THE ABORIGINAL EXPLOITATION OF CUESTA QUARTZITE IN SOUTHERN NEW JERSEY

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The Aboriginal Exploitation of Cuesta Quartzite in Southern New Jersey

by

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Abstract

This thesis explores the aboriginal exploitation of Cuesta quartzite in southern New Jersey. The stone is an orthoquartzite, a silica-cemented quartzite that was formed at or near the earth's surface. The geological distribution of this material coincides with the Cuesta, the geomorphological ridge that separates the Inner and Outer Coastal Plains of New Jersey. Cuesta quartzite takes its name from this association. Although the material is very difficult to knap, it was extensively used in prehistory, principally for stemmed and notched bifaces, but also for hammerstones. Repetitive heat-treatment improves its flaking qualities and enabled ancient knappers to work the stone according to a staged sequence of bifacial reduction. When used as hammerstones, Cuesta quartzite was also repeatedly heated, with the apparent goal of modifying its toughness so as to customize the hammers to the stone being worked. In addition to affecting its toughness, heating the stone tends to redden it, to add luster, and to cause the entrapped quartz grains to sparkle, all of which had probable symbolic significance. The research employed experiments to gauge the effects of heat on the stone. Four skilled experimental knappers also flaked matched pairs of bifaces—consisting of one heated and one unheated specimen—to evaluate the knapping characteristics before and after thermal alteration. In all cases, the knappers reported improvement in the ease of flaking after heating. X-ray fluorescence analysis and laser ablation microprobe-inductively coupled plasma mass-spectrometry establish the geochemical composition of the material. The quartzite consists chiefly of silica with a host of other minerals and trace elements. The petrological analysis does not permit linking archaeological specimens to particular geological deposits. A battery of radiocarbon dates places the utilization of Cuesta quartzite between 6600 and 1600 B.P. Using the chaîne opératoire approach as its theoretical basis, this thesis integrates archaeological data and experimental results to reconstruct the aboriginal technology associated with the use of Cuesta quartzite during the period of its efflorescence. The analysis leads to the conclusion that both the ascendancy and decline of Cuesta quartzite as a lithic resource were fundamentally economic adaptations to a changing landscape. This thesis further highlights the benefits of collections research, archaeological investigations in the field of cultural resource management, and replicative experimentation. The work marks an advance in knowledge respecting a widely used but heretofore little studied lithic material.

Acknowledgments

In a very real sense, this thesis coalesces the collective efforts of many people. I am especially indebted to Jack Cresson for providing free access to his unpublished data, not to mention innumerable insights into the aboriginal use of Cuesta quartzite and virtually all matters relating to the archaeology of southern New Jersey. He also was instrumental in assisting with some of the experiments, including those involving knapping. Further he arranged contacts with experimental knappers, especially Dr. William Schindler, Scott Silsby, and Are Tsirk to whom are due great thanks for their ungrudging participation. He also secured information from certain private collections that otherwise would have been inaccessible. He read and commented on various earlier drafts of this document and capably attended to business affairs during my educational leave of absence.

Alan Carman very generously opened his extensive collection for my examination and provided information about specific objects therein. Gail Robinson, director of the Bridgeton Public Library, performed a similar service by granting access to the George Woodruff collection. Gregory Lattanzi, Registrar for the New Jersey State Museum, arranged for me to study the collections, despite the fact that the facility was closed for renovations during my research. Milan Savich brought several artifacts from his personal collection to my office for inspection and recordation. Lawrence Ledrich made available from his personal collection several examples of Cuesta quartzite bifaces for inspection and measurement.

Dr. Catherine Mathias provided access to the conservation laboratory in the Archaeology Unit at Memorial University, gave many helpful suggestions, and served as liaison with the Earth Sciences Department, where Pamela King consulted on the matter of petrological analysis. Ms. King arranged for sophisticated geochemical testing, the results of which have added immeasurably to the success of this venture.

Gillian Noseworthy, Curator of Archaeological Collections at Memorial University, was very helpful and supportive in many ways. Her very kind encouragement is earnestly appreciated. Also assisting in sundry ways was Karen Woosley, administrative assistant for the Archaeology Unit.

Dr. Jeffrey Behm in the Department of Anthropology at the University of Wisconsin kindly gave copies of scholarly articles and offered constructive comments concerning the heat-treatment of lithic materials. I am indebted to Mark Demitroff, Dr. Kathy Ehrhardt, and James Kotcho for sending obscure bibliographic titles for my use. Dr. Barry Gaulton gave good advice on a number of matters relating to the preparation of this thesis. Dr. Maria-Louise Sidoroff was generous with information concerning applications of chaîne opératoire to archaeological situations. Lauren Cook and Renee Brecht aided me with technical advice concerning matters relating to balky word processing programs. Bernard Powell offered many helpful ideas, particularly relating to aboriginal quartz quarries in New England. Jay E. Mounier read and commented critically on several chapters, and gave both advice and insights on a number of technical matters. Drs. Peter Ramsden, Lisa Rankin, and James A. Tuck examined the first draft of this thesis and offered many valuable remarks for its improvement. Drs. Adrian Burke, Priscilla Renouf, and Peter Whitridge read the revised version. Their critical comments have strengthened and clarified the final edition.

The Archaeology Unit provided comfortable office space for my use and granted a generous fellowship to offset the costs associated with my stay at Memorial University.

I am particularly indebted to my wife, Jerilyn P. Mounier for her unflagging support and constant encouragement. To Dr. Lisa Rankin, my advisor, I proffer sincere thanks, for without her sage guidance and cheerful direction, the attainment of my goal would have gone unrealized. Finally, I owe a debt of gratitude to Dr. James A. Tuck—or Jim, as he prefers to be called—for more than 40 years of encouragement, advice, and friendship. By precept and example, he has taught me and countless others how to do archaeology.

Of course, I am solely responsible for the conduct of this work and for this thesis that is its result. I accept responsibility for any shortcomings, errors, or omissions.

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Introduction

This research investigates the aboriginal exploitation of Cuesta quartzite in southern New Jersey in the interval between 6600 and 1600 B.P., spanning much of the Archaic period and extending well into Woodland times. Present indications are that both the earliest and latest uses were more sporadic than in the period of efflorescence, dating roughly from 3000-5000 years ago. The material was used extensively for the manufacture of bifaces, generally typical of the associated periods. Hammerstone manufacture in Cuesta quartzite—and use, of course—appears to be more common in the transitional episode between Late Archaic/Early Woodland times.

Technically an orthoquartzite, this material occurs in cobble fields along the Cuesta, the ridge that separates the Inner and Outer Coastal Plains in New Jersey. Although quartzite of this sort has been recognized in the region by geologists for well over a century, it has received scant formal geological investigation (Wyckoff and Newell 1988). Until work began on this study, Cuesta quartzite had inspired only local archaeological interest, beginning with loosely structured investigations by Jack Cresson (1975, 1995a, 2004). Later, my work in the field of cultural resource management (CRM) led me to increased interest in the material as a lithic resource in prehistory (see Chapters 4 and 5 for detailed references to my own research). Thus, responding to Ebright's (1987:42) admonition for research into "commonly used, but academically ignored, lithic material[s]," this thesis presents for the first time a detailed archaeological interpretation of Cuesta quartzite.

Archaeological evidence clearly shows that most artifacts produced in Cuesta quartzite were heated before being worked. Thermal alteration, which affects both the appearance and the knapping qualities of the stone, attended virtually all aspects of its use in prehistoric times. Aboriginal populations very likely viewed these changes in symbolic terms.

To understand the manner of its use in antiquity, this study casts Cuesta quartzite into a theoretical framework based upon the sequential modification of materials from their natural states to finished products, use, and on to discard, all within the contexts of the artisan's cultural and social milieu (Audouze 2002; Lemonnier 1992; Leroi-Gourhan 1993). By this device, coupled with extensive experimentation, this thesis develops a clear understanding of the ancient utilization of Cuesta quartzite.

