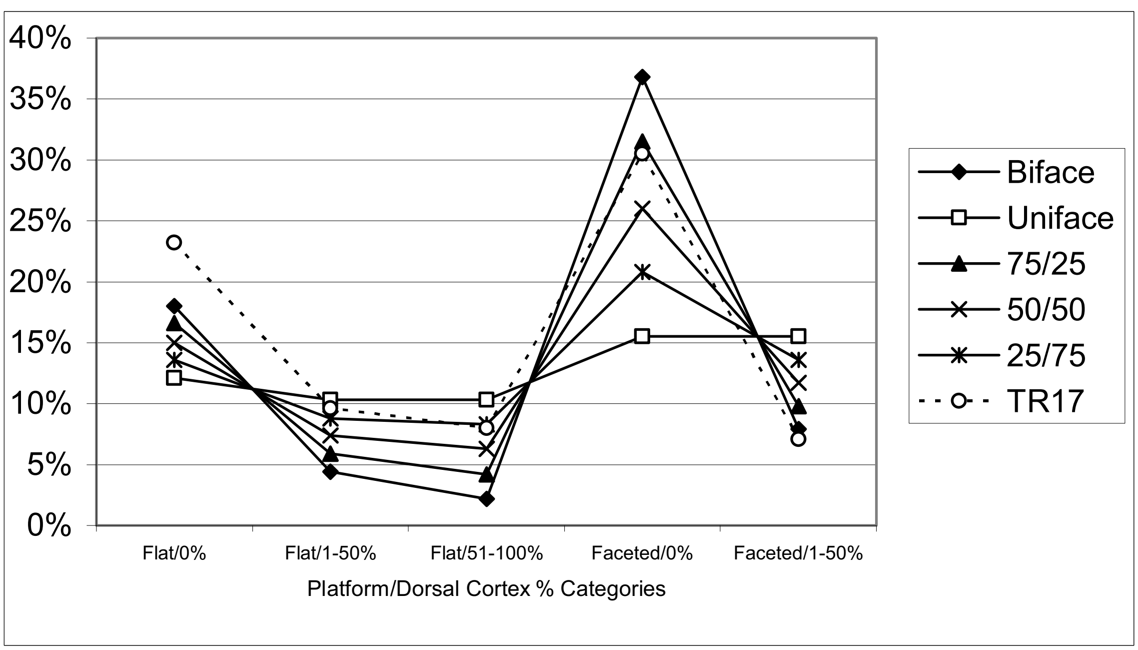

Figure 6.16. Proportions of platform/dorsal cortex % categories significant at .95 CL for debitage from Trench 17, experimental biface, uniface, and simulated mixed assemblages of biface and uniface.

to increase the sample size of debitage for biface and uniface manufacture, and to account for differences in gravel morphology.

In consideration of the above possibilities, the proportions of BF debitage in the categories of Flat/0%, Faceted/0%, and Faceted/1-50% suggest that biface manufacture was the primary lithic activity at the BF locus. The overall proportions indicate a lesser amount of uniface manufacture, which appears to be best represented by the 75:25 ratio of simulated mixed assemblages for bifaces and unifaces.

Biface Reduction Sequence. The somewhat confounding results of the effort to determine the relative proportions of biface and uniface manufacture led to the conclusion that any attempt to partition the BF debitage into three biface reduction stages would be problematic. That the MDA classification of flakes into experimental biface reduction stages could only satisfactorily identify the beginning and the end of the process (Blank and Preform II), but not the middle (Preform I), reinforced this uncertainty. The MDA correct classification results for Preform I were less than could be obtained by simply guessing (Tables 5.39, 5.40, and 5.41) that all pieces belonged to this stage. It is hoped that these results will provide a starting point for further experimentation, rather than provide a formula to partition the relative proportions of debitage from each stage.

Biface Manufacture Trajectory Length. The large component of biface manufacturing at the BF locus, as determined in the *Biface and Uniface Manufacture* portion of the study, and the success in identifying the beginning and end of the process, suggested that the biface manufacture trajectory length could be ascertained with some degree of certainty. The determination of the length of the biface reduction trajectory is more straightforward than the partition of the debitage into the three reduction stages. The identification of Blank and Preform II stages can provide evidence of the length of the reduction trajectory at the BF locus of the KBS. Given the process of reduction as it is known, it appears unlikely that the initial stage and last stage would be present and the middle stage absent.

The determination of the length of the reduction trajectory was approached by the employment of seven variables in a comparison between the archaeological assemblage of debitage and the composite experimental biface assemblage. These variables were found to be significant (.05 level) in delineating biface reduction stages. The variables are SRT (five categories), the presence or absence of dorsal cortex, the proportion of dorsal flake scars and platform/dorsal cortex percentage categories, the percentage of crushed platforms and lipped platforms, the proportion of size classes, and the frequency of debitage weighing 3.0 g or more. In this portion of the study, all size classes larger than 6.4 mm in greatest dimension of chert and jasper debitage were analyzed.

A graph of the proportions of SRT (five) flake categories of the BF debitage to the composite experimental biface debitage assemblage is shown in Figure 6.17. The lines are similar in configuration, but the BF debitage is 9.0 percent greater in complete flakes, and 7.5 percent less in split flakes. The later two stages of the BRS in the biface experiments produced 84.3 percent of the complete flakes, while split flakes were all produced in Blank (48.1 percent) and Preform I (51.9 percent), both of which were accomplished by hard hammer percussion. In the biface experiments, 17.1 percent of all flakes in the Blank stage were split flakes. If reduction in the Blank stage was completed elsewhere, split flakes would still account for 4.2 percent of the total flakes. This is six times the proportion found in the BF debitage. The mean of the nine bipolar experiments of Kuijt et al. (1995:Table 2) for split flakes was 1.6 percent, which is considerably less than the 8.1 percent for the biface experiments. Due to this incongruity, it does not appear

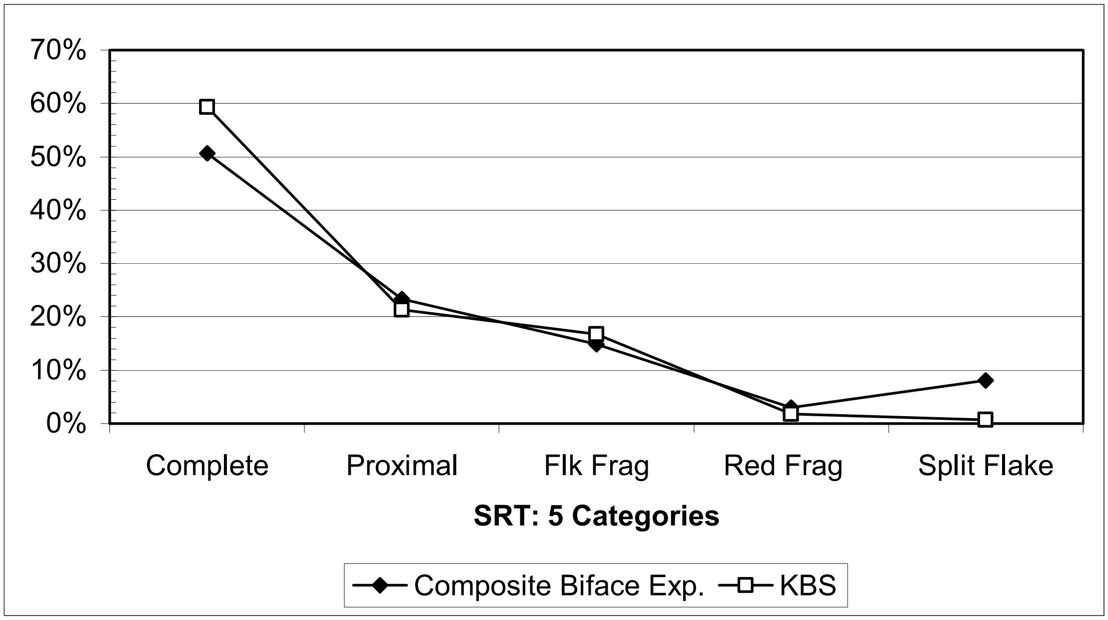

Figure 6.17. Proportion of SRT (5) flake categories for KBS BF and composite experimental biface assemblages.

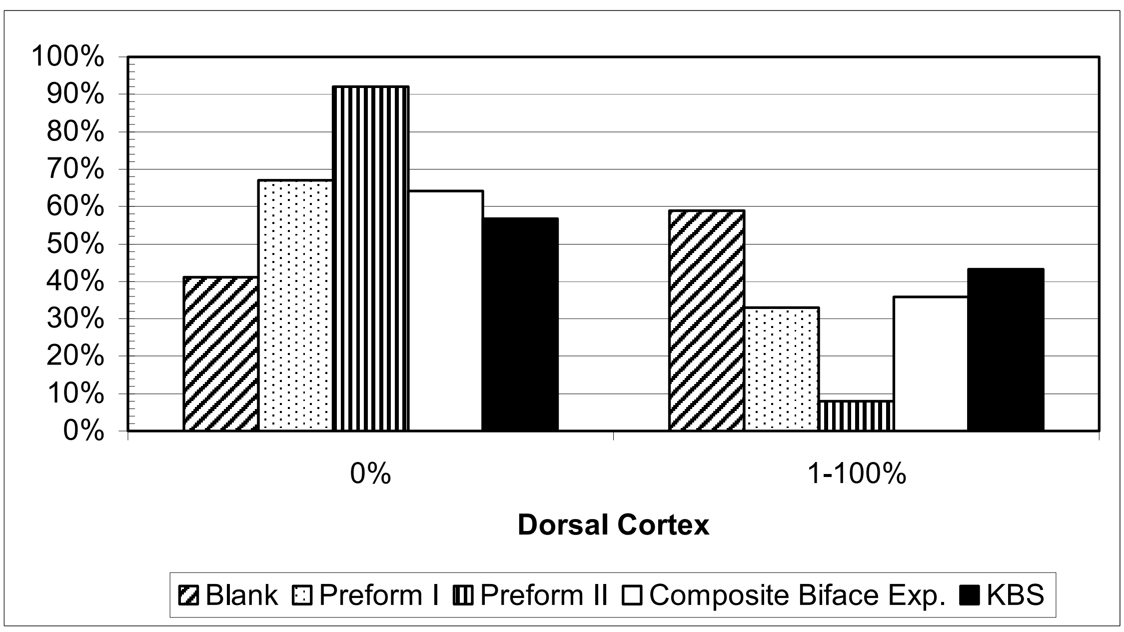

Figure 6.18. Proportion of debitage with dorsal cortex present and absent for KBS BF, composite biface experiments, and BRS stages for experimental bifaces.

that split flakes can be used as a reliable indicator of the presence of the earliest stage, Blank, to infer trajectory length. This relatively large proportion of split flakes in the biface experiments could be due to the raw material and gravel morphology, the knapper, or misidentification by the analyst. However, it is important to note that split flakes marked by longitudinal shearing are relatively easy to identify.

The proportion of flakes with some dorsal cortex decreases as the reduction of alluvial gravels proceeds from Blank to Preform II in biface manufacture, and conversely the proportion of debitage with no cortex increases as reduction proceeds. The two part dorsal cortex variable was chosen because it was significant for differences in BRS at the .05 level, and it is easy to assess. Examination of the BRS stages portrayed in Figure 6.18 readily supports this assertion. Some amount of cortex (one to 100 percent) is retained on 42.7 percent of the BF debitage, while 57.3 percent retains none. In the experimental biface assemblage 35.9 percent of the flakes retained some cortex, while 64.1 percent retained none. This relatively high proportion of dorsal cortex suggests a complete biface reduction trajectory at the BF locus.

The frequency of flakes with dorsal flake scars should increase as the reduction proceeds from Blank to Preform II, as successive flakes removals leave one or more scars on the dorsal surface. The proportions of flake scars categories are compared in Figure 6.19 for the debitage of the KBS BF locus (Table 6.40), composite experimental biface manufacture, and the BRS stages of experimental biface manufacture. The biface manufacture experiments lend support to the assertion that as reduction proceeds, the proportion of flakes with one or more dorsal flake scars increases. Preform II contains nearly three times the percentage of flakes with more than two scars, compared to two scars, and more than seven times that of flakes with one scar (Table 5.33). Debitage with

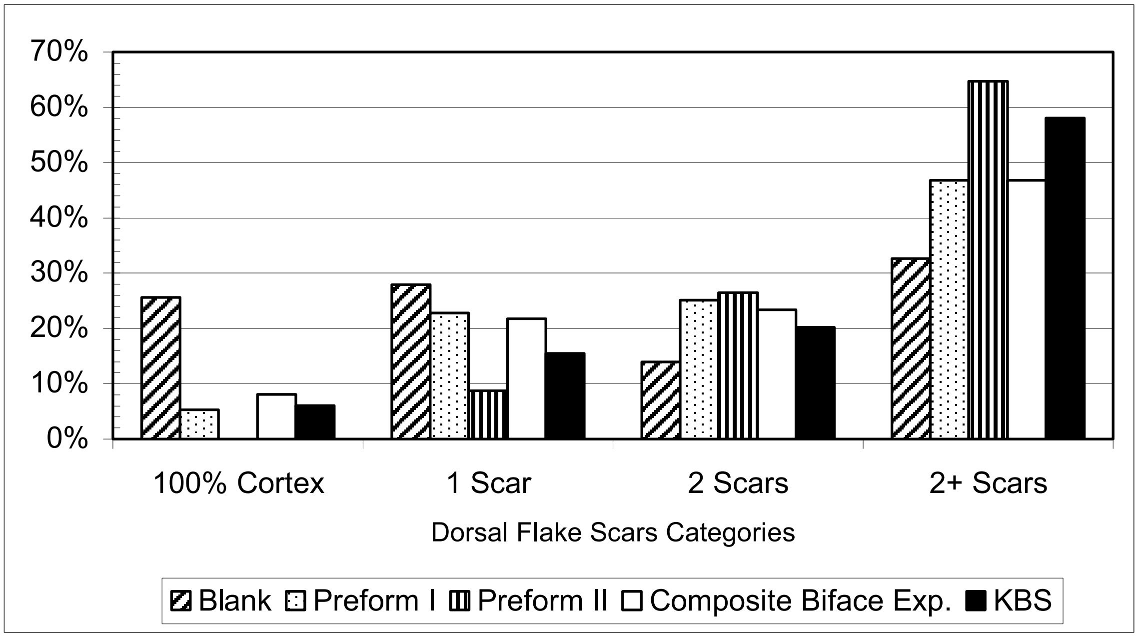

Figure 6.19. Proportion of debitage in dorsal flake scar categories for KBS BF, composite biface experiments, and BRS stages for experimental biface production.

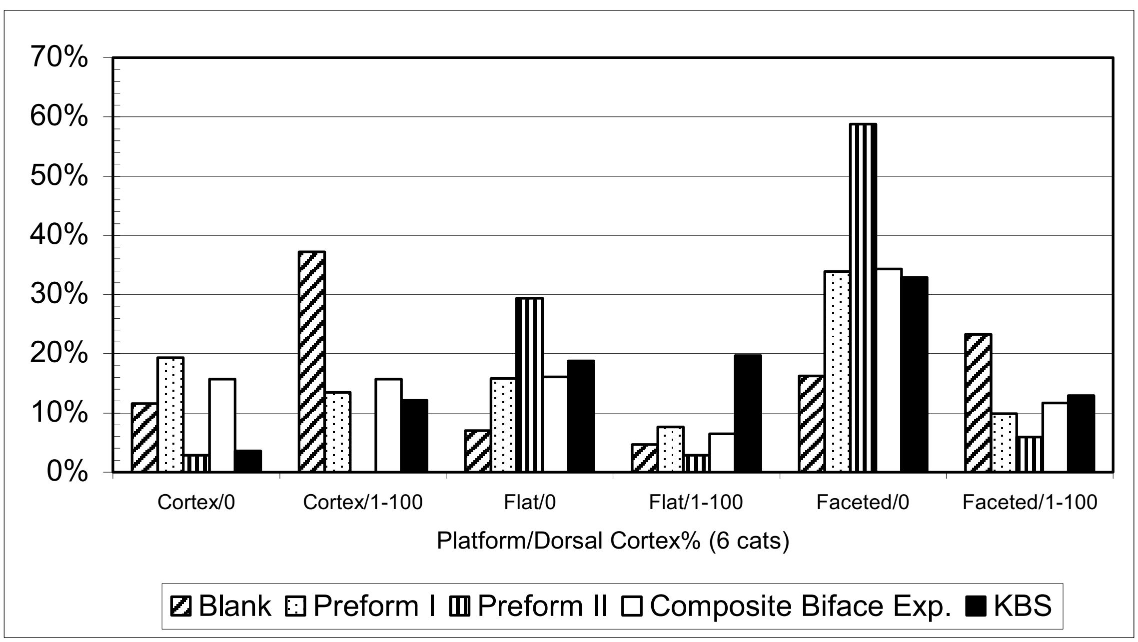

Figure 6.20. Proportion of debitage in the combined platform/dorsal cortex % (6) categories for KBS BF, composite biface experiments, and BRS stages for experimental biface production.

Table 6.40. Frequency of Dorsal Flake Scar Categories for BF Debitage (≥6.4 mm).