Data for this analysis of Cuesta quartzite derive from the largely unpublished work of Jack Cresson (1975, 1995a, 2004) as well as from my own research, some of it extending back to the late 1960s. In this body of work, there are many sites that have yielded at least a smattering of Cuesta quartzite. Twenty of these sites have produced sufficient data to warrant fairly detailed treatment in this thesis.

Supplementary and complementary data come from experiments that concern the techniques and effects of thermal alteration on the rock and knapping in both heat-treated and unheated conditions. Experimentation is critical to learning. In the *Diary of Adam and Eve*, Mark Twain (1893) has Eve saying: "It is best to prove things by actual experiment; then you *know*; whereas if you depend on guessing and supposing and conjecturing, you will never get educated." This statement still rings true, especially for archaeological investigations that deal with unrecorded and long- forgotten technologies.

Each of the seven chapters comprising this work has been written as a free-standing document, which nevertheless links closely with the content of the others. I have attempted to divide the presentation so as to avoid pointless duplication. Cross-references between and within chapters provide readers with easy access to pertinent sections with respectively general or detailed content.

Chapter 1 puts the subject into a meaningful context by providing basic information about Cuesta quartzite in its natural and archaeological expressions. Then a description of methodology follows. That discussion deals with theoretical considerations as well as the techniques employed to measure and record data. Loosely based on chaîne opératoire (Audouze 2002; Lemonnier 1992; Leroi-Gourhan 1993), the technological sequences involved in working Cuesta quartzite provide the theoretical framework and couples the data with their interpretation. The role of symbolism as it relates to color and the use of fires in heat-treating the artifacts is also discussed.

Chapter 2 describes the culture history and environmental characteristics of relevant portions of New Jersey. The discussion then turns to the geology and the use of lithic resources by aboriginal populations, with a particular emphasis on the use of Cuesta quartzite. A series of 13 radiocarbon dates establishes the chronological framework, covering a span of more than five millennia. The chapter ends with a geochemical description of Cuesta quartzite as seen through petrological analysis.

Chapter 3 details the archaeological expressions of Cuesta quartzite in aboriginal material culture. Bifaces, debitage, and hammerstones are the principal artifact classes. I describe the artifacts in summary fashion and follow with a detailed presentation of linear dimensions, relational measures (such as length-to-width ratios), weights, and color. Statistical indices describe central tendencies and correlations in an attempt to evaluate relationships and associations.

The bifacial specimens share strong similarities in form and reduction trajectories demonstrating that they are the products of a single cultural tradition. I comment briefly on the geographic distribution of bifaces. The analysis of debitage indicates the character of knapping and gives insights into the nature of reduction strategies. Hammerstones show a transition from a tabular or cubical form to a nearly spherical shape. Like bifaces, hammers in Cuesta quartzite were often heat-treated to modify their physical properties. By this means ancient knappers could have a variety of hard and soft stone hammers in their knapping kits, while using only one raw material. Because of very extensive wear, accompanied by a reduction in size, I conclude that some hammerstones may have been maintained as heirlooms. The presentation of each artifact category leads to an interpretative discussion.

Chapters 4 and 5 provide archaeological data from my own research dealing with Cuesta quartzite in southern New Jersey. In particular, Chapter 4 details 11 sites in Burlington County, while Chapter 5 follows suit by presenting information on seven sites in Gloucester County. That chapter also makes mention of two other sites, whose contents do not warrant presentation in a separate chapter. Altogether, 20 sites are discussed.

The counties are geographically separated and contain suites of sites that appear to be more closely related within than across county boundaries, possibly because of physical proximity or occupation by related people. For this reason, I treat the remains in each county separately. Each of these chapters has a similar organization, which presents basic information concerning location, topography, edaphic conditions, drainage, as well as the character of the archaeological investigations and the nature of the finds. Artifacts are described and enumerated. Features, if present, receive similar treatment. The data are then interpreted in light of radiocarbon age determinations, if available.

Chapter 6 presents new, critically important data arising from experimentation concerning the thermal alteration and knapping of Cuesta quartzite. Several experiments with fire tested the conditions required to achieve effective thermal alteration of this material. Raising the temperature of the stone to as little as 200°C for a short time can redden the surface, increase reflectivity, and reduce fracture toughness. This chapter also relates changes in color and weight that result from exposing Cuesta quartzite to heat. The visible changes—principally a reddening of the stone and increased luster— provide clues to enhanced flakability and strongly suggest the symbolic role of fire in the manipulation of this material.

Four accomplished knappers experimentally flaked paired bifaces—one heat-treated and one not. All four knappers reported that the thermally altered stone was easier to flake than the quartzite in its natural state. Quantitative data coming directly from the experimentally produced debitage and bifaces substantiates this conclusion.

Chapter 7 offers a synthesis of archaeological and experimental findings, beginning with a discussion of the congruencies between archaeological and experimental data. Data gaps and inconsistencies between the two are also explored. The technological sequence for Cuesta quartzite utilization is reconstructed, with reference to the principal artifact classes found on archaeological sites, viz., bifaces and hammerstones. Dealing with these classes independently, the interpretation examines the aboriginal technology of working Cuesta quartzite in terms of the stages involved and the decisions likely to have directed the steps taken. The interpretation leads to the conclusion that a relationship based on mutual agency prevailed between the ancient knappers and the lithic material. This relationship was imbued with symbolic meaning, especially regarding the importance of color and fire.

A rationale for the initial exploitation of Cuesta quartzite is followed by an interpretation of the decline in its use. Both the ascendancy and descent are seen in economic terms. In the face of competition for valuable resources, Cuesta quartzite was recognized as a suitable complement to long-used materials that could only be obtained at a distance, and at some social and economic cost. The knapping of Cuesta quartzite followed a long-standing tradition of making large bifaces through a staged process of sequential biface reduction. With the realization that the ubiquitous cryptocrystalline pebbles—which comprise a major component of the regional geology—could serve as an alternate source of raw material, the exploitation of Cuesta quartzite diminished and eventually ceased. This change witnessed a shift away from a technology based upon staged biface reduction to one founded on the far simpler process of pebble-splitting. A final section provides an overview of the archaeological and experimental data and presents concluding remarks.

This work integrates traditional archaeology with experimentation, collections research, and investigations undertaken in the field of CRM. Experimentation has provided invaluable clues concerning the physical properties of Cuesta quartzite, the importance of heat-treatment, and knapping techniques, not to mention the intimate and often subtle interplay between knappers and stone.

This investigation further demonstrates the usefulness of collections research, which despite inherent limitations—chiefly involving weak or absent provenience data—provides complementary data concerning the geographic spread of specimens, as well as the range of variation in their size and form.

This work further underscores the validity of CRM as a vehicle for scientific research. Archaeology in that context provides access to data from frequently small or unspectacular sites that might not otherwise receive much notice. The integration of these varied data sources has been important to the success of this undertaking.

Throughout this work, I have tried to provide detailed references to the pertinent work of others, as well as to my own research. Appropriate citations appear throughout the text, and a comprehensive list of the works cited appears at the end of the document.

Chapter 1: General Background

This research investigates the aboriginal exploitation of Cuesta quartzite in southern New Jersey. Like many lithic materials, other than fine-grained or cryptocrystalline stone, Cuesta quartzite has been largely overlooked by archaeologists and geologists. This thesis provides for the first time a comprehensive description and analysis of this material as it was employed in antiquity.

In order to put the subject into a meaningful context, it will be necessary to provide some introductory information on the material itself, its natural and archaeological expressions. No archaeological account can be complete without a discussion of methodology. Methodology involves theoretical considerations as well as the techniques employed to measure and record data. A consideration of technological reduction sequences, inspired by the chaîne opératoire approach, provides the theoretical focal point, and forms a link between data and their interpretation. The techniques, instruments, and standards employed in this study are, for the most part, simple and straightforward. Each of these categories will be treated in turn below.

1.1) Cuesta Quartzite

Cuesta quartzite is a peculiar type of pale grayish brown, pink, or reddish quartzite. Its natural distribution follows the divide between the Inner and Outer Coastal Plains in New Jersey (Mounier 2003a: 157; see also Wyckoff and Newell 1988). That divide consists of a Cuesta, an asymmetrical ridge having one steep scarp and a gently inclined counter-slope (Hunt 1967:50, 137; Thornbury 1954:133). The material derives its name from this distribution. Jack Cresson, an archaeologist and highly skilled knapper, coined the term in the early 1970s.

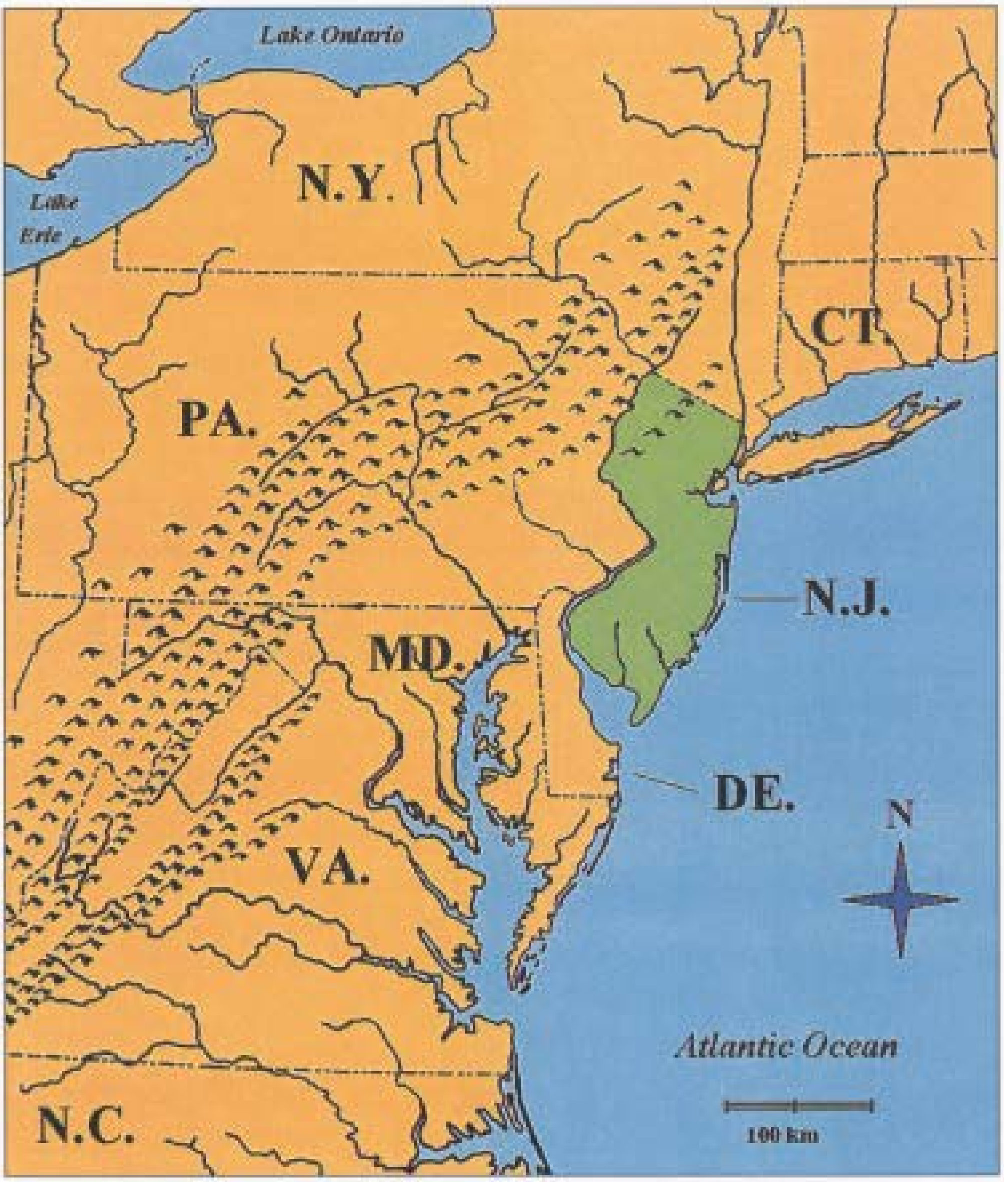


Figure 1.1: Map of New Jersey in Geographic Context
(Adapted from Stephenson and Ferguson 1963: Figure 30)

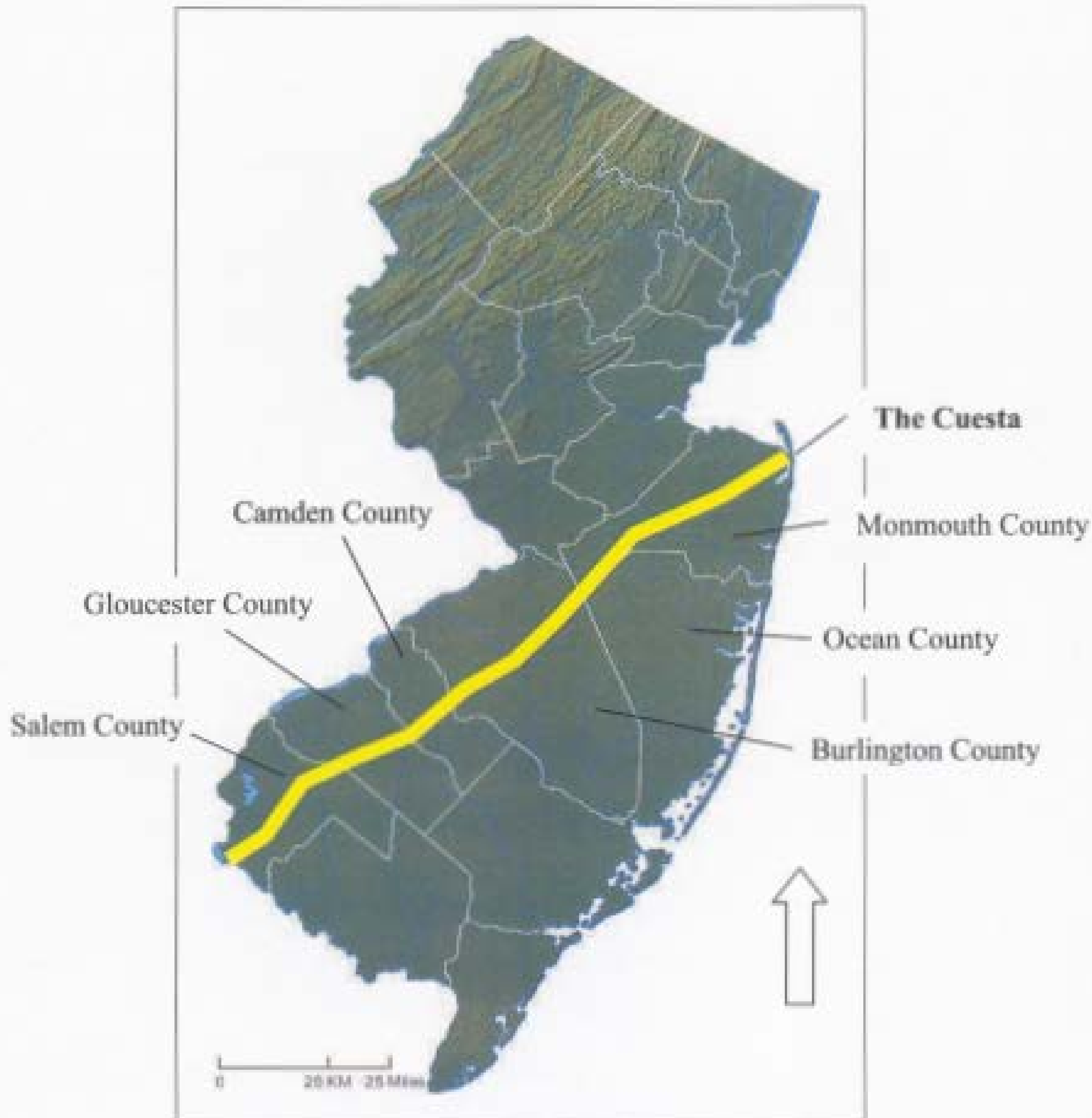


Figure 1.2: Map of New Jersey, Showing the Cuesta
(Source: New Jersey Bureau of Topography and Geology)