Category	KBS BF N %
100% Cortex	112 6.1
1 Scar	287 15.5
2 Scars	374 20.2
>2 Scars	1074 58.1
Totals	1847 100.0

100 percent dorsal cortex comprised 25.6 percent of the Blank stage pieces, while for Preform I it was only 5.3 percent, and for Preform II, zero percent. The problematic Preform I contained a large percentage of flakes with both two scars (25.1) and more than two scars (46.8). Preform I also contains the greatest proportion of total flakes at 69.0 percent. This argues for the necessity of dealing with populations of flakes, rather than attempting to place individual flakes into a BRS stage using this attribute. The overall pattern of dorsal flake scar distribution suggests a complete reduction sequence with perhaps somewhat less initial processing present.

The proportions of Platform/Dorsal Cortex (six categories) for the KBS BF debitage, the composite biface experiments, and the three experimental BRS stages are

Table 6.41. Frequency of Platform Type/Dorsal Cortex % (6 categories) for BF Debitage (≥6.4 mm).

Category	KBS BF N %
Cortex/0%	67 3.6
Cortex/1-100%*	223 12.1
Flat/0%	348 18.8
Flat/1-100%	364 19.7
Faceted/0% *	607 32.9
Faceted/1-100%	238 12.9
Totals	1847 100.0

* sig. at .95 CL for experimental BRS

shown in Figure 6.20. In the KBS BF assemblage, the proportions of the two categories significant at the .95 CL (see Table 5.33), Cortex/1-100% and Faceted/0%, were 3.6 and 1.4 percent less, respectively (Table 6.41), than the composite experimental biface assemblage. The greatest differences in proportions between the BF and the composite experimental biface assemblages were in the categories Cortex/0% (12.1 less) and Flat/1-100% (13.2 greater). Neither of these categories was considered significant (.95 CL) in the composite experimental biface assemblage for differences between BRS stages. The overall pattern for this attribute is suggestive of a complete reduction trajectory present at the BF.

The proportions of crushed platforms and platforms with lips for the KBS BF debitage are contained in Table 6.42. The lesser proportion (12.6 percent) of crushed platforms compared to the composite experimental biface assemblage, suggests that either early reduction in the form of the Blank stage is not as well represented

Table 6.42. Frequencies of Crushed Platforms and Platform Lips of KBS BF Debitage (≥6.4 mm).

Crushed Plt	N	%	Platform Lip	N	%
Present	772	41.8	Present	268	14.5
Absent	1074	58.2	Absent	1579	85.5
Totals	1847	100.0	Totals	1847	100.0

...

in the BF assemblage, and that later reduction, Preform I and II, are better represented. In the experimental assemblage, 83.7 percent of the flakes exhibited signs of platform crushing in the Blank stage, while in Preform II only 8.8 percent of the flakes exhibited platform crushing (Table 5.37). The proportions of crushed platforms for the KBS BF, composite experimental biface, and experimental BRS stage assemblages are portrayed in

Figure 6.21. The proportions of lipped platforms for the KBS BF debitage assemblage are found in Table 6.42. The difference in the proportions of the BF and experimental assemblages is less than .01 for this attribute. Lipped platforms were almost overwhelmingly (97.7 percent) found in the later two BRS stages of the experimental biface assemblage (Table 5.38). These results suggest a similar proportion of later stage reduction, Preform I and II, similar to the experimental biface assemblage.

The proportion of size classes 6.4-25.4 mm and combined 25.5-50 mm are presented in Table 6.43. The proportion of size classes 6.4-10 mm, 10.1-15 mm, and 20.1-25.4 mm are similar for the BF assemblage and the experimental assemblage (Figure 6.23). The greatest differences exist in size classes 10.1-15 mm and 25.5-50 mm. The BF assemblage was 12 percent larger for the 10.1-15 mm size class than the experimental biface assemblage, and smaller by eight percent in the combined 25.5-50 mm size class. The difference in the 10.1-15 mm size class is anomalous, in that the proportions of the other three size classes, equal to or larger than 25.4 mm in greatest dimension, are virtually identical. However, the 47.0 percent in this size class for the BF debitage is within the range of the biface experiments (18.4-64.0 percent). The proportion (1.9) of the combined class (equal to or larger than 25.5 mm in greatest dimension) of larger pieces for the BF debitage is not within the range of the experimental biface proportions (5.9-23.5). The proportions of the BF debitage, composite biface experiments, and BRS stages of the experiments for size classes are shown in Figure 6.23. In the biface manufacture experiments, 52.9 percent of the combined size class was found in the Blank stage (Figure 5.41). The proportions of the combined class found in the BF assemblage suggest that the Blank stage is relatively smaller in proportion than the corresponding

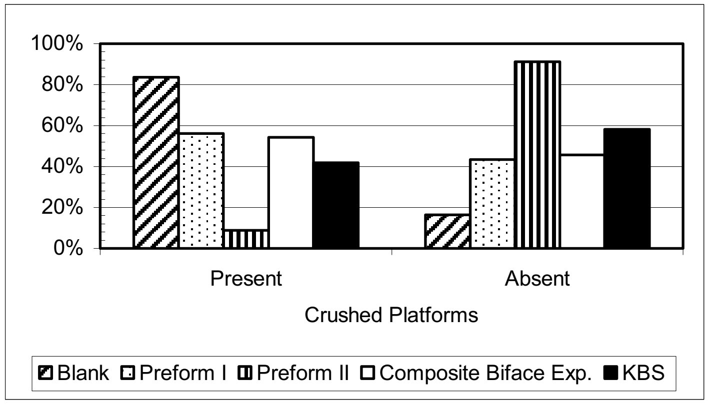

Figure 6.21. Proportion of presence and absence of crushed platforms on debitage for the KBS BF, composite biface experiments, and BRS stages for experimental biface manufacture (≥6.4 mm).

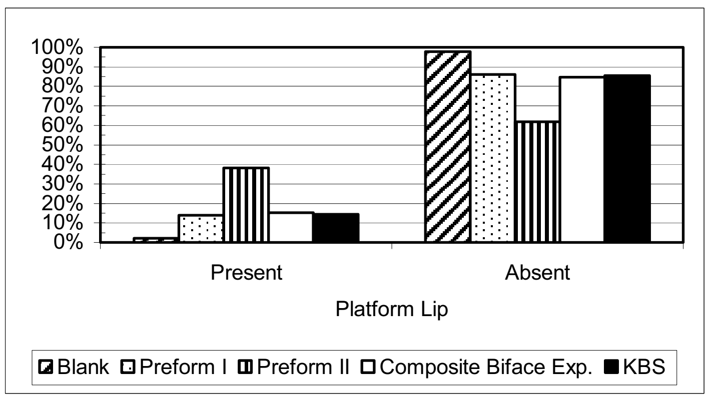

Figure 6.22. Proportion of presence and absence of platform lips on debitage for the KBS BF, composite biface experiments, and BRS stages for experimental biface manufacture (≥6.4 mm).

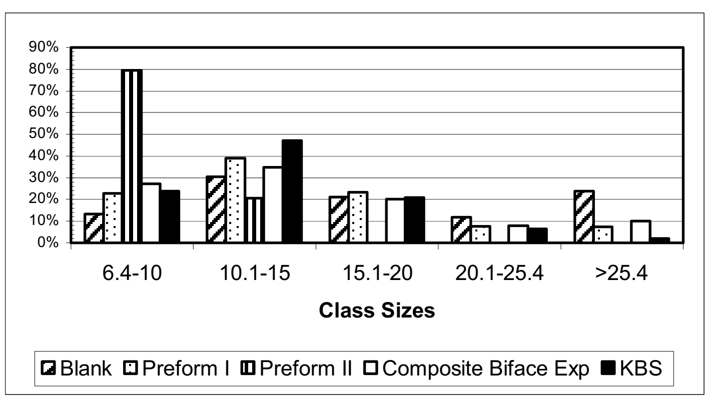

Figure 6.23. Proportions of size classes 6.4 - 25.4 mm (5 mm increments) and combined category 25.5 – 50 mm for the KBS BF, composite biface experiments, and BRS stages for experimental biface manufacture.

Table 6.43. Frequencies of Size Classes 6.4-25.4 mm (5 mm increments) with a Combined 25.5-50 mm Category.

Size Class (mm)	N	%	Cum.%
6.4-10	546	23.8	23.8
10.1-15	1076	47.0	70.8
15.1-20	478	20.9	91.7
20.1-25.4	147	6.4	98.1
25.5-50	44	1.9	100.0
Totals	2291	100.0	100.0

stage in the experimental biface assemblage or, again, that larger flakes were removed for other uses.

The proportion of weights represented in the KBS BF debitage assemblage is portrayed with a log scale Y axis in Figure 6.24. A vertical line marks the 3.0 g weight level. The proportion of pieces equal to or larger than 3.0 g for the BF assemblage is 1.1 percent (*n* = 25), compared to 6.0 percent (*n* = 20) for the experimental biface assemblage. In light of the differences in the proportions of pieces equal to or larger than 25.5 mm in greatest dimension, it is not unexpected. Unlike the experimental assemblage, not all

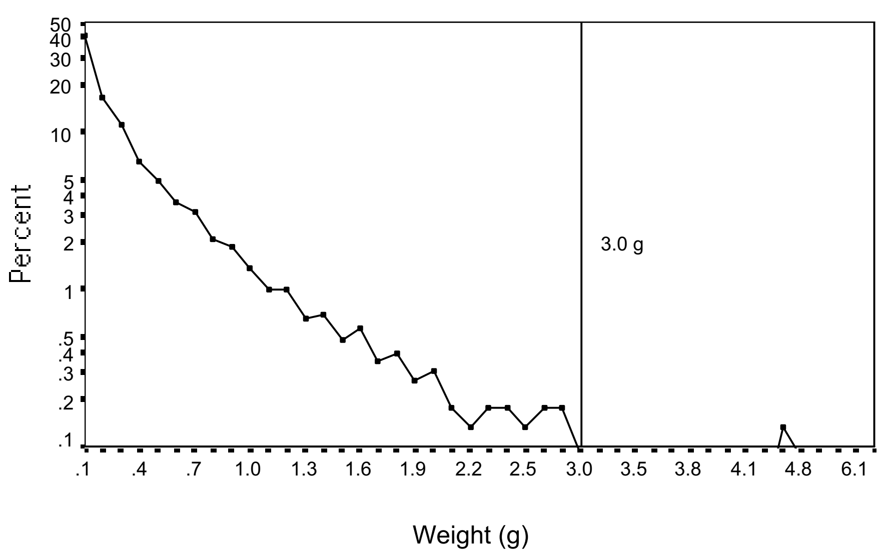

Figure 6.24. Proportional distribution of weights with log scale for KBS BF debitage (≥6.4 mm).

pieces equal to or larger than 3.0 g were found in the size class equal to or larger than 25.5 mm in greatest dimension. Five pieces (25.0 percent) were found in the next smallest size class 20.1-25.4 mm (Table 6.43). Additionally, the range of weights (3.0-7.2 g) for the BF debitage is not as great as the experimental biface debitage (3.0-13.8 g). Forty percent of the weights, equal to or larger than 3.0 g in the experimental assemblage, are larger than 7.2 g, with 75.0 percent (*n* = 6) of these pieces produced in the Blank stage. This evidence reinforces the suggestion from the size classes, that the Blank stage as constituted in the biface experiments is truncated in the BF assemblage.

The presence of special flake types, test flakes (*n* = 7) and bipolar flakes (*n* = 18), suggests that some initial processing took place at the BF area. Test flakes are struck off one end of a pebble to give the knapper a look at what is beneath the cortex (Mounier 2003: 71). Complete test flakes are spall-like in overall morphology, with an ovoid or semi-ovoid shape. The ventral surface is generally flat, rather than convex in cross-section. These flakes often exhibit crushing on the dorsal surface, with force or compression rings on the ventral surface emanating from the point of contact. The dorsal surface is generally covered with cortex, but often there are small flake scars, which indicate earlier blows that failed to detach the flake. The more elongated gravels of prolate, oblate, and blade shape appear to be the best candidates for this type of flake removal. The shape of the test flake generally resembles the small end of a bird’s egg. The gravel testing is usually accomplished by freehand. These BF test flakes are virtually indistinguishable from the flakes struck off to test gravels in order to determine the type and quality of raw material in the lithic collection phase of the study.

Bipolar flakes are generally of two forms at the KBS BF locus. The first type may be distinguished by signs of crushing at both the proximal and distal end, often with force or compression rings on the ventral surface radiating from these crushed areas. The second type is a citrus shaped flake, which resembles a section of an orange with two ventral surfaces and a cortex covered dorsal surface (See Figure 5.18, B).

Test flakes and bipolar flakes, although relatively small in number, are strongly suggestive of some initial processing at the BF. It must be noted that although the pattern of debitage is strongly suggestive of patterned tool manufacture, some bipolar reduction of gravels for useable flakes cannot be ruled out. It is possible that the bipolar flakes are the residue of that activity, rather than the initial bipolar processing of gravels for patterned tool production.

In addition to test flakes and bipolar flakes, a small number (*n* = 18) of flakes with rounded or worn platforms were found in the assemblage. These flakes are thought to be an indicator of biface resharpening or rejuvenation activities (Johnson 1989:21). This would represent a final stage in the reduction sequence prior to discard.

In summary, the analysis of the BF debitage to ascertain the length of the biface reduction trajectory was somewhat mixed, but overall it is suggestive of a complete biface reduction trajectory for alluvial chert and jasper gravels. The proportions of dorsal cortex presence, dorsal flake scar counts, and platform/dorsal cortex (six categories) as compared to the composite biface experiments, suggest a complete reduction trajectory from Blank to Preform II. The lesser proportions of BF pieces equal to or larger than 25.5 mm in greatest dimension, and equal to or larger than 3.0 g than the composite biface experiments assemblage, are suggestive of a more limited amount of initial bipolar reduction to produce either split pebbles or flake blanks. The lesser proportion of crushed platforms in the BF assemblage also may be interpreted as less initial reduction than is represented by the experimental assemblage. The proportion of lipped platforms, which is similar to the experimental assemblage, is suggestive of Preform II reduction. The presence of test flakes and bipolar flakes are indicators of the initial reduction of gravels in the Blank stage. Flakes with rounded or worn platforms, considered to be resharpening flakes, are suggestive of a last step in the biface reduction sequence prior to discard.

The indication of less initial processing of the alluvial gravels at the BF locus may be attributed to a portion of the initial processing of gravels conducted off site, further reduction of larger and heavier pieces to manufacture tools or produce expedient flakes, removal of larger pieces for use at another location, or some combination of these behaviors. The more complete reduction of larger pieces would explain the higher proportion of dorsal cortex than in the experimental assemblage. However, due to their morphology, not all larger and heavier pieces are good candidates for further reduction. Overall, the analysis of the selected nominal, ordinal, and ratio attributes of the debitage, and the presence of special flake types, are strongly suggestive of a complete biface reduction trajectory at the BF locus of the KBS, with some likelihood that a portion of the initial processing was conducted off site. It also may be concluded that analysis of debitage in the absence of CSA specimens can be used to determine the length of a biface reduction trajectory with alluvial chert and jasper gravels as the lithic raw material.

Heat Treatment. It was determined by visual inspection that 20.2 percent of the chert and jasper debitage from the BF locus was purposefully heat treated. In this portion of the study, the occurrence of heat treatment is placed within the biface reduction cycle, and the differences in how chert and jasper were processed in regards to heat treatment are explored. All size classes (6.4-10, 10.1-15, 15.1-20, 20.1-25.4, and the combined size class of equal to or larger than 25.5 mm in greatest dimension) of debitage were analyzed in this portion of the study.

The proportion of heat treated jasper debitage (49.7) is more than three times larger than the chert debitage (15.9). This difference is shown in Figure 6.25, along withreference lines for the mean presence and absence of thermal alteration for the combined chert and jasper debitage. The difference in the proportion of thermally altered chert and jasper debitage is highly significant (X^2 = 251.5715, df = 1, Sig.= .00000 <.05, V = .3314). The proportions of SRT (four categories) pieces used to classify the debitage population into the residue of patterned tool manufacture or bipolar

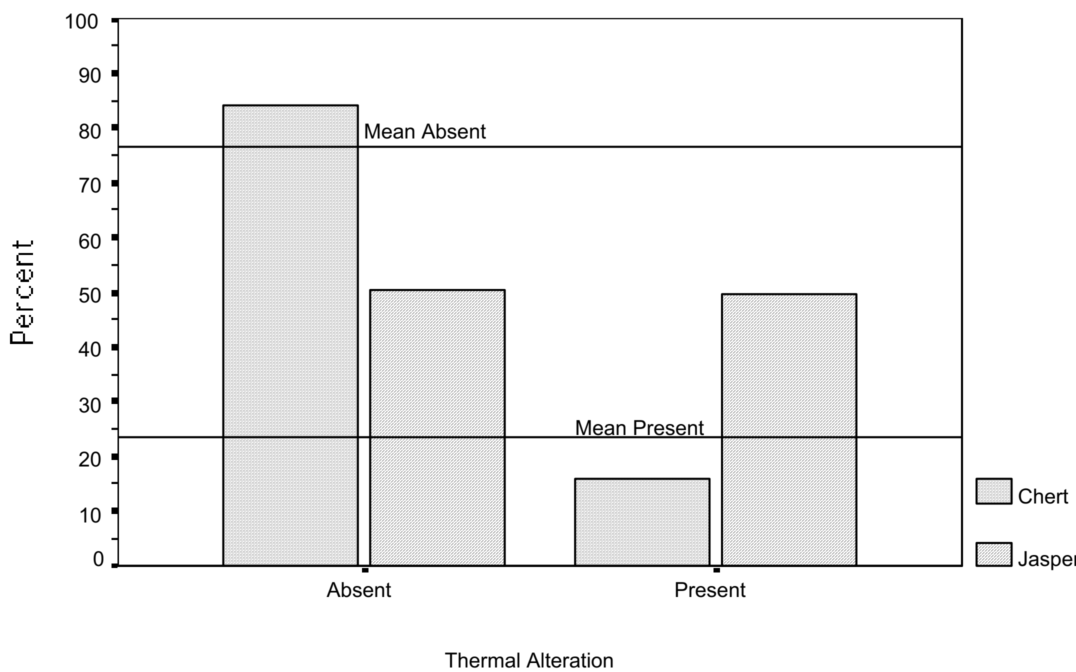

Figure 6.25. The proportions of thermally altered chert and jasper debitage compared to the mean presence and absence of this attribute in the combined BF chert and jasper debitage assemblage (≥6.4 mm).

reduction were calculated for chert and jasper pieces. A Kolmogorov-Smirnov two sample test indicated that the differences in proportions between the two lithic materials are not considered significant (K-S Z = .216, 2-tailed P =1.000 >.05, greatest absolute difference = .1083). It is concluded that the SRT proportions of these two raw materials, whether they are considered individually or combined, represents patterned tool manufacture. For the purpose of this portion of the study, they will be treated as one assemblage.