The geological origin of this material is not well understood for want of detailed investigation. The most current interpretation is that Cuesta quartzite formed as a silcrete or an orthoquartzite within a broad valley on low-gradient surfaces during warm, tropical conditions. Subsequent geological events have left the silcrete in elevated positions on the landscape. Geologists believe that this material dates to Pliocene times, from two to five million years ago (Wyckoff and Newell 1988). Chapter 2 delves into the geological aspects of this material in more detail.

Unlike flint, chert, obsidian and other fine-grained stones, which have been extensively studied in terms of their composition, distribution, physical properties, and flakability (Mercer 1893,1894; Hatch and Miller 1985; Jarvis 1988, 1990; Lavin 1983; Lavin and Prothero 1987, 1992; Loring 2002; Luedtke 1976, 1978, 1979, 1985, 1992; Mason and Aigner 1987; Prothero and Lavin 1990), quartzite has less frequently been the focus of sustained, systematic archaeological inquiry (Holmes 1893, 1919; O'Connell 1977; Dunning 1964; Saul 1964; Bottoms 1968; Ebright 1987; Bamforth 2006. The same is true of the examination of quartzite artifacts in collections (Lacaille 1939; Knowles 1941a, 1941b; Richards 1941), and in laboratory settings (Goodman 1944; Domanski and Webb 1992; Domanski, Webb and Boland 1994).

So far as I am aware, only Jack Cresson (1975, 1995a, 2004), Errett Callahan (1979), and Scott Silsby have undertaken sustained replicative work in quartzite, but others have engaged in short-term or ephemeral knapping experiments (Behm and Faulkner 1974; Ebright 1987; Hurst and Rebnegger 1999; Julig 2002; Hanson 2007).

Cuesta quartzite, itself, has been all but entirely ignored by archaeologists, Jack Cresson and I being the only exceptions. Working closely together, we have examined dozens of sites that contain artifacts in this unusual material. If others have done so, they have—with few exceptions (Liebeknecht et al. 1997)—failed to make note of it. Carol

Ebright's (1987) treatise on archaeological uses of quartzite in the Middle Atlantic region gives a good general summary, yet it too, makes no mention of Cuesta quartzite. Because others have ignored this material, data concerning its archaeological expressions are limited to my CRM studies and the personal researches of Jack Cresson. This thesis conflates those data into a single document.

In its archaeological expressions Cuesta quartzite first appears as isolated examples of very early biface forms. One fluted point of this material is housed in the Cumberland County Prehistorical [sic] Museum. Some stemmed bifaces of Early Archaic forms appear in collections, but they are quite rare. Beginning in mid- to Late Archaic times, Cuesta quartzite witnessed an efflorescence for a period of approximately four millennia (ca. 6000 – 2000 B.P.), after which it fell virtually into total disuse so far as the manufacture of formalized implements is concerned. The discontinuous use of Cuesta quartzite through time is intriguing.

At the height of its popularity, Cuesta quartzite was worked by a staged reduction strategy, proceeding from quarry cores to a series of refined bifaces, and eventually to discard. Another use emphasizes the production of hammerstones. As previously noted, none of this has ever been previously explicated. This thesis sets forth the explication.

In order for archaeological data to make sense, they must be understood in a unifying theoretical context. In this thesis, the concept of technological sequence, inspired by the chaîne opératoire approach, provides a solid theoretical anchor.

1.2) Theoretical Considerations

I explore the technological sequence of Cuesta quartzite reduction in antiquity as the theoretical basis for this thesis. This approach is influenced by chaîne opératoire, but I have not attempted to apply that device in a nuanced way. Generally attributed to Andre Leroi-Gourhan (1911-1986), the chaîne opératoire approach involves consideration of the sequences of choices, actions, and processes that lead to the transformation of a substance from raw material to a finished product. It is understood that the artisans and their operant technology function within a social setting and that their technological behavior can validate or change the social milieu (Audouze 2002; Lemonnier 1992; Leroi-Gourhan 1993). The study of technological systems permits working backward from the product to the procedures, and ideally to the intentions and decisions of the artisans involved in a production sequence.

Because the concept of chaîne opératoire has evolved over time and is applied differently in the Old and New Worlds, I focus on the technological manipulation of Cuesta quartzite. In so doing I make inferences concerning the steps in the reduction process as well as the choices and decisions that artisans made at each point in the sequence of operations.

Although it has been employed for other purposes (Sidoroff 2005), this approach is particularly suited to subtractive (or reductive) processes, such as knapping, in which each operation results in discrete and (often recognizable) residues: cores, bifaces, flaking debris, fragments, and so forth (Bleed 2001:118). Because Cuesta quartzite shows sequential processing, leading to a number of distinct products, its manipulation and use are amenable to this sort of analysis.

The analysis of lithic technology lends itself to integration with other theoretical concepts, such as economics, cultural ecology, agency, and actor-network theory. If one defines economics as the choices that people make in acquiring and disposing of resources (Friedman and Friedman 1980), then economic theory underpins a technological analysis solidly. Similarly, certain tenets of optimal foraging theory also apply (Byrne 1980:114-118; Cooper 1998). This appears to be a potentially fruitful approach for interpreting the periods of activity and quiescence in the ancient exploitation of Cuesta quartzite.

The question of choice plays into cognitive theory (Leroi-Gourhan 1993; Schlanger 1994), agency theory, and intentionality (Ahearn 2001; Dobres and Robb 2005; Sackett 1977; Sinclair 2000:200; Wobst 2000). Knowledge of the physical and social landscape is required to identify resources, to gain access to them, and to deploy them to satisfying ends. In this respect, a technological analysis relates to interpretation of mobility patterns and site function. The potential of an "agency approach" will be explored.

The roles of agents played by knapper and stone in an actor-network (Law 2003) can be seen in the behavior of modern knappers, expressed in gestures and speech (Bradley 2005). Knappers of my acquaintance frequently talk to the stone, coax it, and listen to it. For them, stones have personalities that differ within and between lithic types.

Evidence from modern knappers suggests that prehistoric artisans made a connection between the sounds emitted by rocks and their flaking qualities. While prospecting, contemporary knappers will strike a stone with a hammer. The rocks with more or less uniform internal structure produce clear musical tones and are selected, whereas those with flaws yield only a dull thud and are left in the field.

Upon finding specimens that ring true, Jack Cresson frequently performs a little ritual—a sort of celebratory dance, complete with skyward glances, body tremors, and orgasmic utterances (my personal observation). Cresson clearly has a meaningful, intimate relationship with those rocks, based on their "responses" to his exploratory percussions. For him, they are alive and willing to answer his call to service. I have observed other knappers talking to the stone as they work, coaxing it to give up flakes, and cursing it when it breaks. To generalize from these admittedly limited examples, I believe that ancient knappers must have experienced similar personal relationships with stone.