The seven variables demonstrated to have value in the determination of the length of the biface reduction trajectory (pages 272-277) were subjected to a series of chi-square tests, to determine if any significant differences existed between TA chert and jasper pieces for these variables. The test results are presented in Table 6.44. The only variable considered significant (.05 level) is that of the presence or absence of remnant dorsal

Table 6.44. Chi-Square Tests of Variables Indicative of Length of Biface Reduction Trajectory for Thermally Altered Chert and Jasper BF Debitage.

Variable	X^2	DF	Significance
Cortex (2 Cats.)	9.2981	1	.0023*
Dorsal Flake Scars	2.7604	3	.4301
Plat. Types (3 Cats.)	2.2550	2	.3081
Plat/Cortex% (6 Cats)	8.0763	5	.1521
Size Classes (6.4 - ≥25.5 mm)	4.0990	4	.39277
Platform Crushing	.6203	1	.4310
Platform Lip	.7440	1	.3884

* significant at ≤.05.

cortex. The proportion of TA jasper debitage that retained some cortex is 24.6 percent (61/248 pieces), while 36.9 percent of TA chert pieces (86/252 pieces) retained some cortex. Debitage, which showed no visible signs of thermal alteration, contained even larger proportions of pieces, with some dorsal cortex for both chert (49.6 percent, 730/1471 pieces) and jasper (34.1 percent; 86/252 pieces). The TA and non-TA proportions of pieces that retained some dorsal cortex are both within the range (20.0 - 54.5 percent) of the nine biface manufacture experiments, but the jasper proportions are less than the experimental mean of 35.9 percent (Figure 6.26). This difference in the proportions between the two raw materials for the presence and absence of dorsal cortex may be the result of more jasper reduced off site, and/or jasper imported from outside the site catchment area. Importation of jasper gravels is possible, but unlikely because high-quality jasper gravels may be easily found along the Delaware Bay margins. Greater reduction of jasper than chert off site would only appear to make sense if it was explained by some cultural belief, tradition concerning jasper, or a preference for the color of

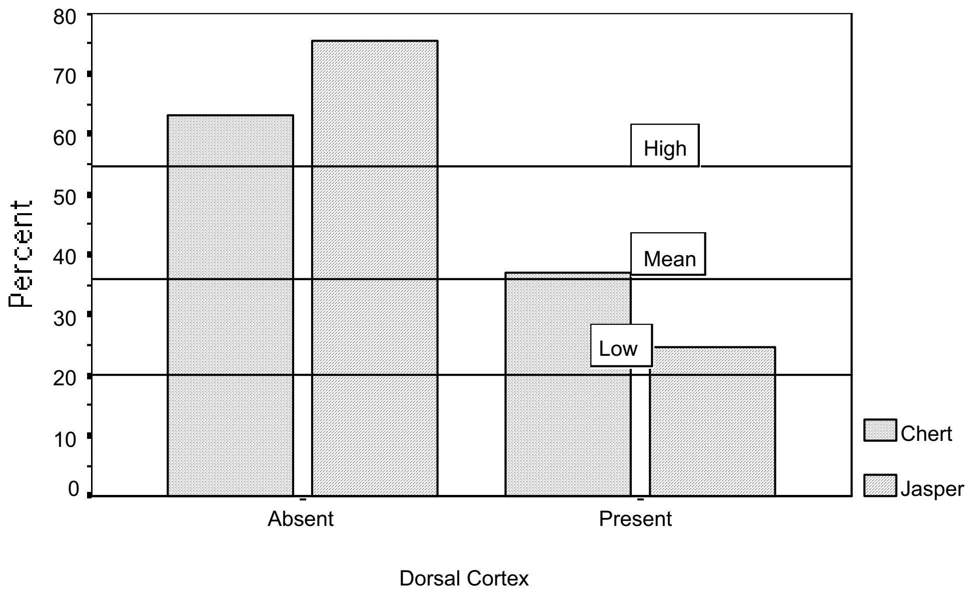

Figure 6.26. Proportions of the presence and absence of dorsal cortex for TA chert and jasper debitage compared to reference lines indicating the mean and range of the presence of remnant dorsal cortex for experimental biface manufacture episodes.

stone used to make tools. It is beyond the scope of this study to pursue this line of inquiry. It has been suggested (Jack Cresson, personal communication 2008) that jasper tends to be found in smaller packages than chert in alluvial gravels, hence, it retains less cortex. This appears to be a common occurrence in the gravel-based lithic technology on the coastal plain of New Jersey. For this study, the chert and jasper assemblage of TA debitage will be treated as one composite assemblage, except for the presence/absent of dorsal cortex.

The relatively low proportion of jasper debitage with some remnant cortex suggests that heat treatment was applied at some point in the biface reduction trajectory, after a gravel was split or reduced to flake blanks. Heat treatment of chert may have been accomplished earlier in the BRS than jasper. The proportions of pieces with some remnant cortex is still large enough (more than 15 percent; see Ranere and Ressler 1981:Table 1) to suggest an alluvial gravel origin, but for jasper it is less than the mean of the experimental biface manufacture episodes.

The seven variables (Table 6.44) deemed to be useful in the determination of the biface reduction trajectory length were subjected to chi-square tests to ascertain the significance of the differences between TA and non-TA combined chert and jasper debitage assemblages. The results of these tests are presented in Table 6.45. Four of

Table 6.45. Chi-Square Tests of Variables Indicative of Length of Biface Reduction Trajectory for Thermally Altered and Non-thermally Altered Combined Chert and Jasper Debitage Assemblage.

Variable	X^2	DF	Significance	V
Cortex (2 Cats.)	43.2918	1	.00000*	.1387
Dorsal Flake Scars	34.2227	3	.00000*	.1361
Plat. Types (3 Cats.)	17.1146	2	.00019*	.0963
Plat/Cortex% (6 Cats)	45.5594	5	.00000*	.1536
Size Classes (6.4 - ≥25.5 mm)	4..7187	4	.3174	____
Platform Crushing	.1.7052	1	.1916	____
Platform Lip	.5527	1	.45721	____

* significant at ≤.05.

attributes, presence/absence of dorsal cortex, dorsal flake scars, platform types (three), and platform types/dorsal cortex (six categories), were significant (.05 level) for differences in the proportions between BF TA and non-TA combined chert and jasper assemblages.

The proportion of dorsal flake scar categories for the combined BF chert and jasper assemblage is contained in Table 6.46. A comparison of the proportion of dorsal flake scar categories, compared to the mean of three or more scars for the composite

Table 6.46. Proportions of Dorsal Flake Scar Categories for TA Combined BF Chert and Jasper Assemblage.

Category	%	N
100% Cortex	2.6	11
1 Scar	12.1	52
2 Scars	15.6	67
≥3 Scars	69.7	299
Totals	100.0	429

biface manufacture experiments, and for Preform II of the same assemblage, is shown in Figure 6.27. The TA debitage assemblage from the BF is greater by 21 percent than the mean for the composite biface experiments, and greater by five percent than the

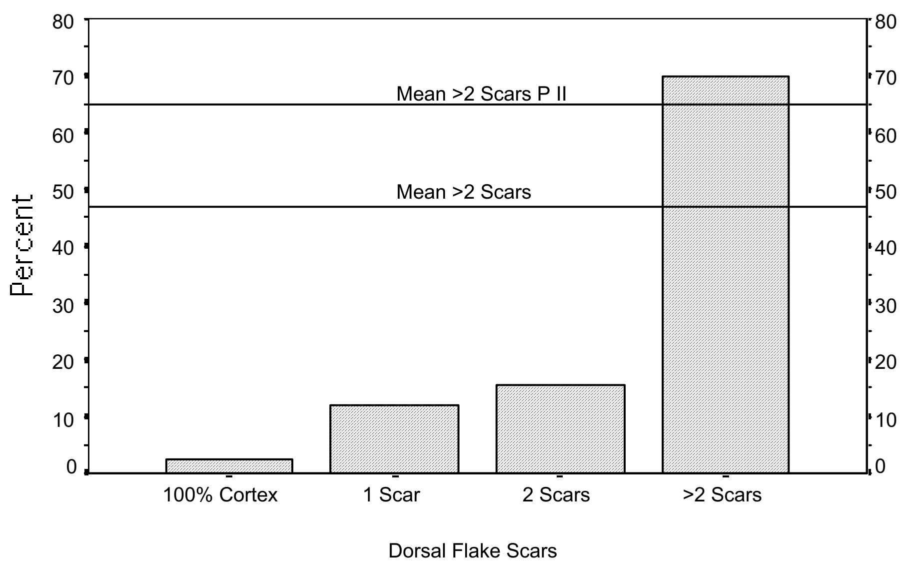

Figure 6.27. Proportions of dorsal flake scar categories for TA combined BF chert and jasper debitage assemblage. Reference lines indicate mean of category >2 scars for nine biface experiments and all experimental Preform II.

mean for Preform II for this category. The proportions for the categories 100% cortex, one scar, and two scars are relatively smaller than the proportions (see Table 5.33) for the composite biface experiments (lesser by 5.5, 9.7, and 7.8 percent respectively). These results suggest that heat treatment was applied after the initial Blank stage, because three or more scars is strongly indicative of Preform II debitage.

Table 6.47. Proportions of Platform Types (3 categories) for TA Combined BF Chert and Jasper Debitage Assemblage.

Category	%	N
Cortical	12.1	52
Flat	33.6	144
Faceted	54.3	233
Totals	100.0	429

The proportions of platform types (three categories) are contained in Table 6.47. The relatively lesser proportion of cortical platforms (12.1), compared to the composite biface experiments (31.5) and the relatively greater proportion of flat (33.6 to 22.6 percent) and faceted platforms (54.3 to 46.0 percent), for TA debitage are indicative of later stage biface reduction.

Figure 6.28 presents the proportions of the three platform types, compared to the means of the composite biface experiments proportions for these attributes, and the mean for faceted platforms for Preform II. These comparative proportions suggest that heat treatment was applied after the initial Blank stage.

The variable of platform type/dorsal cortex (six categories) was examined for the combined TA chert and jasper debitage recovered from the BF (Table 6.48). The relative differences between the BF debitage and the composite biface experiments for the two categories are significant at the .05 level, Cortex/1-100% and Faceted/0%, should provide an indication of the stage at which heat treatment was applied. The TA debitage from the

Table 6.48. Proportions of Platform Type/Dorsal Cortex (6) Categories for the TA Combined BF Chert and Jasper Assemblage.

Category	%	N
Cortex/0%	4.0	17
*Cortex/1-100%	8.2	35
Flat/0%	20.5	88
Flat/1-100%	13.1	56
*Faceted/0%	43.8	188
Faceted/1-100%	10.5	45
Totals	100.0	429

* significant at ≤.05.

BF is approximately half (8.2/15.7 percent) of the proportion of Cortex/1-100% for the biface experiments, but is relatively greater by 9.5 percent (43.8 to 34.3) for the category Faceted/0%. This relationship is portrayed with reference lines superimposed for the means of Cortex/1-100% and Faceted/0% of the composite biface experiments in Figure

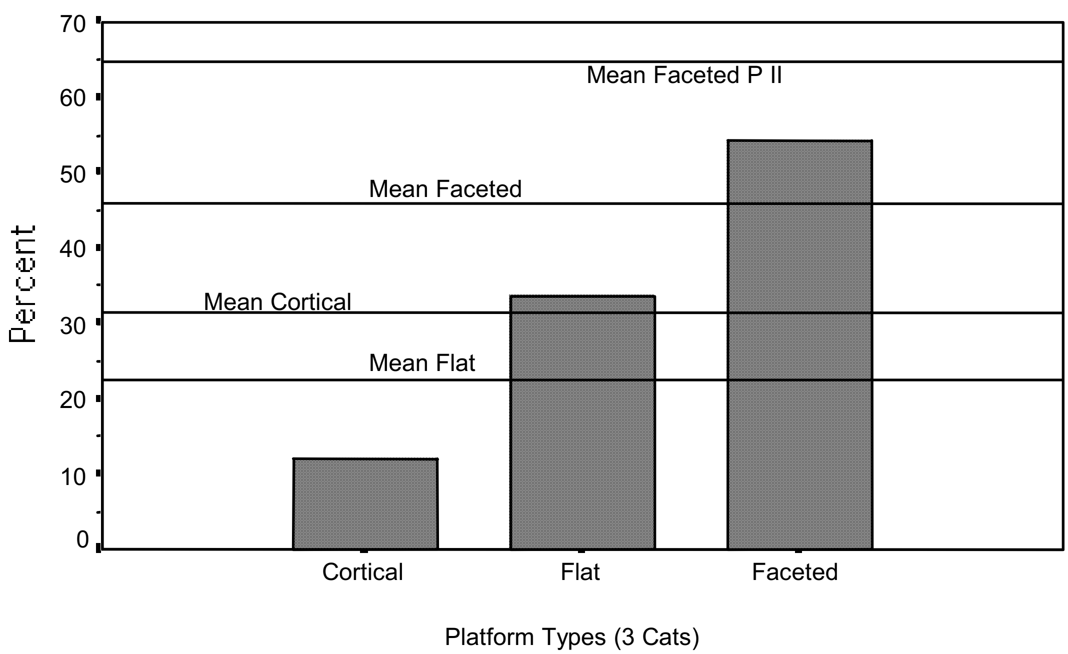

Figure 6.28. Proportions of platform types (three categories) for TA combined BF chert and jasper debitage assemblage. Reference lines indicate mean for the three categories of nine biface experiments and the mean faceted for experimental Preform II.

6.29. Again, the proportions of this attribute suggest that heat treatment was accomplished in a later stage than Blank.

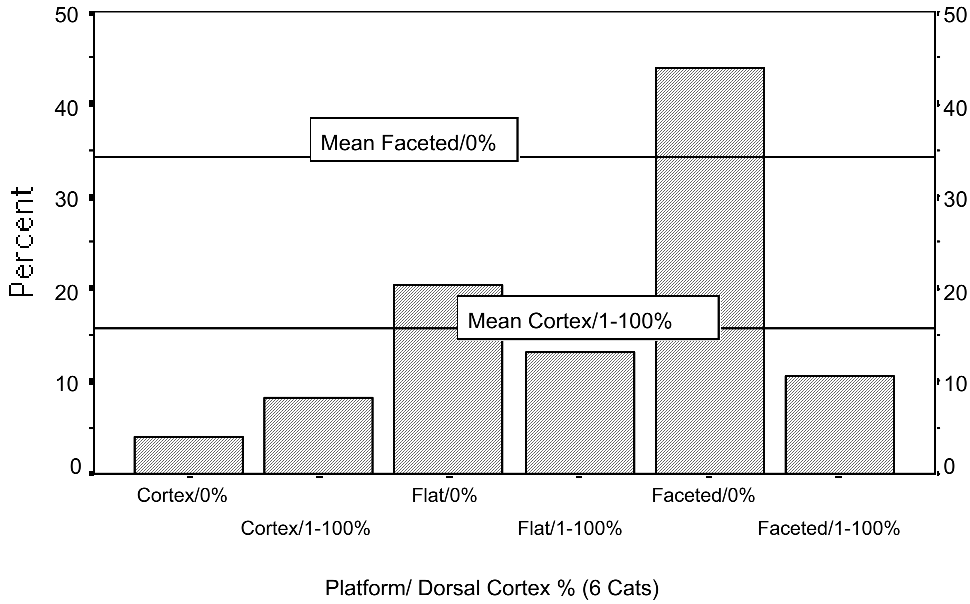

Figure 6.29. Proportions of platform types/dorsal cortex (6 cats.) for TA combined BF chert and jasper debitage assemblage. Reference lines indicate the mean for Cortex/1-100% and Faceted/0% for nine biface experiments.

Prior to the comparison of the TA debitage from the BF to the composite biface experiments for weight, the BF chert and jasper TA debitage were compared for this attribute by a *t* test. The result of this *t* test indicates that TA chert and jasper debitage are fairly likely the same for this attribute (*t* - value = .94, df = 535, 2-tailed-sig = .345 >.05, equal variances). As a result, the assemblage of TA debitage of the two lithic materials were combined for analysis of this attribute.

Summary data for the weight of the TA debitage from the BF and the debitage of the composite biface experiments is presented in Table 6.49. The lower mean and smaller standard deviation of BF debitage than the biface experiments are a direct result of the smaller number of larger (equal to or larger than 3.0 g) pieces than the biface experiments. The identical medians are reflective of the predominance of lower weights

Table 6.49. Summary of Data for Weight (g) of Thermally Altered BF Debitage and Composite Biface Manufacture Experiments.

Assemblage	N	Mean	Median	SD	Range
BF Debitage	537	.407	.200	.572	.1-5.5
Biface Exps.	335	.774	.200	1.655	.1-13.8

(.1 and .2 g pieces) in both assemblages. The greater range of weights for the biface experiments compared to the BF debitage suggests more complete reduction of TA material on the BF, or that initial reduction was conducted off site.

The combined TA chert and jasper debitage recovered from the BF by weights is portrayed in Figure 6.30, with a log percent scale and a reference line at 3.0 g. The

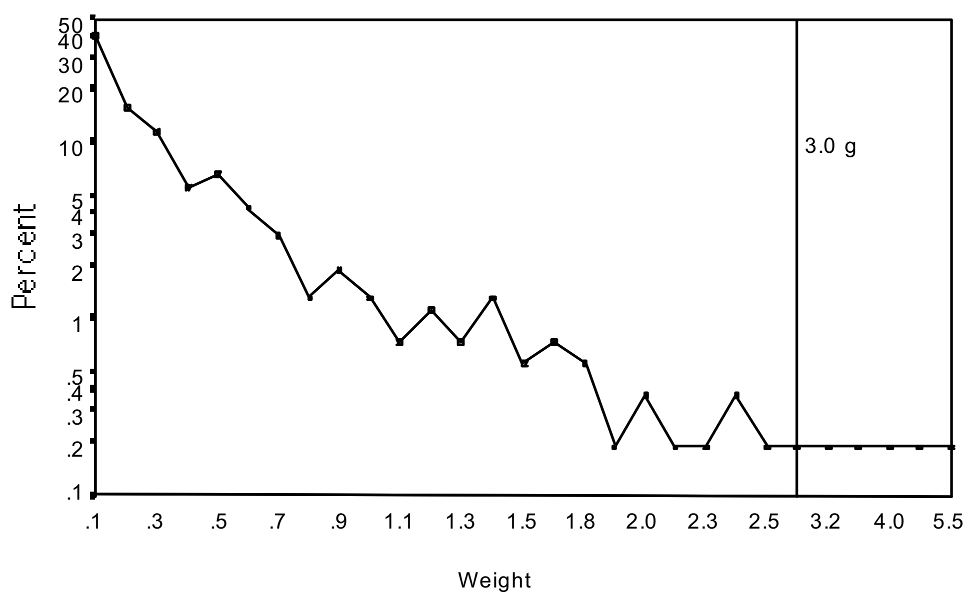

Figure 6.30. Proportion of weights for TA chert and jasper debitage from the BF with log percent scale.

proportion of these larger pieces is 1.1 percent of the total assemblage of TA debitage, which is approximately one-fifth of the proportion of larger pieces in the biface experiments (6.0 percent). The total weight of the larger pieces in TA debitage recovered from the BF is 24.46 g, or 11.2 percent of the total for these pieces (278.3 g). These larger pieces comprised 50 percent of the total weight in the experimental biface assemblage. The larger (equal to or larger than 3.0 g) pieces of debitage are indicative of the Blank stage of biface reduction, which suggests that this stage is less well represented among the BF chert and jasper TA debitage.

Overall, to place the heat treatment of the chert and jasper debitage from the BF in the biface reduction trajectory would be inexact, and no more than an interpolation based on the analysis of the variables just discussed. However, it is clear that heat treatment was accomplished somewhat later in the reduction trajectory than the Blank stage. It appears most likely that heat treatment was applied in the later portion of Preform I, after much of the cortex was removed and a majority of thinning accomplished, or in preparation for pressure flaking in Preform II. The results of the variable analyses are suggestive of a considerably larger proportion of Preform II debitage among the TA debitage recovered from the BF, as compared to the experimental biface episodes.

Classification of Hard Hammer and Pressure Flakes. This portion of the study provides an example of how the results of the discriminant analysis could be used to classify hard hammer and pressure flakes. The relatively small sample (*n* = 42) of pressure flakes (PRB's only) used to produce the classification matrix precluded testing of the external validity of the discriminant function. The following results must be viewed with caution, no matter how intriguing the outcomes.

Classification of flakes from the BF was accomplished by multiplying the individual flake data for each variable by the *unstandardized canonical discriminant function coefficients* (Table 5.52), and adding the results to the constant. The variables used in the classification were crushed platform, platform lip, length, maximum width, platform width, platform/dorsal cortex categories (six), platform width, and weight. Only chert and jasper pieces 6.4-25.4 mm in greatest dimension were considered. Discriminant analysis considers only those cases that contain data for each independent variable, so in effect only PRB flakes were considered. Table 6.50 contains the classification results for the flakes of the composite biface experiments, KBS BF locus, and four excavation units with a count of 100 or more flakes.

Table 6.50. Frequency of Hard Hammer (HH) Flakes and Pressure Flakes (PF) of Biface Experiments, BF Assemblage, and Excavation Units (≥100 pieces of debitage) Classified by Discriminant Function (chert/jasper: 6.4-25.4 mm).

Assemblage	HH		PF		Totals*	
	N	%	N	%	N	%
Biface Exps.	178	80.9	42	19.1	220	73.1
KBS BF	1156	64.0	650	36.0	1806	81.4
Trench 1	88	72.1	34	27.9	122	6.8
Trench 2	226	56.8	172	43.2	398	22.0
Trench 3	64	62.1	39	37.9	103	5.7
Trench 17	291	66.7	145	33.3	436	24.1

*PRB flakes only; % of total flakes in assemblage.

If the disciminant function is assumed to be valid, then the proportion of pressure flakes in the BF assemblage (36.0 percent) is more than twice that of the experimental biface manufacture (15.6 percent). These classification results suggest a greater proportion of Preform II reduction at the BF than would be expected based on the experimental biface manufacture data. It would also seem to confirm conclusions about the length of the biface reduction trajectory (see pages 368-369). The results of the discriminant analysis function classification of pressure flakes indicates that 94.7 percent were in size classes 6.4-10 mm and 10.1-15 mm, compared to 57.3 percent of the classified hard hammer flakes. These results were similar to the biface experiments, in which 100.0 percent of the pressure flakes and 63.4 percent of the hard hammer flakes were in these two size classes. This is not surprising, considering the data in the independent variables for the biface experiments were used to develop the discriminant classification function. Generally, in any comparison of the classified flakes in the BF assemblages to the biface experiments for any common attribute, there will be a close correspondence.

The preceding is an example of how the classification of HH flakes and PF's could be accomplished with discriminant analysis. Due to the relatively small number of pressure flakes, an external validation of the discriminant function could not be undertaken, although the number of flakes was considered sufficient to conduct a DA (Hair et al. 1995:195). Based on the proportion of pressure flakes in the biface experiments, another nine biface manufacture episodes would be required to obtain a sufficient sample (n = 40) to validate the discriminant function. It was not feasible to do so at this time. This portion of the study is then preliminary, awaiting a sufficient number of PF's resulting from biface manufacture from alluvial cherts and jaspers to validate the discriminant function.

Utilized Flakes. The debitage assemblage from the BF locus contained 44 utilized flakes, all of chert (n = 28) and jasper (n = 16). The majority of the specimens exhibited only moderate to light edge-damage. The most common forms of edge-damage was micro-flaking or nibbling, with some crushing and rounding/smoothing apparent to the naked eye or with 10 X magnification. This type of damage is associated with scraping and cutting activities (Lawrence 1979:Figure 9). Edge-damage was observed in 72.7

percent (n = 32) of the specimens on one margin, and 27.3 percent (n = 12) on two margins. Eleven of the specimens (25.0 percent) exhibited edge-damage on the distal portion and one (2.3 percent) on the proximal end of the flake. Intentional retouch was not observed on any of the specimens.

Table 6.51. Summary Data for Utilized Flakes and *t* tests for Chert and Jasper Specimens.

Attribute	N	Mn	S.D.	Range Min Max	*t* - stat	d.f.	*prob.
Length (mm)	42	20.19	6.35	9.70-40.20	.55	40	.586
Width (mm)	44	16.16	4.97	8.10-35.75	.51	42	.612
Thickness	44	4.27	2.08	1.45-11.75	1.30	42	.200
Weight (g)	44	1.34	1.23	.1-7.2	.92	42	.364

*two-tailed probability, .95 CL. Equality of variances confirmed by Levene Test.

The combined summary data for the utilized flakes of chert and jasper is contained in Table 6.51. A series of *t* tests indicated that the differences between chert and jasper utilized flakes for ratio measurements were not considered significant at the .95 confidence level. The majority of the utilized flakes (75.0 percent) ranged from 15.1-25.4 mm in greatest dimension (Figure 6.31). Edge angles were not measured for these flakes.

The utilized flakes comprised 1.8 percent of the entire BF assemblage. In comparison, Stewart (1987a:Table 12) reported 157 total unifacial flake tools out of 16,385 pieces of debitage (Table 15) from the Middle/Late Woodland deposits of the Gropp's Lake site (28Me100G). These flake tools comprised 1.0 percent of the total debitage.

Signs of TA were observed in 54.5 percent (n = 24) of the utilized flakes, which is more than double the percentage (20.2 percent) of heat treated pieces of debitage in the BF assemblage of chert and jasper. Utilized flakes of chert were thermally altered in 35.7 percent of the specimens, compared to 15.9 percent of all chert debitage. Utilized flakes of jasper were thermally altered in 87.5 percent of specimens, compared to 49.7 percent of

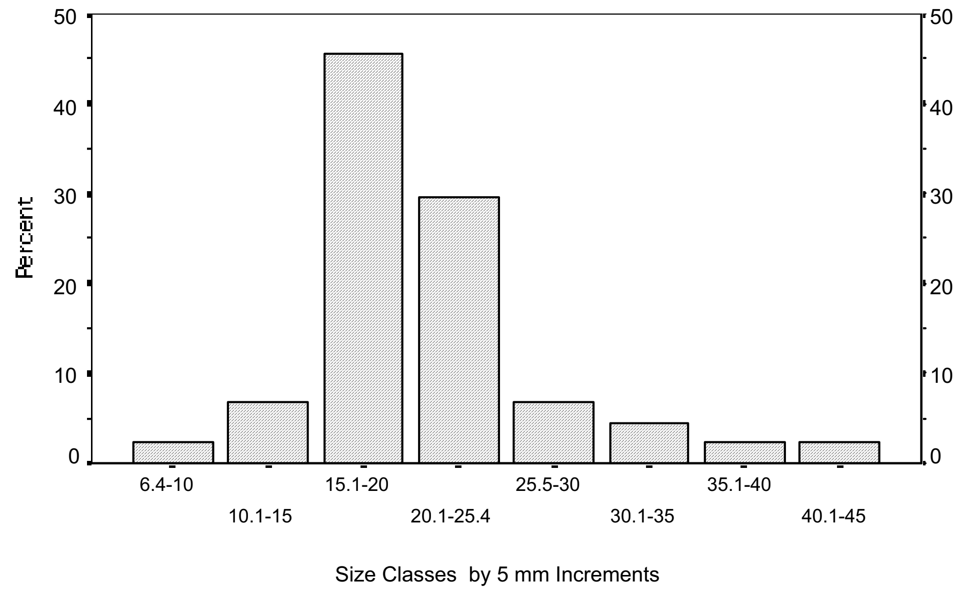

Figure 6.31. Proportions of size classes by 5 mm increments for utilized flakes.

all jasper debitage. As with the total population of chert and jasper debitage, the differences in the proportions between thermally altered utilized flakes of chert and jasper were significant and of strong association (X^2 = 11.0131, d.f. = 1, p = .0090 <.05, V = .50030).

Half of all the utilized flakes retained some cortex, while half contained no remnant dorsal cortex. This approximates the proportions for the total chert and jasper debitage assemblage (Figure 6.18).

The proportions of the combined platform types/dorsal cortex categories (6) for both utilized and non-utilized flakes is shown in Figure 6.32. The assemblage of utilized flakes is similar in proportions to the composite chert and jasper assemblage of flakes from the BF locus and is similar to the composite experimental biface assemblage (Figure 6.20) for this attribute. Although the sample of utilized flakes is relatively small, the overall similarities in the proportions of remnant cortex, relatively high levels of TA,

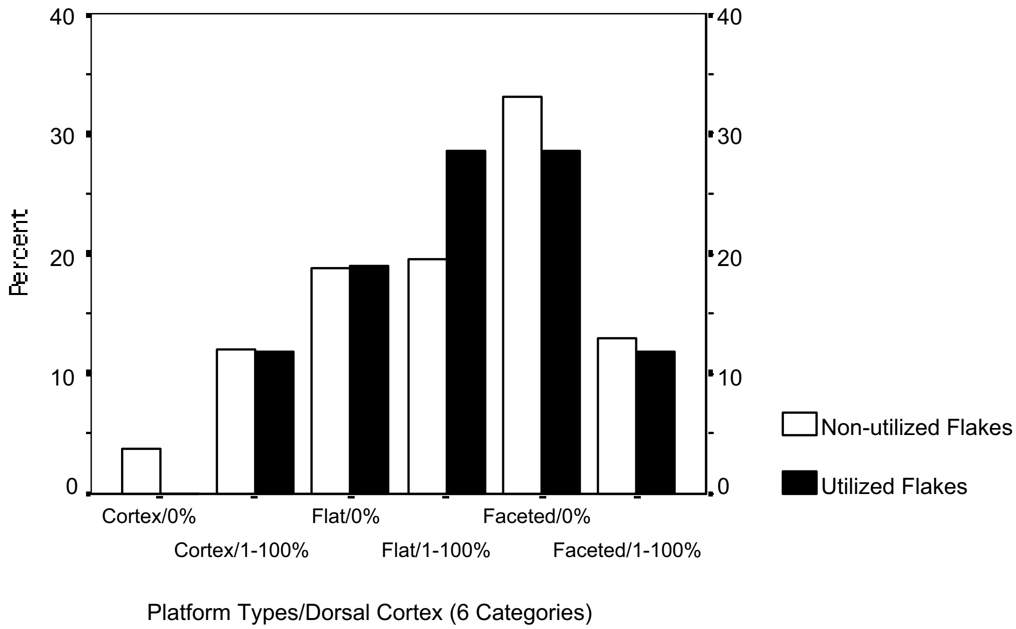

Figure 6.32. Proportions of platform types/dorsal cortex categories (6) for utilized and non-utilized chert and jasper flakes.

and platform types/dorsal cortex categories (6) suggests that these flakes were largely selected from the residue of biface manufacture rather than from the reduction of bipolar cores. A few of the utilized flakes were noted as possessing parallel margins, but no effort was made to categorize these as blade-like flakes similar to those reported by Stewart (1987a:Table 12) for the Gropp's Lake site (28Me100G) in the Trenton Complex.

The edge damage, lack of intentional retouch, the level of TA, the proportion of platform types/dorsal cortex categories (6), and the presence of waterworn cortex suggest that these flakes were expedient tools selected from the residue of biface manufacture with some specimens derived from bipolar reduction of gravels. The edge damage observed is consistent with patterns produced from experiments in cutting and scraping of animal bone and hide (Lawrence 1979:116) and plant material (Kamminga 1979:154).

Level of Production at the Beach Face. In this portion of the study, the experimental production rate is used to estimate the number of patterned tools manufactured, and chert or jasper gravels reduced, to produce the KBS BF debitage assemblage, 6.4-25.4 mm (pages 289-293). The prior determination that the debitage at the BF area was primarily the result of patterned tool manufacture makes this a straightforward process. The total number of chert and jasper pieces of debitage in this size range is 2,247. The total amount of debitage is divided by the mean of the amount of debitage produced in the patterned tool experiments, 30. The result is divided by two, which is the estimate of the number of flake blanks or split pebbles that a competent knapper can produce per gravel. The estimated number of patterned tools represented by the debitage is:

$$\frac{2247}{30} = 74.9 = 75$$

Assuming two flakes blanks or split pebbles per gravel, the approximate number of gravels reduced are:

$$\frac{75}{2} = 37.5 = 38$$

Assuming the prior conclusion that the debitage represents the manufacture of patterned tools is accurate, then approximately 38 chert and jasper gravels were reduced to manufacture 75 patterned tools. No effort was made to calculate the number of gravels reduced by the bipolar method due to the imprecise proportions derived from the data. Based on the times of the experimental episodes of manufacture, minus any pauses for photography, measurement, and bagging, each episode represents approximately 15 to 25 minutes of labor for the actually knapping. This equates to approximately 19 to 31 hours of labor, not accounting for collection time, which most likely was embedded in basic subsistence forays along the bay margins (Binford 1979:259).