Some living people still use stone tools as elements of their traditional technology. For such people the relationship with stone assumes metaphysical significance that is intimately tied to its possession, manipulation, and an appreciation of its properties (McBryde 1997; Paton 1994). There is no reason to believe that earlier populations did not also embrace stone in spiritual terms (Moulton and Abler 1991).

I further believe that the enhanced color, luster, and reflectivity of Cuesta quartzite when heated played an important role among ancient knappers, with both symbolic and pragmatic considerations—symbolic because of the imagery evoked by redness and brilliance (Hamell 1983, 1992; Hall 1997; Miller and Hamell 1986; Mooney 1891; Morphy 1999; Taçon 1999; Kraft 2001; Loring 2002; Turner 1967), and pragmatic because of the enhanced knappability obtained by annealing the stone (see Chapter 6).

The role of individuals and groups as agents interacting with each other and with the resources themselves can only be understood within a theoretical framework (Dobres and Robb 2000). Sinclair (2000:200) has equated technological operations with the concept of agency, and Dibble (1995:304) has pointed out that sequential production leans heavily on the idea of intentionality. This focus raises the hopes that the biface reduction process that applies to Cuesta quartzite can be unraveled as has been done with other materials (Callahan 1979; Cresson 1982, 1984). Having discussed the general theoretical thrust of my research, I now turn to a discussion of methods.

1.3) Research Goals

The research was directed toward the completion of several tasks. For instance, I sought to explore the relationships between the natural and cultural distributions of Cuesta quartzite. By means of petrographic analysis I hoped to determine whether artifacts could be traced to particular geological deposits. I was also concerned with learning about the physical properties that made the stone attractive to human use. These properties include such things as mineral composition and the sizes of rock available for reduction. These characteristics must have influenced the range of artifacts that could be produced as well as their form and functions, not to mention the mechanisms involved in production.

It was important to ascertain how the stone was rendered into implements. Examination of archaeological specimens strongly indicated the importance of thermal alteration in the production of both bifaces and hammerstones. Accordingly, the role of heat-treatment was explored experimentally and the results compared against archaeological specimens. The same holds true for the characteristics of reduction by knapping. I employed the services of four accomplished knappers to attempt replications of formalized specimens recovered from archaeological sites. My observations of knappers in the process of gathering and working stone helped me to cast my interpretations of ancient human behavior in theoretical terms.

I was concerned with understanding the economic decisions that affected the use of Cuesta quartzite in terms of its initial exploitation, its transformation into tools and weapons, and its eventual abandonment as a raw material. This concern required that I place Cuesta quartzite into a regional archaeological context with regard to culture history, trends in settlement patterns, and inferred demographic conditions. Finally, I attempted to tie all of the foregoing elements into a plausible interpretive synthesis.

1.4) Methods

The following pages will discuss the methods employed in the investigation. The presentation begins with a word about official site-naming, followed in turn by a description of field methods, laboratory procedures, and collections research. The discussion then moves on to a description of the instrumentation used for taking measurements. Chapter 6 details the design and implementation of experimental work.

The classification and analysis of lithic remains is based upon current techniques and information in the fields of experimental stone-working and functional interpretation. Jack Cresson did all of the lithic analysis for the excavations herein described, thus eliminating the liabilities sometimes posed by employing multiple analysts (Gnaden and Holdaway 2000).

1.4.1) Collections Research

Beyond my field experience, research for this thesis took me to collections, both private and public. The principal private collections examined in this work include the Alan Carman collection and the George Woodruff collection, both huge assemblages, mostly gathered from sites in Gloucester, Salem, and Cumberland Counties, New Jersey. In addition, the collections of the New Jersey State Museum were examined for items made of Cuesta quartzite.

Gregory Lattanzi, Registrar for the New Jersey State Museum, generously arranged for me to examine the collection of relics gathered by the Indian Site Survey in the Depression Era (1936-1941), and summarized in two volumes by Dorothy Cross (1941, 1956). The requested items were selected after a review of the accession catalogues for all sites that included quartzite or sandstone bifaces.

In addition to the Indian Site Survey collections the State Museum also houses many donated collections. One particularly helpful collection was amassed by Ernest Stahl, formerly of Palmyra, New Jersey. Mr. Stahl was uncommon among collectors in his willingness to gather artifacts regardless of their condition. He also kept good records as to the location of his discoveries, which all derived from surficial contexts. His collection adds critically important information concerning bifaces as well as hammerstones in Cuesta quartzite.

Milan Savich kindly brought a few Cuesta quartzite bifaces from Marlton, New Jersey to my office for examination. Data concerning a few other samples came from the collection of Lawrence Ledrich, of Palmyra, New Jersey. The Gloucester County Chapter of the Archaeological Society of New Jersey generously provided information about lithic artifacts from the Ware site (28-SA-3), in Salem County, New Jersey.

Several items come from my own research in various parts of southern New Jersey over the last 40 years. Although the formalized specimens are not numerous, these specimens have the value of known provenience, recorded under controlled circumstances. In addition, the research was directed toward data acquisition rather than toward relic collecting for its own sake, in consequence of which the assemblages include not only finished specimens, but also items in various stages of reduction, as well as fragmentary examples, copious quantities of flaking debris, and several hammerstones.

Because of collector bias in favor of "perfect pieces" many assemblages in private hands do not display the range of forms that are known from controlled excavations to have been present anciently. Except for the artifacts in the Ernest Stahl collection, the private holdings contain few broken pieces, no hammerstones, and no flakes.

Many specimens in private collections have very weak provenience information. This lack prevents a full understanding of the geographic range of Cuesta quartzite in archaeological contexts. As presented in Chapters 4 and 5, the distribution of sites at which Cuesta quartzite was employed is as completely portrayed as presently available data permit.

The composite assemblage examined for this thesis comprises a representative sample of Cuesta quartzite bifaces from no fewer than 36 sites in Camden, Burlington, Gloucester, and Salem Counties. The range of forms includes early- and mid-stage bifaces and flake blanks, as well as formalized specimens that represent pristine, broken, and exhausted items in stemmed and notched varieties, each of which will be described in detail below (see Chapter 3).

1.4.2) <u>Measurement Techniques</u>

The following pages describe the particulars concerning the measurement of dimensions, the units used, and the instruments employed.

1.4.2.1) *<u>Linear Measures</u>*: All of the specimens that I examined directly were measured for length, width, and thickness, which later were used to compute important index ratios, such as width to thickness and length to width. I used digital calipers to measure the linear dimensions of the artifacts to 0.01mm. These dimensions were then rounded to the nearest 0.1 mm. Measurements previously made by others were recorded to the nearest millimeter.

1.4.2.2) Angular Measurements: Angles were recorded using an accurately inscribed steel protractor or goniometer of double-beam design. This instrument was used to measure tip-, blade-, and edge angles on bifaces and the facet angles on hammerstones. Measurements were recorded to the nearest degree.

1.4.2.3) Temperature: Three thermometers were used for measuring temperature in connection with heat-treating experiments. A minimum-maximum recording thermometer, graduated only in the Fahrenheit scale, was employed to measure ambient air temperature.

For direct readings of fire and heated rock I employed an electronic K-type, contact-thermocouple thermometer, having a capability of reading up to 1093° C (2000° F). I protected the plastic portions of the thermocouple from heat damage by inserting the probe through a hole in a refractory brick. Ordinary red clay bricks were used to build a tunnel to protect the instrument from flying embers.

For reading the temperatures of rock and earth at the hearth site, an electronic, non-contact thermometer was also employed. This instrument is calibrated only in degrees Fahrenheit and has an upper limit of 500° F (equivalent to 260° C). It is equipped with a laser pointing beam to identify the point of heat emanation. The contact- and non-contact thermometers were tested to ensure their compatibility and the reliability of test results. The dedicated calibration of some of the thermometers in the Fahrenheit scale required a conversion to degrees Celsius

1.4.2.4) <u>Weight:</u> I used a Hanson Model 9920 hanging scale, graduated in one kilogram increments, to record gross measurements of rock samples. An Ohaus Dial-O-Gram® beam balance with a capacity of 2,610g was used to measure artifact weights to the nearest 0.1g. The New Jersey State Museum had a traditional Ohaus triple beam balance, without a dial, with similar capacity. Specimen weights measured at the Archaeology Unit at Memorial University of Newfoundland were taken on an Ohaus Scout Pro digital scale. Reference samples previously weighed on other devices were found to have the same weights (within 0.05g) thus ensuring compatibility of results.

1.4.2.5) <u>Soil Moisture:</u> Because the amount of water present in the soil can affect its thermal and mechanical properties, it was necessary to record soil moisture in connection with experiments involving outdoor fires. A Kelway Soil Tester was used to measure soil moisture at the hearth site during heat-treatment experiments. This device gives a measure of available moisture, expressed as a percentage of the total if the earth were saturated. It is not a measure of saturation per se.

Measuring soil moisture is important because damp soil has much higher thermal conductivity than the same soil when dry. Damp soil has a larger capacity to store heat as well, so it takes more heat to raise the temperature to a certain level at a given depth in the soil.

1.4.2.6) Colors: Munsell Soil Colors are a recognized standard for recording the colors of artifacts (Munsell Soil Color Company 1975, 1988, 1992). Because of the complexity of recording colors, a brief description of the Munsell system will be presented. The Munsell scheme divides colors according to Hue, Value, and Chroma, wherein Hue represents the relation of a color to Red, Yellow, Green, Blue, and Purple. Value indicates the lightness of a color, and Chroma indicates departure from neutral for colors of the same lightness.

Although it provides a standard for judging colors, the Munsell system is not without its difficulties. For one thing, it is very unusual to find artifacts with colors that actually match any of the sample chips, so the investigator needs to develop some facility in interpolating colors. No two people see colors the same way, and specimens will radiate different colors depending upon the nature of the light source, whether the specimen is wet or dry, glossy or matte in texture, and so on. Accordingly, the principal problem with the Munsell system is arranging to record colors under circumstances that permit some degree of uniformity.

1.4.2.7) Fracture Toughness: Short of extensive physical testing, the mechanical properties of the stone can only be determined in an off-handed way. Based on extensive experience in knapping a broad variety of materials, Callahan (1979:16 [Table 3]) devised a scale for grading the ease of knappability. The scale ranges from 0.5 to 5.5, varying respectively from elastic to tough. Examples of very elastic materials include opal, some cold asphalts, and hard candy. On the opposite end of the scale are coarse quartzites, coarse rhyolites, felsites, and basalts. Most lithics rate about 3.5 on this scale. Cuesta quartzite would rank among the toughest materials. Cresson (pers. comm. 4 April 2007) ranks it as the toughest material likely to be encountered in prehistoric lithic assemblages.

Cuesta quartzite is amenable to heat-treatment, which renders it much more tractable. In this research, I have relied upon the experience of accomplished knappers to gauge the toughness of the stone in its heated and natural conditions. The consensus is that in its raw state, the material can be worked but only with great difficulty, whereas after successful thermal alteration, the knapping qualities are very much improved. Details of testimony from four knappers are presented in Chapter 6, which deals with experimentation.

The improved workability is accompanied by some loss in physical strength, which can be demonstrated simply by attempting to break heated vs. unheated flakes, as suggested by Callahan (1979:166). The former snap readily in the hands, whereas the latter cannot be broken this way. It is scarcely necessary to quantify the physical strength of Cuesta quartzite in engineering terms so long as the testimony of accomplished knappers can be trusted, for it is, after all, the question of knappability that is at issue.

There is good reason to believe that ancient knappers recognized the relationship between heating and loss of toughness. Biface designs offered substantial mass to compensate for the loss in material strength associated with heat-treatment. In addition, heat was evidently used to regulate the percussive qualities of hammerstones. Such behaviors cannot be dismissed as simple coincidences.

1.5) Analytical Framework

In order to produce a cogent interpretation of the prehistoric exploitation of Cuesta quartzite, I established a regime of quantification and testing. Artifacts from archaeological as well as experimental assemblages were counted and measured. The specimens were sorted into classes by form or inferred use (e.g., bifaces vs. hammerstones vs. flaking debris). I then recorded the linear dimensions (i.e., length, width, thickness or diameter) for formalized artifacts and calculated relational measures, such as the ratios of length to width and width to thickness.

All of the experimental pieces, including debitage, were weighed so that the loss of mass from early-stage bifaces to finished artifacts could be calculated. This procedure permitted the comparison of the economy of working Cuesta quartzite with respect to other materials, such as cryptocrystalline pebbles.

The experimental work also involved time studies to gauge the effectiveness of heat-treatment on Cuesta quartzite as well as a comparison of the time required to fashion artifacts from the quartzite in relation to cryptocrystalline pebbles.

I calculated simple statistics—such as Chi-Square and measures of central tendency—using the various dimensions of both archaeological and experimental specimens. When it seemed appropriate to do so, I also performed an analysis of correlations and regressions. The results are presented in tables and graphs.

1.5.1) Proportional Indices

I employed two proportional indices in the analysis of archaeological assemblages. Seventeen sites yielded suitable data. The first index is the proportion of unbroken or identifiable flakes by types, which compares flakes presumably derived from earlier stages of bifacial reduction to those of later stage processing. The second relates the number of flakes to the number of bifaces of a given material. I attempted to determine pertinent threshold values for each index so that simple ratios would provide some basis for determining the characteristics of knapping at the sites under consideration.

1.5.1.1) Proportional Flake Analysis: Proportional flake analysis attempts to assess the character of knapping at a site by calculating the ratio of earlier to later stage flakes. Earlier stage flakes include early-stage, decortication and primary flakes, which reflect the massive removal of stone in the initial stages of tool production (see Chapter 3). The later stage flakes—thinning and late-stage flakes—derive from biface thinning, finishing, or resharpening. When the proportions or earlier to later stage flakes are approximately the same, a full range of multi-stage processing can be assumed, all else being equal.

If the proportion of one stage rises sharply in relation to the other, then the predominance of the more strongly represented member may be tentatively inferred. For example, experimental knapping undertaken for this thesis shows a ratio of approximately 6.3:1 for later to earlier stage flakes as a result of the reduction of mid-stage bifaces to formalized specimens. Assuming an unbiased archaeological sample, the greater the difference between the calculated ratio and its inverse, the more likely the index is to read true. In sites with fewer than 200–300 flakes, I would regard ratios of less than 3.0:1 as being weak indicators of specific flaking activity. As the flake count increases, smaller indices may assume greater interpretive value.

For each site with sufficient data, I also plotted the percentages of primary, thinning, and late-stage flakes, which respectively represent the early, middle, and late stages of bifacial reduction. A simple ternary diagram, using only four sites for clarity, appears in Figure 1.3. Each corner represents 100% of the designated flake types, and the opposite boundary represents a value of zero. In this graph, the flakes at 28-BU-473 (A) show an emphasis on early-stage processing, while those at 28-BU-403 (B) indicate a more balanced range of bifacial reduction. The flakes at 28-GL-344 (C) exhibit a slight emphasis on thinning and then on late-stage work. Finally, the debitage at 28-BU-492 (D) displays an emphasis on late-stage reduction; A similar graph, depicting the arrangement of flakes at all sites with suitable data, appears in Chapter 7 in support of my interpretations of the ancient technological sequence of Cuesta quartzite knapping.