Summary: Beach Face Debitage. The chert and jasper debitage from the BF locus of the KBS provided several insights into the behavior of the Late Woodland residents use of lithic technology. Discriminant analysis of the experimental data for the SRT (4 categories) produced a discriminant function that was successful in classifying debitage populations, either as derived from patterned tool manufacture, or bipolar reduction to produce usable flakes. The *unstandardized canonical discriminant coefficients* classified the total debitage assemblage as primarily that of patterned tool production. All excavation units of 30 or more pieces of debitage were also classified likewise, as the result of patterned tool production. This high level of patterned tool manufacture permitted the further partition of this assemblage into the proportions of biface and uniface manufacture represented by the debitage. Comparison of the nine category Platform Type/Dorsal Cortex percent of the BF assemblage, to the experimental proportions of biface and uniface manufacture, as well as the simulated composite biface and uniface assemblages, suggested that a 75:25 proportion of biface to uniface manufacture was represented by the debitage. It was concluded that the primary lithic activity at the BF locus was the manufacture of small triangular bifaces.

Classification of debitage into the BRS stages was not attempted, due to the inconclusive results in the experimental section. The first stage, Blank, and the last stage, Preform II, could be identified with a fair degree of certainty with multiple discriminant analysis, but the middle, Preform I, was poorly identified, resulting in a classification rate lower than was achieved by guessing. However, since the beginning and the end of the BRS is identified with a fair degree of certainty, determination of the length of biface reduction trajectory was attempted. The attributes that proved significant at the .05 level in separating the BRS stages were compared for proportions of BF debitage and experimental biface manufacture. The results of this comparison suggested that a complete biface reduction trajectory was present at the BF. However, the debitage signature suggests that less initial processing and more later-stage processing, Preform I and II, was accomplished at the BF locus. This is likely due to initial processing conducted off site, more complete reduction of the gravels than in the experiments, larger pieces from the Blank stage removed to another location, or a combination of some or all of these behaviors. The presence of special flake types, test flakes and bipolar flakes, suggests that some initial processing was accomplished at the BF. Flakes with rounded and worn platforms in the assemblage are suggestive of resharpening activities, which is the last stage prior to discard of a biface. The proportions of debitage attributes and the presence of special flakes types suggest a complete biface reduction trajectory at the BF. It is concluded that debitage, in the absence of flaked lithic artifacts, can be used to ascertain the length of the biface manufacture trajectory with alluvial chert and jasper gravels as a lithic raw material source. Johnson (1989) and Morrow (1984), working in the Southeastern United States, reached the same conclusion concerning debitage derived from alluvial chert gravels.

Visual examination of the BF debitage indicated that approximately one-fifth of the chert and jasper pieces displayed signs of thermal alteration as a result of intentional heat treatment. Almost one-half of the jasper pieces bore signs of thermal alteration, compared to approximately 16 percent of the chert debitage. A chi-square test of the two populations indicated that this difference in proportions was highly significant. However, a series of chi-square tests of the seven variables, considered useful in the determination of the length of biface reduction trajectory, indicated the only significant (.05 level) difference between chert and jasper was in the presence/absence of dorsal cortex. As a result, the TA chert and jasper pieces were treated as one assemblage in the attempt to place heat treatment within the biface reduction trajectory. Chi-square tests of the difference in proportions between TA and non-TA debitage indicated that four variables were considered significant at the .05 level. These variables were the presence/absence of dorsal cortex, dorsal flake scars, platform types (three categories), and the combined platform types/dorsal cortex (six categories), and were compared to the composite experimental biface manufacture episodes. Added to these variables was the proportion of large pieces (3.0 g or larger) of debitage. These variables suggested that heat treatment was accomplished after the initial Blank stage, but exact placement within the biface reduction trajectory is inexact. However, interpolation of the results led to the conclusion that heat treatment was generally accomplished in Preform I, after the majority of the cortex was removed and a substantial thinning of the objective piece accomplished. The data suggests that jasper was heat treated later in the BRS than chert.

Discriminant analysis of experimental hard hammer and pressure flakes produced a discriminant function that classified these flakes at over 90 percent accuracy. The derived *unstandardized canonical discriminant coefficients* were used to classify the PRB flakes from the BF locus. Thirty-six percent of the flakes were classified as pressure flakes, which was twice the proportion of the composite experimental biface assemblage. These results must be approached with caution, because the biface experiments did not produce sufficient numbers of pressure flakes to derive the discriminant function, and to hold out a sample to validate the results. See pages 221-226 for a discussion of this process. The foregoing is proposed as an example of how discriminant analysis may be used to separate the products of the two flake removal technologies. It awaits a larger sample to conduct an external validation of the discriminant function.

Edge damage consistent with use of flakes for cutting and scraping activities was observed in 44 flakes of chert and jasper. High levels of TA and similar proportions of platform types/dorsal cortex categories (6) to the biface experiments led to the conclusion that these flakes were largely selected from the residue of biface manufacture. The foregoing factors and the lack of any intentional retouch strongly suggest these were expedient tools used and discarded when dull or the task at hand was completed (Parry and Kelly 1987:285).

The level of production at the BF locus, with chert and jasper alluvial gravels as the lithic raw material, was calculated from the experimental reduction episodes. The results of these calculations suggest that the debitage represented the reduction of 38 gravels and the production of 75 patterned tools. The range of times for the experimental manufacturing episodes, multiplied by 75, produced an estimated range of approximately 19-31 hours of labor to fabricate the patterned tools, without any consideration of collection effort.

1. Luster does not appear on the original surface of heated material, but is only visible on flake scars that were made on the piece after the application of heat (Luedtke 1992:95). Consequently, any debitage that exhibits luster on its surfaces was likely not altered by burning in a hearth fire, but through intentional heat treating.

CHAPTER 7

THE LITHIC TECHNOLOGY OF KIMBLE'S BEACH

In this chapter, the results of the chipped stone artifacts, other lithics, and debitage analyses are synthesized into a proposed explanation of behavior in the lithic technology of the BF locus of the Kimble's Beach site[1] . A summary of raw material types and procurement, reduction strategies employed, heat treatment, biface manufacture, and tool types for KBS are contained in this chapter. Conclusions concerning the site function, any intrasite differences, and mobility strategies are discussed. A behavioral flow model that accounts for the choices that the Native American inhabitants of Kimble's Beach made in their use of lithic technology to meet their needs for lithic raw materials and the manufacture of tools is presented. Finally, recommendations for future directions in research on the KBS are given.

Raw Materials

The lithic raw materials represented in the chipped stone artifacts, some other lithics, and the BF debitage are overwhelmingly of chert and jasper. If the chipped stone artifacts, reutilized material, and unflaked pebbles were combined into one class (n = 131), then chert and jasper comprise 89.3 percent of the raw materials represented in the nondebitage lithic assemblage. Chert and jasper represent 96.1 percent of all the debitage from the BF locus. If the chert and jasper chipped stone artifacts, reutilized material, and unflaked pebble specimens are combined with the debitage of the same materials, then chert and jasper represent 96.5 percent of the total artifacts from the BF locus. All of the patterned tools in the assemblage were manufactured from these two lithic materials. It can be said with confidence that the Late Woodland knappers of Kimble's Beach had a decided preference for the high-quality cryptocrystalline materials.

The relatively small size of the chipped stone artifacts and debitage, as well as the high percentage of remnant waterworn cortex, indicate that alluvial gravels were the source of this raw material. The chipped stone artifacts specimens (98.0 percent equal to or less than 71.2 mm in greatest dimension) and the debitage (97.9 percent are equal to or less than 25.4 mm in greatest dimension) indicate that they could easily be derived from these alluvial gravels. Approximately 85.0 percent of the chipped stone artifact specimens and 43.3 percent of the debitage retained some amount of waterworn cortex. The data, along with the proximity to the bay margins and the lack of another source within 10 km, indicates that the Delaware Bay gravels were the sole source for the lithic assemblage at the BF locus. Collection of these gravels was most likely embedded in foraging activities along the bay margins, as Binford (1979:259) has suggested.

Lithic Reduction Activities

The Sullivan-Rozen typology (Sullivan III 1987; Sullivan III and Rozen 1985) of four categories, coupled with the *discriminant function* obtained from the discriminant analysis of the tool manufacturing experiments, indicate that the manufacture of patterned tools was the primary lithic activity at the BF locus of the KBS. The application of the *unstandardized discriminant function coefficients* to the assemblage of chert and jasper debitage indicated that the assemblage as a whole, and the individual units (equal to or greater than 30 pieces), were the result of patterned tool manufacture.

Patterned tool manufacture is characterized by larger proportions of complete and proximal flakes with much lower proportions of flake fragments and reduction fragments. Bipolar reduction is characterized by relatively low proportions of complete and proximal flakes, and high proportions of flake fragments and reduction fragments. Multiple discriminant analysis (three group) was unable to satisfactorily distinguish the episodes of freehand reduction of gravels from those of patterned tools. This was not deemed an obstacle to analysis of the debitage, because there were very few freehand cores in the chipped stone artifact assemblage suggesting little use of this technique. In addition, freehand reduction of the gravels was not likely to have been practiced, due to the small size of the gravels. Although bipolar cores were present at the site, their reduction was masked by the relatively greater amount of patterned tool production. The greater proportion of chipped stone artifact specimens representing biface and unifacial scraper manufacture, compared to bipolar cores, reinforces the analysis of the Sullivan-Rozen typology data from the debitage assemblage. It appears likely that the manufacture of patterned tools provided enough waste flakes to meet the needs of the knappers for expedient tools.

Employing the experimental results, the BF debitage data was statistically analyzed to determine the relative proportions of biface and scraper production. The proportions of the combined platform type/dorsal cortex percentage of nine categories was calculated for the assemblage as a whole, and for individual units of 100 or more pieces of debitage. Comparison of the data to the experimental results and simulated experimental assemblages of various proportions of biface and scraper manufacture suggest that a proportion of 75:25 of biface to scraper manufacture was responsible for production of the debitage in the assemblage as a whole. Four of the five individual units possessed similar proportions with Trench 1, giving proportions that were most similar to an equal amount of biface and scraper manufacture. The proportion of bifaces (n = 24) in various stages of manufacture and scrapers (n = 7) is roughly similar to the proportion of debitage attributed to each type of patterned tool manufacture in the chipped stone artifact assemblage from the BF locus. The results of the intrasite analysis suggest that lithic reduction activities were similar across the BF locus.

The two radiocarbon dates obtained for the site indicate that the deposits in at least two of the excavation units may have been separated by as much as 350 years. It is probable that the lithic reduction activities represented in the excavation units demonstrates a continuity of these activities over time by the Late Woodland inhabitants of Kimble's Beach. This is most likely due to following similar patterns of behavior to exploit similar natural resources over time and represents a long standing knapping tradition or technological adaptation to a local source of tool stone.

Biface Reduction Sequence

The complete and incomplete biface specimens present in the chipped stone artifact assemblage and the resulting debitage signature suggest that a complete biface reduction sequence was accomplished at the BF locus for at least a portion of the biface manufacture episodes. The debitage signature suggests more Preform I and II reduction and less Blank production than the biface manufacture experiments. The relatively smaller proportions of larger pieces of debitage, 3.0 g or more in weight, and 25.4 mm or more in greatest dimension, are indicative of less Blank reduction. As previously discussed, three behaviors could be responsible for this result: initial reduction was accomplished off site, most likely at the Late Woodland period beach face; the larger pieces were further reduced; the pieces were removed for use at another area; or some combination of the foregoing. The presence of special types, test flakes, resharpening or rejuvenation flakes, and bipolar flakes, suggest that a reduction trajectory from initial processing through use as a tool and discard was present to some extent. The analysis of the debitage variables suggested that a complete biface reduction trajectory was present at the BF locus.

The biface specimens representing the different stages of production, the debitage signature, and the signs of damage due to bipolar reduction on chipped stone tools and flakes, suggest that the sequence of manufacturing steps and reduction techniques as proposed in Chapter 4 are valid to represent the sequence of biface manufacture at the BF locus. This sequence includes bipolar reduction of gravels to produce either a split pebble half or flake blank suitable for biface manufacture. The split pebble or flake blank is then thinned and shaped by hard hammer percussion. The final step involves final shaping, thinning, and sharpening of edges by pressure flaking. This is the sequence that was followed in the experimental knapping episodes, which produced the sample to which the BF debitage was compared.

Starting Forms

The starting form, split pebble or flake blank, for chipped stone tool production is somewhat difficult to ascertain. The biface reduction sequence represented by the biface specimens in Figure 4.2 for BF locus presents a split pebble starting form, but this does not preclude flake blanks as a starting form. If flake blanks were used, it is most likely that they were reduced completely, because there are few good candidates as flake blanks remaining in the chipped stone artifact assemblage that could be used to manufacture patterned tools, which is similar to the assemblage reported by Stewart (1987a:96-100) for the Gropp's Lake site (28Me100G).

The attempts to distinguish the debitage signature of split pebbles from flake blanks with the available variables were unsuccessful (Chapter 5, *Starting Forms*). A serviceable triangular biface of the dimensions found in the archaeological assemblage can be manufactured from either form, as demonstrated by the knapping experiments. Based on foregoing discussion, it is likely that both forms were utilized, depending on the morphology of the individual gravel and the preferences of the individual knapper.

Hard Hammer and Pressure Flakes

The attempt to identify pressure flakes through discriminant analysis showed some promise, but the lack of a large enough sample to validate the discriminant function raised some concerns. The *undstandardized discriminant function coefficients* developed in the experimental analysis, when applied to the raw data from the BF debitage assemblage, identified a large proportion of the debitage (36.0 percent) as pressure flakes. This is nearly twice the proportion (19.1 percent) of the pressure flakes recovered from the biface experiments. This rather large proportion of pressure flakes is reinforced by the results of the study to determine the length of the biface reduction trajectory, in which Preform I and II are better represented in the archaeological assemblage. Preform II, in the experimental biface manufacture, was almost exclusively accomplished through pressure flaking with a deer antler.

The results above appear to indicate a relatively higher proportion of pressure flakes, which suggests more later stage reduction (Preform II) was accomplished at the BF locus than would be expected based on the biface manufacture experiments. Again, these results await a larger sample of pressure flakes to externally validate the discriminant function before it can be used with complete confidence.

Thermal Alteration

The Late Woodland knappers at the KBS applied heat treatment to the stone used to produce chipped stone artifacts approximately 30.0 percent of the time. The analysis of the BF debitage indicated a similar level of thermal alteration at 23.0 percent. What is readily apparent from the chert and jasper chipped stone artifacts and debitage is the differential in the level of heat treatment of these two materials. Almost one-half of the jasper debitage showed signs of thermal alteration, while only 16.0 percent of the chert pieces were so treated. This is similar in the overall proportions to the chipped stone artifacts with signs of thermal alteration (Table 6.2). Chert specimens were heat treated approximately 22.0 percent of the time, while two-thirds of the jasper pieces received such treatment. Among the biface reduction sequence specimens recovered, the proportion of heat treated chert (38.9 percent) and jasper (83.3 percent) was higher than the overall chipped stone artifact assemblage, but the differential between the two materials was still present. It is likely that the difference in the heat treatment of the two types of stone is due to cultural preferences, such as desirable color change, than for technological reasons.

The sample of specimens that represent the biface reduction sequence at the BF locus is relatively small (n = 24), but the signs of thermal alteration do not appear until after the Blank stage, suggesting that the stone was heat treated in Preform I or II. It is possible that heat treatment was accomplished with flake blanks rather than with split pebbles.

Level of Production

A formula for the computation of the level of production for chert and jasper gravels from debitage was developed from the patterned tool experiments and bipolar reduction to produce usable flakes (Chapter 5, *Level of Production*). The application of these formulae to the BF assemblage of debitage suggests that it represents 75 episodes of patterned tool manufacture, derived from the reduction of 37 or 38 chert and jasper gravels. Based on the times of the experimental knapping episodes, it is estimated to represent between 19 to 31 hours of labor, not counting the collection effort or any off site reduction. As stated previously in the this chapter, the collection of gravels was most likely embedded in the foraging activities on or near the prehistoric beach face.

Intrasite Differences

Analysis of intrasite distributions of chipped stone artifacts, other lithics, and debitage suggest that there were few differences represented by the lithic assemblage across the BF locus of the KBS (Appendix C). The largest and densest concentrations of lithic artifacts are found in Trenches 2 and 7, along with three of the five features discovered. These two excavation units account for 25.6 percent of the nondebitage lithics and 55.2 percent of the total debitage. Based on the amount of lithic materials and the features, it is most likely that Trenches 2 and 17 represent longer periods of occupation, rather than reoccupation over time, or a larger number of individuals. Although there are some small differences between the excavation units, by most measures they are similar in composition. For example, Trench 2 contained four bipolar cores, but the proportion of Sullivan-Rozen typology flakes indicate patterned tool production was the major lithic activity represented, and there was little difference from the proportions for this attribute across the entire assemblage. See discussion of intrasite differences in various sections of Chapter 6. Overall, the excavation units are fairly uniform in terms of the recorded attributes of the recovered debitage (Appendix C).

If it is assumed the excavation units represent many occupations over a period of time, as indicated by the divergence of the two radiocarbon dates, then it appears that the lithic data suggests continuity over time in the types of behaviors represented. It is likely that the same natural resources were sought and processed over the entire period of occupation represented by these excavations. The lithic reduction strategies employed appears to have changed little over this time. Ethnohistorical studies indicate that extended families most probably occupied this land over successive generations (Becker 1988; Kraft 2001; Weslager 1961; Weslager 1972), exploiting the same natural resources with similar techniques and technologies. The conservatism observed by Stewart (1998d) in certain technologies practiced by the Late Woodland peoples of the Delaware Valley is supported by the lithic technology of the BF locus at the KBS.