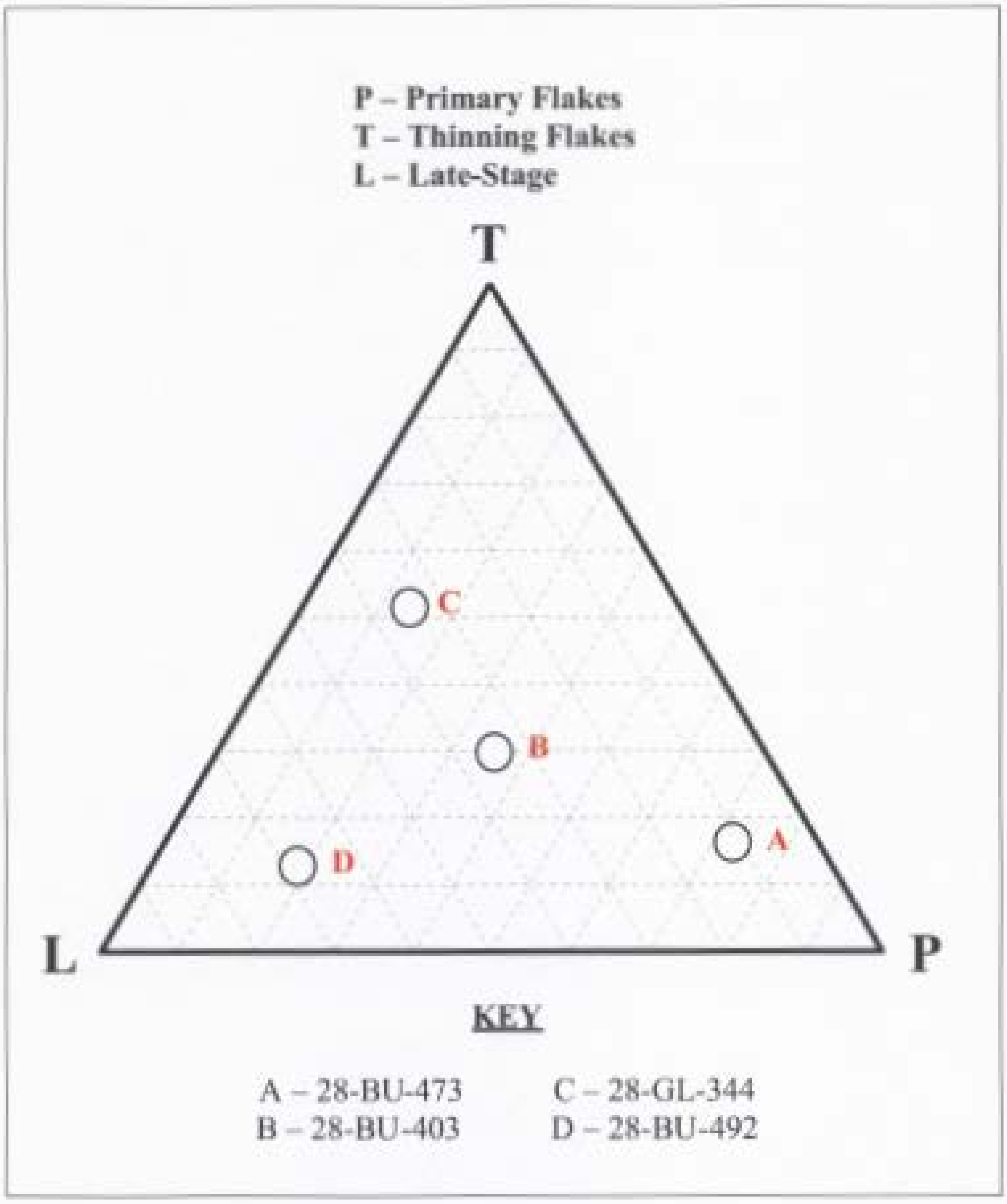


Figure 1.3: Flakes as Interpretive Aids
(Percentage of Flake Types at Various Sites)

1.5.1.2) Flake-to-biface Analysis: The second index relates the number of flakes to the number of bifaces of the same material on a given site. A high proportion of flakes to bifaces indicates the manufacture and, possibly, the maintenance of tools. This statement holds true because knapping—especially production work—creates a great number of flakes. A low flake-to-biface ratio more likely indicates maintenance only. In this case, the tools subject to maintenance may have been manufactured off-site and imported as finished or nearly finished pieces. A disproportionately small flake-to-biface ratio may also indicate sampling errors.

Experimental knapping yielded from 959 to 2,943 flakes of all types for each successfully produced biface (Chapter 6). For bifaces made experimentally from large flakes rather than from cores, the ratio is approximately 60:1. Generally, the archaeological data yielded much lower flake-to-biface ratios than those obtained by replicative knapping. The range in archaeological sites varies from 7.9:1 to 458:1. I discuss the reasons for, and the implications of, this discrepancy in Chapter 7. In light of experimental work, I would consider values of less than 60:1 to be weak indicators of biface knapping on any given site, especially if the assemblage otherwise indicates the production of bifaces from cobble cores.

1.5.1.3) Assessment of Proportional Indices: Both proportional flake analysis and flake-to-biface analysis work best in sites that have not been subjected to heavy collecting pressure or undue disturbance by natural and cultural agencies. Both are susceptible to sampling errors, which may be difficult to identify or quantify.

These indices must be employed with caution and interpreted in relation to each other and with respect to the general composition of the assemblage. For instance, site 28-GL-33 lies adjacent to a natural deposit of Cuesta quartzite and yielded a relatively high number of early-stage bifaces. Accordingly, one would expect that the knapping debris would show an emphasis on early-stage production. However, if considered alone, the proportional flake analysis would indicate a predominance of late-stage knapping. The flake-to-biface ratio was 46:1, which is not an especially strong measure of biface manufacture from cobble cores. I suspect that the removal of finished bifaces from this site (by ancient artisans and modern collectors) masks the formalization of bifaces at this site. On sites where the composition of the assemblage and the proportional indices are in accord, these measures help to define the nature of knapping more clearly than would be possible without them; otherwise, the results must be cast in more tentative terms.

1.6) Summary

This chapter has reviewed the archaeological desiderata concerning the study of Cuesta quartzite. It has given general information about the material in its natural and cultural contexts. The various methods employed in this research have also been considered along with a review of the theoretical basis of the study. Finally I identified pertinent research questions and analytical approaches.

Chapter 2: Cultural and Geophysical Background

This chapter sets forth descriptions of the culture history and environmental characteristics of New Jersey. The chapter begins with a summary of pertinent archaeological cultures in New Jersey. A description of the physiography, climate, vegetation, and wildlife is then offered. These topics are followed by a presentation of facts relating to geology and the use of geological resources by aboriginal populations, with a particular focus on the ancient use of Cuesta quartzite in archaeological context. A brief section summarizes the chronometric framework established on the basis of radiocarbon dating. The chapter ends with a description of Cuesta quartzite as seen through geochemical analysis.

2.1) Archaeological Cultures in Time

The prehistoric archaeology of New Jersey has been ordered within a general cultural-historical framework that has been applied over the years to the entire eastern United States. The basic outlines of this framework have remained unchanged since the 1952 publication of Griffin's *Archaeology of the Eastern United States* (Griffin 1952), in which sub-regional summaries of the development of aboriginal culture were divided into the following categories: Paleoindian, Archaic, and Woodland.