Attribute Analysis

Attribute analyses of the debitage derived from the lithic experiments suggested that certain attributes provided valuable information for the gravel based lithic technology employed at Kimble's Beach. Class size, as used in Patterson's's (1982) log-linear model did not appear to be useful, because similar curves and slopes were given when plotted and transformed logarithmically for different lithic reduction strategies (See Chapter 5, *Log-Linear Results*). The Sullivan-Rozen typology of four categories proved to be able to discriminate between patterned tool production and bipolar reduction to obtain usable flakes. Distinguishing between patterned tool production and the freehand reduction of gravels to obtain usable flakes was problematic because both strategies produced similar proportions of the Sullivan-Rozen typology categories.

Platform types of three categories combined with dorsal cortex percentage of three categories was combined into a single variable of nine categories, which proved useful in distinguishing between the proportions of debitage derived from biface and scraper manufacture. The category of Faceted Platforms/Zero Percent dorsal cortex was shown to be the signature of biface manufacture. This is similar to the findings of Morrow (1984) and Johnson (1989) who utilized a similar attribute combination in determining the length of a biface production trajectory from alluvial gravels in the Southeastern United States during the Late Mississippian period.

Split flakes, dorsal flake scar count, dorsal cortex of three categories, size classes, and platform crushing and lipping, were useful in discrimination of the initial Blank stage and the pressure flaked Preform II, but could not successfully identify the middle stage of biface manufacture, Preform I, when used in a multiple discriminant analysis. Platform types/dorsal cortex (six categories), unrestricted class sizes, and weight in combination with the foregoing attributes that were used to determine biface reduction sequence stages, were used to infer the length of the biface reduction trajectory. Testing of individual categories, in the combined platform types and dorsal cortex categories in both six and nine categories, indicated that not all categories were significant in regard to differentiating between biface reduction sequence stages or in the determination of the length of the biface reduction trajectory (Drennan 1996). Generally, length and width were not useful in answering any of the questions posed, although they are commonly recorded attributes. Size classes derived from length and width measurements proved to have value in determination of the length of the biface reduction trajectory. Crushed platforms and platform lips were valuable in separating hard hammer and pressure flakes with discriminant analysis and in determination of the length of the biface reduction trajectory. Weight and thickness were shown to covary in the experimental analysis. Weights equal to or greater than 3.0 g were helpful in determination of the length of the biface reduction trajectory. Due to the small size of the resulting debitage from reduction of alluvial gravels, the weight should be recorded to the nearest .01 g to gain maximum discrimination, as demonstrated in the experimental analysis to separate hard hammer and pressure flakes. A large percentage of this debitage weighed less than .1 g, but was recorded as .1 g, as per the original protocol for this study. Special flake types, such as test flakes, bipolar flakes, and resharpening or rejuvenation flakes, provided insight into the behaviors and lithic strategies at the BF locus.

One of the stated purposes of the attribute analysis of debitage in the experimental portion was to determine which attributes were helpful in solving different problems that may be posed in studies involving the reduction of alluvial gravels. Generally, in regard to attributes, this study suggests that the questions to be answered should determine the attributes to be recorded or measured. It is hoped that the recommendations made above will provide a starting point for future researchers.

Sampling

The initial 20 percent sample of debitage provided some valuable insights into the composition of the assemblage. The sampling, following the methods outlined in Chapter 4, gave the proportions of raw materials, heat treated pieces, pieces with remnant cortex (also cortex type, e.g., waterworn cortex), and overall flake size proportions fairly accurately. It also provided a reasonable estimate of the point at which heat treatment was applied: that is some point after initial bipolar splitting of gravels, rather than the heat treatment of whole gravels.

In light of the results of the experimental portion of the study, some modification of the attributes would be advisable to provide more useful information. The original size classes utilized in the Rutgers University Center for Public Archaeology (RUCPA) lab were utilized for the sample, but experimentation demonstrated that more discrete classes (5 mm increments) were more valuable, at least for the purposes of this study. The proportion of whole and broken flakes used in the RUCPA lab protocol would have been more useful if the Sullivan-Rozen typology of either four or five categories was employed. However, the use of the two category typology did lead to the use of the Sullivan-Rozen typology to separate patterned tool manufacture from bipolar reduction.

A random stratified sample of a statistically determined proportion with the modified categories noted above would provide valuable information without time-consuming and labor-intensive measurement of all individual pieces of debitage. The addition of platform types, weight, and a modified dorsal cortex variable of three or four categories would yield more valuable information with less time and labor. This study reinforces the value of probabilistic sampling in archaeology, especially with a large assemblage of debitage, or when time or labor are limited (Hester et al. 1997:26-35; Renfrew and Bahn 1996:72-73).

Mobility and Settlement Strategies

The use of the stone tool assemblage and debitage to infer mobility patterns of the Late Woodland inhabitants of Kimble's Beach is somewhat problematic. In the following section an attempt is made to use the lithic data to infer the mobility strategy employed, and the length of occupation of the BF locus through comparison to theoretical propositions (Andrefsky Jr. 1991; Andrefsky Jr. 1994b; Kelly 1992; Shott 1986) and a model proposed by Magne (1989).

The pattern of few formal tool types, the use of unstandardized and expedient core technology with bipolar reduction, and the use of informal or expedient flake tools at the KBS is similar to the trends in the Late Woodland period in the Eastern Woodlands reported by Parry and Kelly (1987:289). Formal toolkits, able to adapt to changing circumstances, including limited or difficult access to lithic raw materials, are normally considered a part of the lithic technology practiced by highly mobile groups (Parry and Kelly 1987:300). Expedient technologies can be found in both mobile and sedentary populations if the lithic raw material is easily accessible and widely available (Andrefsky Jr. 1994b:23; Parry and Kelly 1987:301). In an environment of easy availability of high-quality lithic materials, both formal and informal designs should be manufactured regardless of whether a group employs residential mobility or sedentism as a strategy (Andrefsky Jr. 1994b):30 and Figure 2). There is little doubt that the alluvial gravels from the bay provided both high-quality cryptocrystalline raw materials and easy accessibility to the Late Woodland inhabitants of the BF locus. Bipolar reduction is represented by the distinctive flake morphology and damage patterns, and the expended bipolar cores. Biface technology was limited to the production of small triangular projectile points. The chipped stone artifact assemblage contains four scraper types, unifacial flakes tools, and unretouched expedient flakes. The other lithics consist of mostly quartzite and quartz cobbles that were easily procured at the Late Woodland beach face, and thus could be easily discarded after limited use. The overall pattern of the lithic assemblage was representative of a move to sedentism. There is, however, no evidence of the adoption of horticulture on the Outer Coastal Plain, which is usually seen as the major cause of the shift to sedentism[2] (Kelly 1992:50-51), and the evidence for permanent housing is rare at best (Kraft 2001:228-229; Mounier 1982:170; Stewart 1998d). The excavations at both the BF locus and the upland areas of the KBS produced no evidence of either, although signs of house floors are difficult to find in forested areas with sandy soils (Michael Gregg, personal communication 2008).

The inhabitants of Kimble's Beach in the Late Woodland period had ready access to marine, wetland, and upland (oak-hickory forest) resources. It seems likely that a single family or a small extended family would be able to sustain itself for an extended period of time or a season with such resource plenty (Kelly 1992:47). There is, however, no direct evidence for the duration of the occupation. The presence of shell deposits of mollusks (principally quahog clam and oyster), and the bones of fish, turtle, deer, bear, and river otter indicate that all three environments were exploited during the times when the archaeological assemblage was deposited (Bierbrauer et al. 2002). The inventory of faunal and plant remains are similar to that catalogued by Mounier (1978) for the Inner Coastal Plain and Outer Coastal Plain of New Jersey. Sandy Bierbrauer (2002), who served as botanist and zoologist for the excavations, suggested that deer and bear are best harvested in the fall, winter, and spring, while clams, oysters, and fish could be taken at any season. The presence of hickory and acorn shell along with grape seed suggest a late summer or early fall harvest. Turtles are generally taken in late April through early November. However, box turtles hibernate in cold weather under leaves and decaying vegetation, and are easily collected at this time (Morris 1997). Some degree of seasonality may be inferred from the vegetative and faunal remains, but one can also infer that a seasonal independent occupation could have occurred.

A study of the rim sherds recovered from BF locus indicated that over 50 percent of the represented vessels mouths were 11 in (28 cm) or greater in diameter. It was suggested that these vessels may represent storage vessels rather than cooking pots (Cavallo et al. 1996). No carbonized residues were noted on the interior surface of the sherds. None of the five features excavated was interpreted as representing storage pits (Cavallo et al. 1996; Cavallo et al. 1997).

The lithic data, the potential richness of the resource base, ceramic vessels, along with faunal and botanical evidence strongly suggest that a semisedentary characterization of the site would be appropriate. Kelly (1992:52) suggests that the coastal regions of the Eastern North America, with their rich marine and wetland resources, could support a sedentary or semisedentary pattern in the absence of horticulture. Murdock (1967:159) defined semisedentary as "...communities whose members shift from one to another fixed settlement at different seasons or who occupy more or less permanently a single settlement from which a substantial portion of the population departs seasonally to occupy shifting camps." I believe, based on the information presented in the preceding discussion, that the settlement strategy of the Late Woodland people responsible for the deposits excavated from the BF locus corresponds to the seasonal moves in the anterior portion of Murdock's (1967:159) definition.

In Binford's (1980) dichotomy of foragers and collectors, the inhabitants of the BF locus would be considered foragers, people who make residential moves to exploit seasonally available resources. These residential moves may be seasonal, or moves within seasons to limit the distance of daily forays (Binford 1980:5-10). People who employ this strategy will produce two kinds of sites: residential sites and locations (Binford 1980:9). The former site type is the origin point from which foraging parties emanate. The location is a temporary site where extractive activities take place. Greater numbers and diversity of tools, reflective of the duration of occupation, will be characteristic of residential sites. The location or temporary site will have few tools abandoned unless they are redundantly occupied. These sites will be accretions of specialized tools over years of use.

The BF locus deposits, especially Trenches 2 and 17, suggest they are the result of a longer term occupation. The excavated assemblage of abandoned Late Woodland tool types and concentrations of ceramic sherds and the diversity of faunal remains recovered are suggestive of a residential occupation (Binford 1980:9). The deposits recovered from the BF locus are most likely, in this researcher's view, the remains of different individual periods of occupation over an extended period of time, rather than reoccupations, although that possibility cannot be ruled out. The upland characteristics of the site would place it geographically in a position to exploit forest, wetland, and marine resources with daily forays. The faunal and vegetative deposits suggest the possibility of exploitation year round. This does not assume the residential bases were occupied for this length of time, but rather that the camps were likely moved for reasons in addition to seasonality, such as the availability of firewood, avoidance of insect pests, and the reduction of food resources in an area.

The classification of chipped stone artifacts and the identification of pressure flakes with the discriminant function permitted the use of a lithic assemblage model (Figure 7.1) proposed by Magne (1989). The chipped stone artifact types used in this portion of the study were bifaces, scrapers, unifaces, drills, and core tools. In Chapter 6, the results of a discriminant analysis were used to classify the hard hammer and pressure flakes. Since the pressure flakes are almost exclusively produced in Preform II, they were a good fit for the "late stage flakes" used in the model. Magne (1889: Figure 2 and 3) actually used resharpening flakes from another study as "late stage flakes"

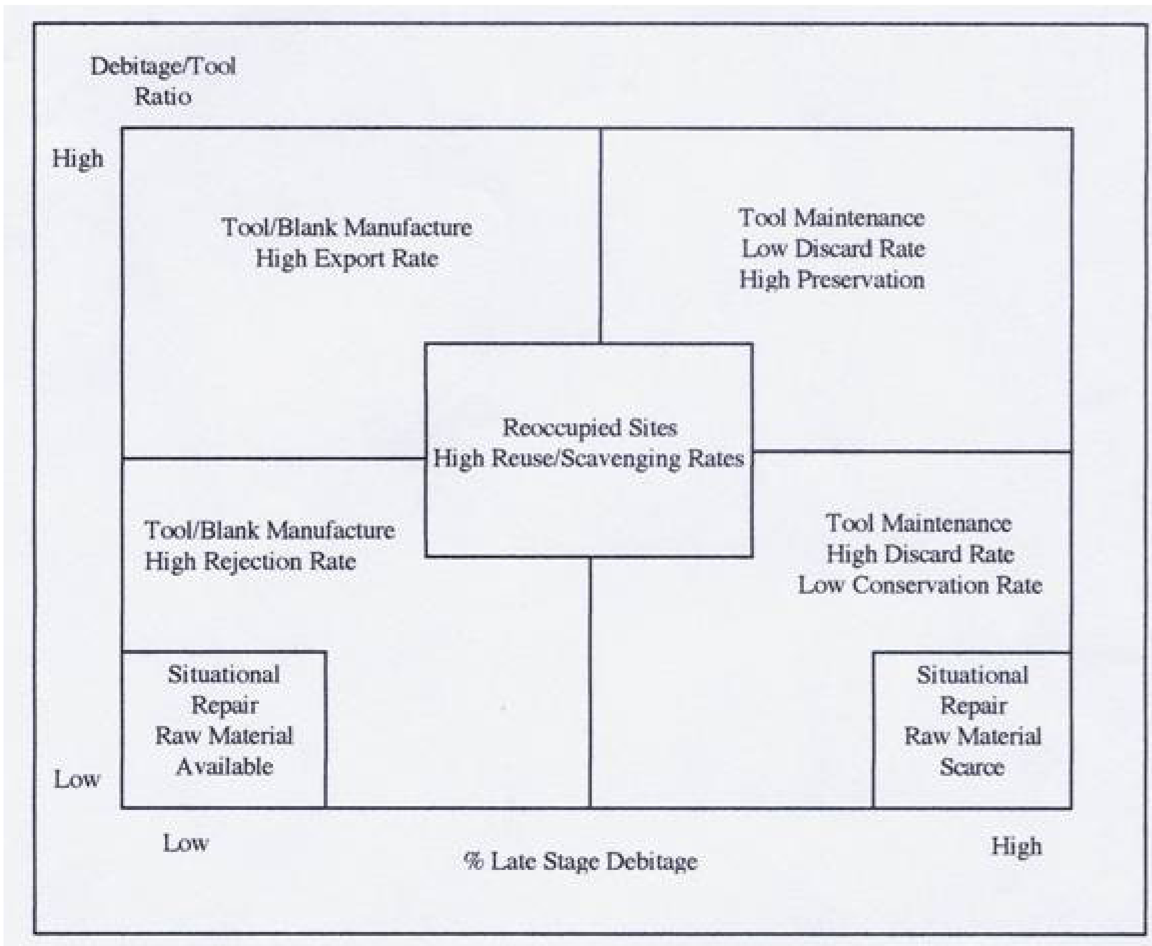

Figure 7.1. Assemblage formation model utilizing debitage/tool ratio and late stage debitage proportion (after Magne 1989:Figure 1).

to test the model. Again, it must be noted that the admonition, previously discussed in Chapter 5 and repeated in this section, concerning the lack of sufficient numbers of flakes to validate the discriminant analysis, require that any conclusions be treated with caution. However, this model does provide an opportunity for comparison of these results to other information about the site and previous conclusions.

The model proposed by Magne's (1989:Figure 1) plots the ratio of debitage to chipped stone tools against late stage debitage. The purpose of the model is to discriminate between rates of curation and maintenance and expedient and situational tool production (Figure 7.2). The model predicts lower rates of tool maintenance in the presence of lithic abundance and higher tool replacement rates. Accurate identification of late stage flakes and tool types are essential to this model. The comparison of points in plots (scattergrams) to the model shown in Figure 7.1 will produce an interpretation concerning the site. Any interassemblage comparisons with these results must utilize the same chipped stone tool definitions (Appendix A) and the same minimum size for recovered debitage (quarter-inch screening) to have any validity. It must be noted that this is an interpretive schematic model, that does not possess mathematical precision.

The debitage/tool ratio (the numbers on the Y axis are the ratio's, e.g. 62:1 for the KBS) plotted against the proportion of Preform II flakes (X axis) is shown in Figure 7.2 for chert and jasper debitage for the total assemblage and the four units (Trenches 1, 2, 3, and 17) equal to or greater than 100 pieces. The points that represent the total assemblage and four excavation units fall into the upper left quadrant, which represents the higher end of the debitage/tool ratio and the lower end of the Preform II flakes. The total assemblage and the points from Trenches 1, 2, and 3 fall within the tool/blank

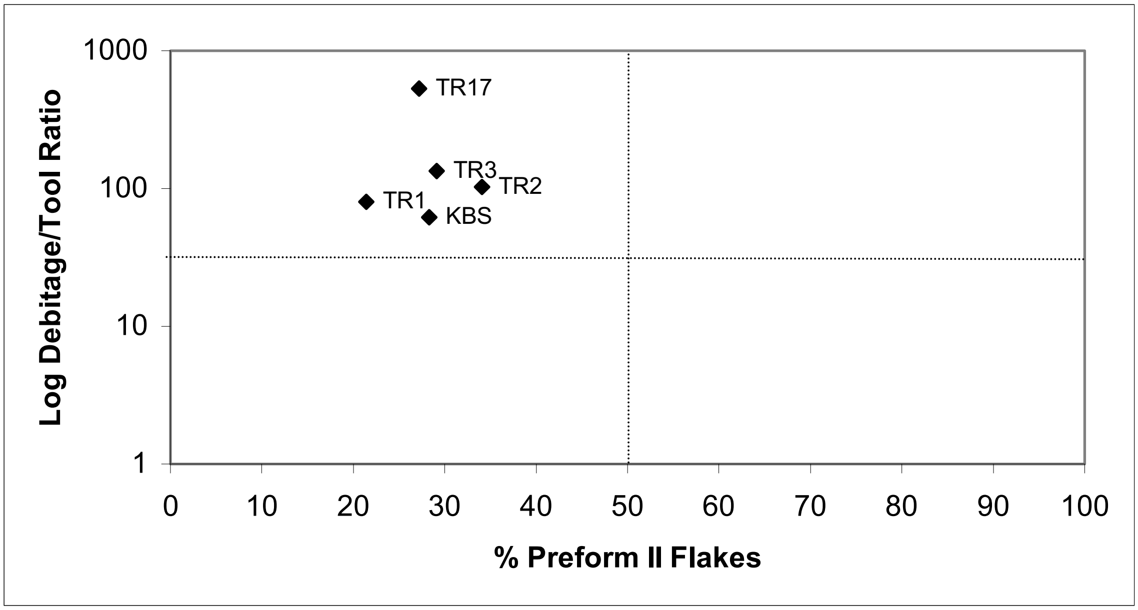

Figure 7.2. Log debitage/tool ratio plotted against the proportion of Preform II flakes for Trenches 1, 2, 3, 17 and the composite KBS assemblage (chert and jasper only).

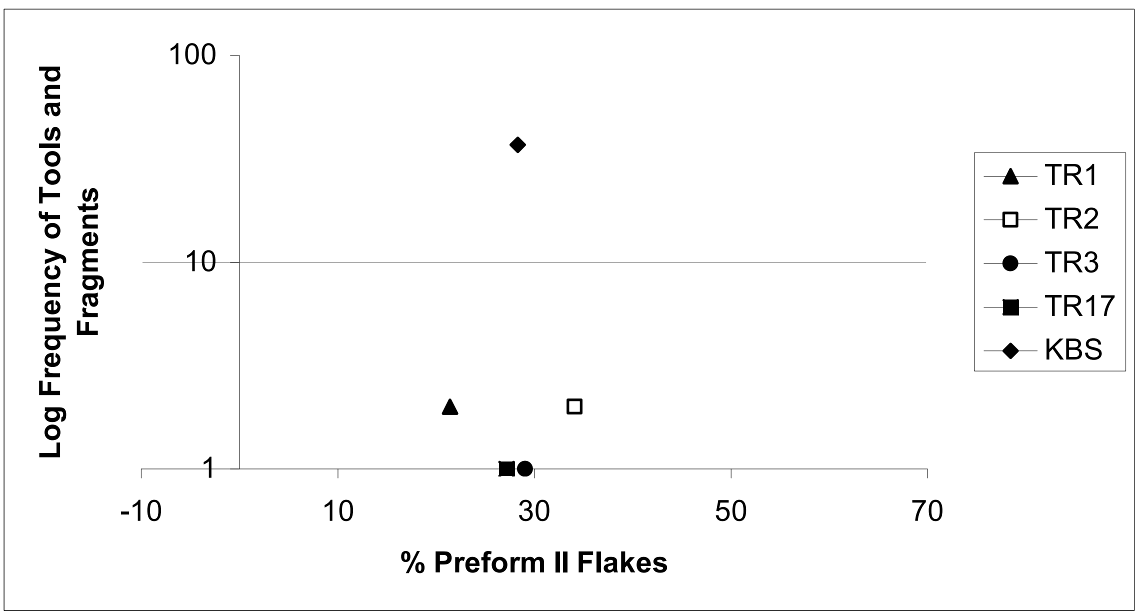

Figure 7.3. Log frequency of tools and tool fragments plotted against the proportion of Preform II flakes for Trenches 1, 2, 3, 17 and the composite KBS assemblage (chert and jasper only).

manufacture with higher export rates, but they are also near the center, which represents reoccupied sites and high reuse and scavenging rate. Trench 17, from which only one specimen of chipped stone tool was recovered, is within the upper quadrant, but far from the center. Since the archaeological assemblage was recovered from the intact A horizon, in which no strata were discernible, it is difficult to detect evidence of reoccupation. A geomorphic analysis of deposition rates was not undertaken in the course of the excavations, so it is not possible at this point to determine how quickly the deposits were buried. It is possible that these units may represent reoccupation over time, rather than one single occupation.

Magne (1989) further proposed a model that plots the number of tools and tool fragments (Y axis) against the proportion of late stage flakes, in this case Preform II, to determine the length of occupation. This model is based on the reasoning that as site occupation or reoccupation continues over time at sites with nearby sources of chippable stone, the numbers of late stage flakes, while increasing, will be a smaller proportion of the total debitage as more early stage reduction takes place over time. The excavation units, when considered individually, show the effects of short term occupation, while the BF assemblage as a whole suggests longer periods of occupation or reoccupation (Figure 7.3). This may be due to the uneven distribution of chipped stone tools recovered from the excavation units (Appendix C). The four largest units produced a debitage assemblage of 1,332 pieces, or 58.0 percent of the total. The chipped stone tool specimens (*n* = 6) recovered from these units only comprised 16.2 percent of the total for this tool assemblage. It may be that tool production from gravels, with the resulting small tools, offers different conditions than those envisioned by Magne (1989). The expectation is that when lithic raw materials are difficult to obtain, more bipolar reduction is employed and biface reduction flakes are used as expedient tools (22). Both of these conditions are reflected in the lithic assemblage from the BF locus. It appears that evidence of bipolar reduction, relatively small tools, high levels of dorsal cortex, and utilized biface reduction flakes will be present in a Late Woodland environment of relative lithic abundance from gravel sources. Magne (1989:21) anticipated such an environment when he noted the need for data from experimental work in tool production from pebble sources. The gravels of the Delaware Bay appear to have satisfied the need of the Late Woodland inhabitants of Kimble's Beach to produce small triangular bifaces and other relatively small tools. The reduction of these gravels to manufacture patterned tools provided suitable flakes to function as expedient tools. There is nothing in the examination of the lithics, resource availability, and the site formation models that negate the impression that this site was the product of a semisedentary mobility strategy followed by a foraging people.

Behavior in Lithic Reduction

The alluvial gravels of chert and jasper from the margins of the Delaware Bay provided the lithic resources for the chipped stone tools and the expedient flakes employed by the inhabitants of the BF locus. The behaviors of these Native Americans knappers in processing these gravels is portrayed in Figure 7.4. The diagram presents behaviors indicated or inferred from the analysis of the chipped stone artifacts and the debitage recovered from the BF. Possible behaviors inferred without direct lithic

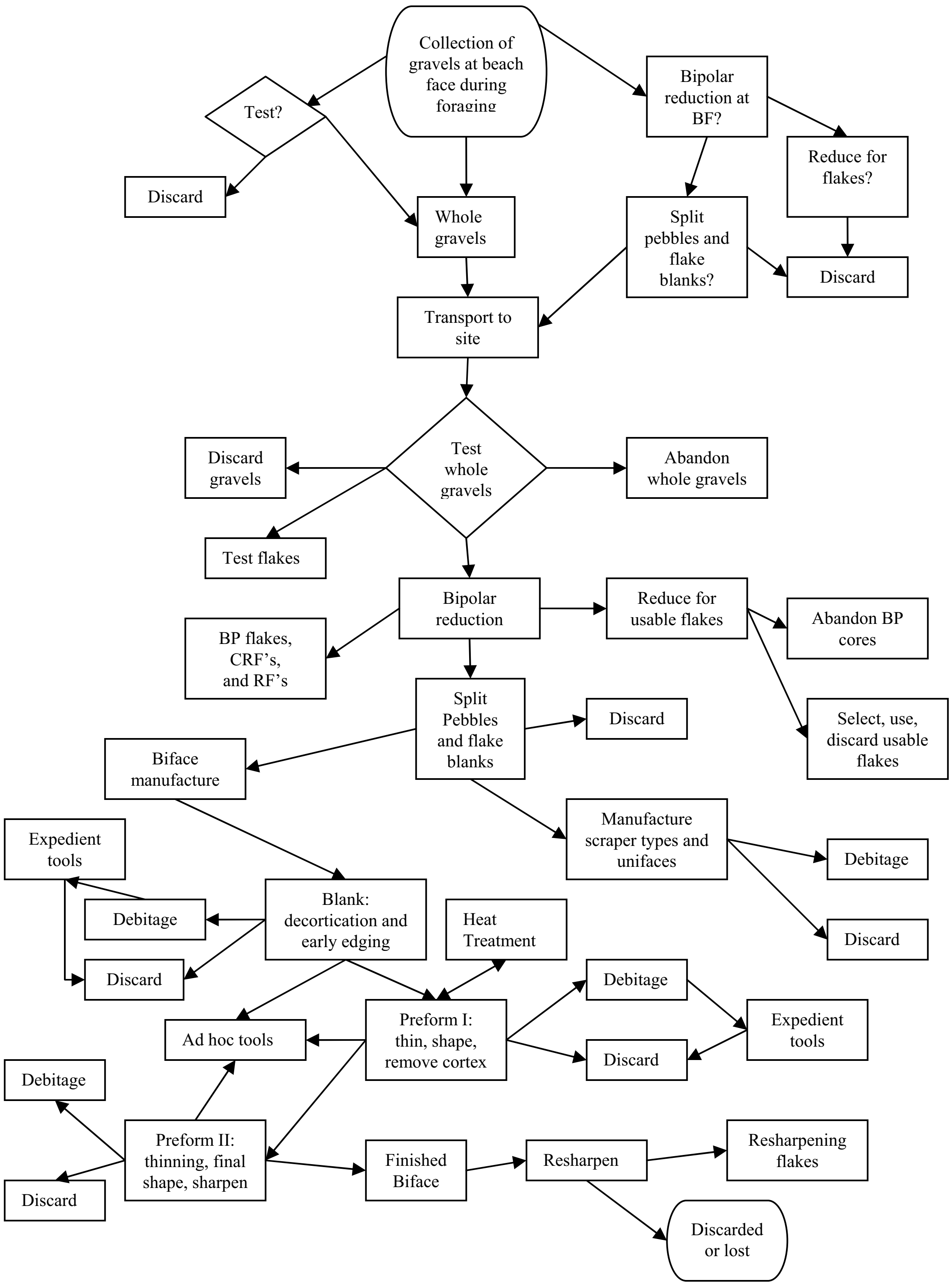

Figure 7.4. A behavioral diagram portraying lithic reduction of chert and jasper gravels and patterned tool manufacture at the Beach Face locus of the Kimble's Beach site.

evidence, such as those at the Late Woodland beach face, are marked with a question mark (?).

The processing begins with the collection of gravels, mostly of chert and jasper, during foraging episodes along the Delaware Bay margins. It is unlikely, but possible, that intentional forays were made to the bay with the sole purpose of collecting gravels; however it seems much more likely that the collection was embedded into regular foraging trips to the beach face. The diagram presents alternatives as to whether testing and/or initial bipolar reduction for patterned tool manufacture or the bipolar reduction to obtain usable flakes were accomplished at the Late Woodland beach face or at the site. Hammerstones and anvils of various sizes are easily obtainable from the same bay margins, so at least Figure partial reduction there is quite possible. The diagram portrays the process by which the chipped stone artifacts and debitage were likely deposited in the archaeological contexts.

Bipolar reduction was employed in the initial processing of the gravels to produce either split pebbles or flake blanks to manufacture small triangular bifaces or several types of unifacial tools. The work of lithic reduction appears to have been accomplished by small hammerstones of quartzite to thin and shape bifaces and rough out unifacial tools. Pressure flaking was employed to thin and sharpen edges. It is a relatively simple set of technological strategies, compared to the more sophisticated and staged biface manufacturing procedures employed to make large thin patterned bifaces in earlier cultural periods (Stewart 1998d). It is also not surprising that the tools recovered from the deposits were relatively small considering the small size of the raw materials.

Rejects from biface manufacture episodes contain use-wear evidence indicating their employment as *ad hoc* tools, while debitage from the process were selected and employed as expedient tools. This may have obviated some of the need to specifically reduce a pebble or cobble for usable flakes, at least at the BF locus. Analysis of the chipped stone artifacts and the debitage supports the manufacture of patterned tools as the primary lithic activity at the BF locus. This use of flakes from the manufacturing process is more practical and energy conservative than a bipolar strategy adopted due to a lack of suitable raw material. Stone was employed and readily discarded, which is suggested by the limited wear patterns on chipped stone tools, expedient tools, hammerstones, and pecked pebbles. The lithic technology is relatively simple, but was one that served the needs of the people who lived in this relatively resource rich environment.

Recommendations for Future Research

First, the total artifact assemblage from the BF locus and the upland portions of the KBS should be examined, and the attributes recorded in an acceptable digital statistical analysis and data management system. Work already accomplished in the undergraduate lab classes should be verified by sampling to insure its accuracy. If it is found to be deficient, then an analysis by more experienced individuals should be undertaken. Appendix B of this study provides a list of attributes for the lithic portion of this proposed endeavor. The results of this study indicate that a minimum set of attributes for debitage would include the Sullivan-Rozen typology categories (four or five), raw material, evidence of heat treatment, presence or absence of dorsal cortex, platform types, crushed and lipped platforms, weight, and size class in 5 mm groups. This abbreviated list of attributes would allow for the employment of the statistical procedures demonstrated (see Chapter 5) to be most useful to support the conclusions reported in Chapters 6 and 7.

Secondly, further testing of all the experimental results presented in this study should be undertaken. This requires more knapping to produce a sufficient number of pressure flakes in the manufacture of triangular bifaces from alluvial chert gravels to externally validate the discriminant function used to identify hard hammer and pressure flakes. It is hoped that all of the conclusions reached in the experimental work in this study will be tested with further experimentation, especially the use of the Sullivan-Rozen typology to separate bipolar reduction and patterned tool manufacture.

Thirdly, a separate use-wear analysis of the chipped stone artifacts and debitage with 50-100 X magnification would provide valuable information needed to better understand this site and the activities conducted with the tools, both formal and expedient. This type of analysis for the BF locus would have been helpful in picturing the activities represented by these artifacts.

Fourthly, Dr. Sandra Bierbrauer has done extensive work on the faunal and plant remains recovered from the various portions of the site (Sandra Bierbrauer, personal communication 2006). This data should be integrated with the data provided by the first recommendation. In addition, a study of seasonality, to determine when mollusks (principally quahog clam and oyster shell) were harvested during the year, should provide additional information as to the season of harvest and hence occupation.

Lastly, serious consideration should be given to archiving the records of the excavations and artifacts recovered from the KBS with the New Jersey State Museum. This institution has the facilities to house and conserve these archaeological materials. In addition, with the museum as the depository, greater access to artifacts and its attendant data will be available to a wider pool of researchers than the current storage plan provides.

1. In consideration of the length of this paper and to enhance readability, most abbreviations have been replaced by the actual words and terms in Chapter 7.

2. Sedentism may also be the result of an abundance of resources. Marine and wetland resources are often associated with this nonagricultural move to sedentism. The coastal areas of eastern and northwestern North America, coastal/highland Peru, and the gulf coast of Florida are among the areas that had experienced major reductions in residential mobility without agriculture (Kelly 1992:49-52).

APPENDIX A

Glossary of the KBS Lithic Artifacts Types

<u>Abrader:</u> A tool usually of oval to round gravels of quartzite or sandstone which is used to grind or prepare lithic edges for knapping. Possesses longitudinal scratches on one or more surfaces from contact with an objective piece.

<u>Biface:</u> A tool that is flaked on two surfaces to form an edge that circumscribes the tool.

<u>Bifacial Wedge:</u> A gravel that is bifacially flaked on one edge that forms a wedge shape. Flaking is accomplished by the bipolar method and evidence of crushing may be found on the distal portion where it comes in contact with the anvil. Sometimes referred to as a pièces esquillés.

<u>Bipolar Citrus:</u> A reduction fragment produced by the bipolar method which resembles the section of an orange usually from a roundish pebble with cortex in place of the orange rind.

<u>Bipolar Core:</u> An amorphous core that exhibits two opposing striking platforms or zones of percussion from which flakes have been detached. These zones are directly opposite each another. Generally one zone may be recognized as the base or the portion resting on the anvil. The basal zone usually has smaller flake scars that end in a hinge fracture, an area of crushing and bruising, and the large flake

scars on the core originate on the opposite or the proximal end struck by the hammer.

Bipolar Flake: A detached piece formed as a result of compression forces. These flakes often show signs of impact on opposing ends and have compression rings moving in two directions toward one another.

Core: Cores are objective pieces that have served as the parent source of flakes and display multiple flake scars. Cores may be unidirectional, that is the flakes have been removed in one direction only and they usually possess a single large flat surface from which flakes are struck. Cores may also be multidirectional in which flakes have been removed from several directions using different striking platforms.

Core Reduction Fragment: A blocky or angular piece of stone, rather thick, with remnant cortex, often with crushing apparent from hard hammer blows, truncated medially, which is the residue of core reduction of gravels by the bipolar method to produce flake blanks for tools or useable flakes for expedient use. Piece can be oriented as to dorsal and ventral surfaces.

Core Tool: A tool usually produced from cobbles or pebbles exhibiting little more than edge modification on one margin through the removal of decortication or edging flakes to create a simple cutting or chopping edge. Typically exhibits usewear in the form of small step fractures, crushing, or striations on the created edge.

<u>Fire Cracked Rock:</u> Thermally altered stone which exhibits color change due to impurities within the artifact which appear as cracks or holes in the stone surface caused by rapid heat combustion. Generally rough, angular, fractured sandstone, quartzite, and quartz, but also cherts in smaller sizes. Larger pieces are often associated with hearth features and smaller pieces with stone boiling.

<u>Flaked Cobble:</u> A stone fragment worn smooth by abrasion during transport whose greatest dimension is between 64 and 256 mm and has 1-2 flakes removed generally to test or determine the quality of the stone beneath the cortex.

<u>Flaked Pebble:</u> Small, roundish, waterworn rock fragment between 4 and 64 mm in greatest dimension and has 1-2 flakes removed generally to test or determine the quality of the stone beneath the cortex.

<u>Hammerstone:</u> A rounded hand-sized rock, often of quartzite and sandstone, used as a percussor to detach flakes from an objective piece and exhibits impact damage in the form of crushed edges.

<u>Pecked Stone:</u> Small, roundish, waterworn pebble/cobble or rock fragment with small pits or hollows (pockmarked) produced by battering on the edges or surfaces. May be an expedient tool for lithic reduction or processing of other resources.

<u>Projectile Point:</u> A biface which has an area for hafting and is used as a projectile tip for an arrow, dart, or spear.

<u>Reduction Fragment:</u> Any fragment of the processes of lithic reduction and manufacture which cannot be assigned to a flake type or to a flake fragment category. Dorsal and ventral surfaces cannot be identified. Often referred to as "shatter," "non-orientable fragment," or "chunk."

<u>Reutilized Material:</u> A gravel that shows signs of flaking or testing which has exposed the interior of the stone in a earlier time period. The margins of the flake scars are rounded or smoothed by the action of water and the formation of cortex on the flake scars has begun. The pattern and number of flake scars preclude natural fracture as a cause. This potentially usable material likely eroded out of sediments in the bay and was deposited on the beach face.

<u>Scraper:</u> A general term to indicate a tool that possesses unifacial retouch to produce an edge angle of approximately 60 to 90 degrees. The four types of scrapers found at the beach face are end scrapers, a double-sided end scraper, thumbnail scraper, and core scrapers.

<u>Split Pebble:</u> A pebble that has been split into halves, usually longitudinally, by the bipolar method which produces a relatively flat ventral surface. No evidence of flaking on margins.

<u>Uniface:</u> A tool derived from a flake which shows a unifacial preparation of the functional edges on either the dorsal or ventral face; usually ascribed to scraping or planing activities.

Unmodified Pebble: A pebble which is not found naturally in the contexts in which it was recovered and is assumed to have been brought there via human action. This item is often referred to as a "manuport."

Utilized Flake: A flake which has not undergone any intentional flaking modification and bears signs of use-wear on one or both margins usually in the form of tiny step fractures or striations/scratches. Often referred to as an expedient or informal flake tool.

APPENDIX B

Prehistoric Lithic Database Codes:Kimble's Beach Site (28CM36A)

James P.Kotcho
Rutgers University Department of Anthropology

Use With	Field	Explanation
All	Artifact Number	Unique number beginning with 1
All	Catalog Number	Field Catalog Number
All	Unit **TR**=trench **EU**=Excavation Unit **TU**=test unit **ST**=shovel test **GP**=general provenience	Provenience Unit
	Context or level	Provenience number beginning with 1
All	Quad **A,B.C,D, etc.** **SW,NW,SE,N**E	
	Feature	Feature number beginning with 1
All	Count	Number of specimens
All	Artifact Class	
	CS=chipped stone	flakes, core reduction fragments (shatter), points, scrapers, retouched flakes, cores, etc.
	OL=other lithic	FCR, cobbles, hammerstones, etc

Use With	Field	Explanation
	Artifact Type	
CS:	**BI**=biface	
	BF=blade flake	
	BL=blade	
	BLF=blade-like flake	
	BP=bipolar flake	
	BPC=bipolar citrus	
	BT=backed tool	
	BC=bipolar core	
	BW=bifacial wedge	
	BU=burin	
	CO=core	
	COM=composite tool	
	CRF=core reduction fragment	
	CT=core tool	
	DEN=denticulate	
	DR=drill	
	FC=flaked cobble	
	FP=flaked pebble	
	PER=perforator	
	PE= *pièces esquillées*	
	PP=projectile point	
	RBF=retouched blade flake	
	RTF=retouched flake	
	RPP=reworked projectile point	
	SCR=scraper	
	SP=split pebble	
	UF=unretouched flake or debitage	
	UTF=utilized flake	
	UN=uniface	
OL:	**AB**=abrader	
	ADZ=adze	
	ANV=anvil	
	ATL=atlatl weight	
	AXE-axe	
	BPS=bi-pitted stone	
	CEL=celt	
	FCR=fire cracked rock	
	HAM=hammerstone	
	MAN=mano	

Use With	Field	Explanation
	(OL, cont'd)	
	MET=metate	
	PIP=pitted pebble	
	PS=pecked stone	
	RUM=reutilized material	
	UC=unmodified cobble	
	UP=unmodified pebble	
CS, OL	<u>Raw Material</u>	
	ARG=argillite	
	ASH=argillaceous shale	
	CHA=chalcedony	
	CHT=chert	
	COH=cohansey quarzite	
	FEL=felsite	
	JAS=jasper	
	MET=metasediments	
	QITE=quartzite	
	QUE=questa quarzite	
	QTZ=quartz	
	RHY=rhyolite	
	SILT=siltstone	
	SND=sandstone	
UF	<u>Debitage Categories (SRT)</u>	
	1=complete flake	Complete distal and proximal end with intact striking platform.
	2=proximal fragment	Intact striking platform.
	3=medial fragment	No proximal end and stepped distal end.
	4=distal fragment	No proximal end and intact distal end with feathered, hinged, or plunging termination.
	5= reduction fragment	No recognizable dosal or ventral surface.
	6=split flake	Sheared axis of flaking.
UF	<u>Flake Termination</u>	Record for complete flakes and distal fragments
	1=feathered	

Use With	Field	Explanation
	(Flake Terminations, cont'd) **2**=stepped **3**=hinged **4**=plunging	
UF	Dorsal Cortex	
	0	No dorsal cortex.
	1	Cortex >0% and ≤50%.
	2	Cortex <100% but >50%.
	3	100% cortex on dorsal surface .
UF	Flake Size Classes **1**=>7.5cm **2**=5-7.5cm **3**=3.5-5cm **4**=2.5-3.5cm **5**=1.5-2.5cm **6**=.75-1.5cm **7**=<.75cm	Used for 20% sample only; longest dimension used to classify for heat treatment percentage. Size Classes used in this study were calculated by SPSS based on greatest linear dimension. See Chapter 4 for size classes.
UF	Platform Types	
	1=cortical	Platform completely covered by cortex.
	2=flat	Smooth flat surface; one scar.
	3=faceted	Platform ≥ 2 flake scars and rounded.
	4=abraded	Rounded platform that is abraded or ground.
UF	Platform Width	Measured in mm across the striking platform from lateral margin to lateral margin.
UF	Platform Thickness	Measured in mm in a perpendicular line across the platform width at the greatest distance from dorsal to ventral surfaces.
UF	Platform Crushed **0**=No **1**=Yes_	
UF	Platform Lip **0**=No **1**=Yes	

Use With	Field	Explanation
UF	Eraillure **0**=No **1**=Yes	
UF	Location of Point of Force **0**=Indeterminate **1**=one end of flake **2**=both ends of flake	
UF	Flake Scar Count	
	0=none	Completely cortical surface,no dorsal flake removals.
	1=0ne	One dorsal scar and some cortex.
	2=two	Two dorsal scars with some or no cortex.
	3=>two	More than two dorsal flake scars.
UF	Weight	Weight in grams.
UF	Maximum Length	Measured from point of impact in line perpendicular to the width of striking platform from proximal to distal end.
UF	Maximum Width	Measured in a line perpendicular to the line of flake length measurement.
UF	Maximum Thickness	Measured as the maximum distance from the dorsal to the ventral side perpendicular to the line of flake length measurement.
BI,PP,DR, SCR	Condition **1**=whole **2**=broken	

Use With	Field	Explanation	
	Broken-Description		
BI, DR, PP, SCR	**1**=proximal section	Basal section of tool	
	2=medial section	Mid-section of tool (tip&base missing).	
	3=distal section	Tip of tool.	
	4=base missing	Distal and medial portions present.	
	5=distal missing	Proximal and medial portions present.	
	6=tang missing		
	7=shoulder missing	One shoulder of triangle missing.	
CS	Thermally Altered	Thermal Indicator	
	0=No	**0**=None	**2**=Color
	1=Yes	**1**=Waxy Gloss	**3**=Color/Gloss
BI,DR, PP, SCR	Fracture Type		
	1=transverse		
	2=oblique		
	3=tip (impact)		
BI	Biface Reduction Stage (BRS)		
	0=Blank	Split cobble, incomplete working of lateral margins.	
	1=Preform I	Some cortex remains, lateral margins complete.	
	2=Preform II	Lateral edges not straightened, humps not removed.	
	3=Finished Biface	Completed triangular biface.	
PP	Point Type		
	ADE=Adena		
	AT=Archaic Triangle		
	BI=Bare Island		
	BIF=Bifurcate		
	BCN=Brewerton Corner-Notched		
	BEN=Brewerton Eared-Notched		
	BSN=Brewerton Side-Notched		
	ClO=Clovis		
	DAL=Dalton		
	ESH=Eshback		
	FIS=Fishtail		

Use With	Field	Explanation
	(Point Type, cont'd) **FCS**=Fox Creek Stemmed **FCL**=Fox Creek Lanceolate **GRE**=Greene **HEL**=Hellgramite **JRCN**=Jack's Reef Corner-Notched **JRP**=Jack's Reef Pentagonal **KIT**=Kittatiny Point **KCN**=Kirk Corner-Notched **KSE**=Kirk Serrated **KST**=Kirk Stemmed **LAC**=Lackawaxen **LAM**=Lamoka **LB**=Lehigh Broad **MSN**=Meadowood Side-Notched **MCB**=Meadowood Cache Blade **MM**=Morrow Mountain **NOR**=Normanskill **OC**=Otter Creek **PAL**=Palmer **PET**=Petalas **PERK**=Perkiomen **POI**=Poplar Island **ROS**=Rossville **SK**=Snook Kill **SNY**=Snyders **STN**=Stanly **SB**=Susquehanna Broad **TEA**=Teardrop **TRIA**=Triangle(Isoceles) **TRE**=Triangle (Equilateral) **TST**=Turkey Swamp triangle **UNY**=Untype **UCN**=Untyped Corner-Notched **VOS**=Vosburg **UNT**=Untyped Triangle **US**=Untyped Stemmed **USN**=Untyped Side-Notched	
CS, OL	<u>Weight (g)</u>	

Use With	Field	Explanation
BC,CO, CT,FP,BI, UC,UP,UP, HAM, RTF, SP,SCR, UNI	Maximum Length (mm)	Maximum distance in a line from proximal to distal end (BI). Long axis of piece.
	Maximum Width (mm)	Perpendicular line to axis of length at maximum width (BI). Maximum dimension perpendicular to length on the same plane.
	Maximum Thickness (mm)	Maximum width along a line perpendicular to length (BI). Maximum dimension. perpindicular to the planes of length and width.
FP,UP,UC, greatest BC, CO	Maximum Circumference (mm)	Measured by string along the circumference.
BC, CO, CT,FP	Core Type	
	1=Unidirectional	Flake removal in one direction away from a prepared platform
	2=Multidirectional	Flakes removed in more than one direction.
BC,CO,CT	Max. Linear Dimension (MLD)	Length of the greatest dimension (mm).
BC,CO,CT, UC,UP,FP	Geometric Shape	
	1=Oblate (Disk)	See measurement of length, width, and thickness for
	2=Bladed	all non-UF and BI above.
	3=Equant (Spheroid)	Shape determined by
	4=Prolate (Roller)	dividing width by length and thickness by width. Intersection on x and y axis of the ratios determines category.

Use With	Field		Explanation
FP,UP,CO, CT,BC,CRF, SCR	Percentage of Cortex		
	0	None	
	1	<10%	
	2	10-20%	
	3	20-30%	
	4	30-40%	
	5	40-50%	
	6	50-60%	
	7	60-70%	
	8	70-80%	
	9	80-90%	
	10	90-99%	
	11	100%	
PP	Blade Length (BL)		Tip of PP to tip of shoulder in mm
	Neck Height (NH)		Neck to base in mm
	Haft Length (HL)		Top of haft element to base in mm
	Blade Width (BW)		Shoulder to shoulder in mm
	Neck Width (NW)		Neck edge to neck edge in mm
	Shoulder to corner (SBC)		Shoulder to basal corner in mm
	Maximum Thickness (MT/PP)		Thickest portion in mm
	Basal Depth (BD)		Triangles, depth from a straight line connecting both shoulders to the midpoint of the base.
PP, BI, BW, CT, DR, PE, RTF, Scr, UN	Edge Angle Margins Base		Measured with goniometer, three measurements, enter as a range, e.g. **2**=30-39 degrees. PP-both margins, 5mm from tip and shoulder and midpoint.

1=20-29 **2**=30-39 **3**=40-49 **4**=50-59 **5**=60-69 **6**=70-79

Use With	Field	Explanation
RBF, RTF	Modified Surface (NOTES) **1**=dorsal **2**=ventral	
	Margin Modified (NOTES)	Orientation: Proximal end downward, ventral surface facing analyst.
	1=proximal **2**=distal **3**=left margin **4**=right margin	Use note block to describe retouch: if both sides, length of edge, and shape
PP	Sides **1**= straight **2**=incurvate **3**=excurvate **4**=Recurvate	
	Base **1**=straight **2**=concave **3**=convex	

APPENDIX C

LITHIC ARTIFACT DISTRIBUTION WITHIN EXCAVATION UNITS
BEACH FACE LOCUS, KIMBLE'S BEACH SITE

Excavation Units	Chipped Stone Artifacts*	Other Lithics*	Debitage	Totals** CSA N/%	Totals** OL N/%
TR 1	BC=1; BI=2; CRF=3; FP=1; SCR=3; SP=2	FCR=3	165	12/11.4	3/3.2
TR 2	BC=4; BI=2; CO=2; CRF=2; FP=1; SP=4	AB=1; FCR=9	529	15/14.3	10/10.6
TR 3	BC=2; BPC=1; CRF=2; FP=1; PP=1; SCR=1; SP=1	FCR=6; RUM=1	141	9/8.6	7/7.4
TR 4	BI=6; BPC=2; CRF=2; CT=1;FP=1	FCR=1; RUM=1	132	12/11.4	2/2.1
TR 5	FC=1; PP=1; SCR=1; UN=1	FCR=1; RUM=1	35	4/3.8	2/2.1
TR 6	SCR=1	0	0	1/1.0	0/0.0
TR 7	BI=1; CRF=1; FP=2; SP=1	FCR=4; RUM=2	89	5/4.8	6/6.4
TR 8	0	0	5	0/0.0	0/0.0
TR 9&9A	BI=5; CO=1; CRF=3; FP=1	AB=; PIP=4; UP-1	70	10/9.5	6/6.4
TR 10	CRF=1; FC=1	RUM=1	102	2/2.0	1/1.1
TR 11	BI=1; PP=1; SP=2	UP=1	30	4/3.8	1/1.1
TR 12	BC=1	0	1	1/1.0	0/0.0
TR 13	0	0	8	0/0.0	0/0.0
TR 14	BW=1; CRF=1	0	0	2/2.0	0/0.0
TR 17	BC=1; BI=1; BPC=1; CRF=5	AB=1; FCR=8; HAM=3; RUM=1; UP=5	553	8/7.6	18/19.2
TR 18	CO=1; CRF=1	FCR=2; RUM=1	51	2/2.0	0/0.0
TR 19	BI=2; CRF=1; CT=1; FC=1;SCR=1; UN=1	0	79	7/6.7	0/0.0
TR 20	CRF=1; SP=1	FCR=1; HAM=1; PIP=1; RUM=1; UP=1	0	2/2.0	5/5.3
TR 21	0	FCR=14; RUM=2; UP=1	0	0/0.0	17/18.1
TU 1	CT=1; SP=1	RUM=1	19	2/2.0	1/1.1
TU 2	BI=2; CRF=2; DR=1	RUM=1	68	5/4.8	1/1.1
TU 3	0	FCR=5	34	0/0.0	5/5.3
TU 4	0	0	9	0/0.0	0/0.0

APPENDIX C

LITHIC ARTIFACT DISTRIBUTION WITHIN EXCAVATION UNITS
BEACH FACE LOCUS, KIMBLE'S BEACH SITE

Excavation Units	Chipped Stone Artifacts*	Other Lithics*	Debitage	Totals** CSA N/%	OL N/%
TU 5	0	FCR=2; RUM=3	12	0/0.0	5/5.3
TU 6	FP=1	RUM=1	0	1/1.0	1/1.0
TU 7	0	0	54	0/0.0	0/0.0
TU 8	0	0	41	0/0.0	0/0.0
ST 11	PP=1	0	2	1/1.0	0/0.0
ST 21	0	0	1	0/0.0	0/0.0
Totals	105	94	2389	105	94

Note: *Abbreviations for artifact types found in Appendix B. **Number of artifact class/percentage of that class.

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