The primary use of Cuesta quartzite pertains to the transitional era between the Late Archaic and Early Woodland periods; hence the following summaries will highlight only that segment of the culture history in New Jersey. Further, the importance of knapping—

and to a lesser extent, the manufacture of stone hammers—in Cuesta quartzite justifies the highly abbreviated treatment of cultural historical development that follows.

2.1.1) The Archaic Period (ca. 8,000 - 3,000 years ago)

Emerging out of the Paleoindian tradition, the Archaic period was first described by William A. Ritchie in New York State. Ritchie (1932) defined the Archaic period as "an early level of culture based on hunting, fishing, and the gathering of wild vegetable foods, and lacking pottery, the smoking pipe, and agriculture" (also see Ritchie 1965:31). Among archaeologists, the term "Archaic" is now generally taken to mean a period of time or a stage of cultural development characterized by a hunting and gathering economy based upon the seasonal exploitation of natural resources by relatively small, mobile bands.

Typical toolkits included a broad range of weapons and implements, fabricated by knapping and grinding. Archaeological assemblages include but are not limited to projectile points and knives, scrapers, flake tools, as well as axes, adzes, grinding tools, and expedient, rough-service implements. The foremost in this list are of particular interest here because of their similarities and contrasts to bifacial implements of Cuesta quartzite.

The archaeological expressions of the Archaic period reflect the continual cultural adaptation to new environments emerging in post-Pleistocene times, particularly in riverine settings. These adaptations led to expanding populations that extended into the most remote headwaters by Late Archaic times, although the hinterlands remained sparsely settled throughout prehistory (Figure 2.1; cf. Figure 2.2).

Archaeological sites of this period show increasingly extensive and intensive exploitation of predictable resources, especially nuts and acorns. Net fishing is archaeologically evident along the Delaware River, particularly above the head of tide, but elsewhere is rather poorly represented (Cross 1956: 70, 104; Kraft 1975:112; Mounier 2003:138-141). Where preservation is good, there is abundant organic evidence for hunting, particularly of whitetail deer. A plethora of projectile points and atlatl weights denotes the same practice.

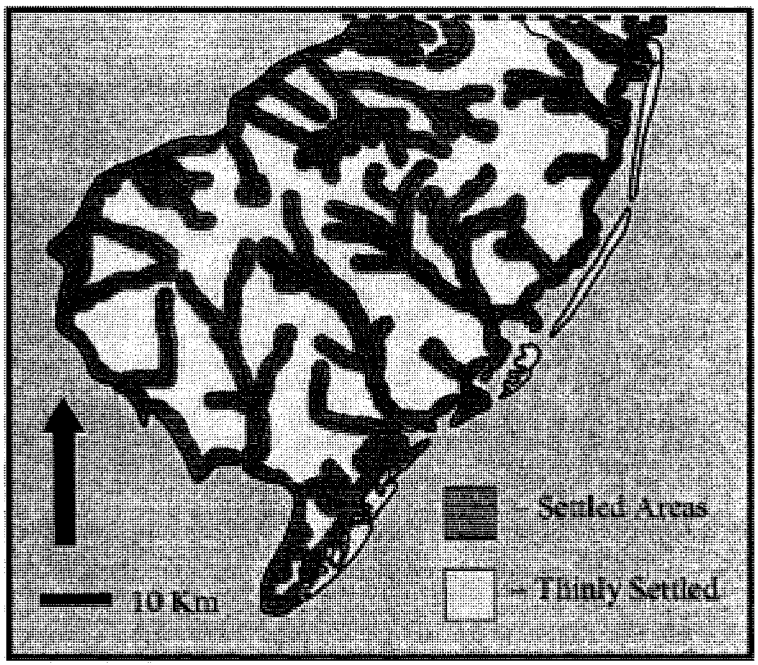


Figure 2.1: Settlement at Archaic Maximum (5000 – 3000 B.P.)

The earlier Archaic cultural expressions are mostly broad-bladed bifaces, some of which are stemmed, or notched near the base. Others have bifurcated bases (Coe 1964; Broyles 1966, 1971; Dincauze 1971; Ritchie and Funk 1971). Many bear serrated blades. The Palmer, Kirk-Stemmed and Corner-Notched are among the best known Early Archaic bifaces. The bifurcate-base LeCroy points are examples of Middle Archaic bifaces. The distribution of the cultures at the early end of the time scale is somewhat spotty.

Also appearing in Middle Archaic times are long, contracting-stemmed bifaces in the Morrow Mountain-Poplar Island-Rossville continuum (Coe 1964: 37-43; Ritchie 1961: 44-46), which transcends the Middle, and Late Archaic periods and endures into Woodland times. Bifaces of this form appear at sites across the region about five or six thousand years ago. It is about this time that Cuesta quartzite came to be used extensively in the southern portions of the state.

Very late in the Archaic period, broad-bladed bifaces–sometimes called "broadspears"–make their appearance (Ritchie 1961: 42-43, 53-54; Witthoft 1953). These are forms that appear to have originated in the Southeast about 4,000 years ago (Coe 1964). There are a number of varieties, which seem to overlap in time. In New Jersey, broadspears often were made from argillite, chert, or rhyolite, imported from distant quarries. Broadspears are principally interesting in the present work because of the staged nature of their reduction, which offers certain parallels with the technology employed in knapping bifaces of Cuesta quartzite.

An abundance of ground stone tools, particularly grooved axes, demonstrates a focus on land-clearing, along with the performance of simple maintenance tasks, such as gathering firewood. Axes, adzes, and gouges indicate the importance of woodworking in a forest environment. They signify the production of watercraft, principally dugout canoes, which facilitated access to varied points on the landscape, well up into the headwaters of the drainage basins (Mounier 2003:113). Moreover, woodworking gear also implies the construction of structures and facilities, which, in turn, suggests increasing residential stability.

The largest and most complex settlements occur along the tidal stretches of the streams, in locations that afforded both an abundance and diversity of natural resources. Sites at the river mouths and in the headwaters are generally smaller in size, technological complexity, and inferred population density.

As the landscape filled up over time, the human populations must have witnessed increased competition for resources of all sorts. Taking recourse to marginal lithics, such as Cuesta quartzite, may be viewed as a response to the increasing social and economic costs associated with using the more tractable materials, such as quarried jaspers and argillite, which were very widely exploited, but quite distant and localized in their natural distribution.

2.1.2) The Woodland Period (ca. 3,000-500 years ago)

The advent of pottery making about 3,000 years ago ushers in the Woodland period, which endured through successive stages of development (identified as Early, Middle, and Late Woodland) into the sixteenth century. Archaeology says little about the period between A.D. 1500 and the arrival of Europeans in the early decades of the seventeenth century, possibly because of a decline in the native population as a result of exotic diseases (Witthoft 1963:64; Ramenofsky 1987).

In general terms the Early Woodland is represented by material survivals of the preceding Late Archaic period to which was added the fabrication of ceramic vessels. Along with pottery and woodworking tools, there existed a variety of stemmed and notched projectile points and other lithic implements (Kinsey 1959; Ritchie 1961; Hummer 1994). Many Cuesta quartzite bifaces are typical of these forms.

Additions and refinements in material culture continued apace through the Middle Woodland period, which remains nebulous across most of the state and the region as a whole (Cross, 1941, 1956; Ritchie 1961, 1965; Ritchie and Funk 1973; Thomas and Warren 1970; Williams and Thomas 1982; Hotchkin and Staats 1983; Mounier 1991; Mounier and Martin 1992; Stewart 1998). Some patterns of Late Woodland life developed as an out-growth of earlier cultural adaptations.

There is an apparent increase in the size and number of occupied settlements, but the range of intensively exploited habitats shrinks from the peak witnessed in Archaic times (Figure 2.2). Sites in the extreme headwaters are no longer occupied, or were visited so infrequently as to leave little detectable trace (Mounier and Martin 1992). Some of the larger sites contain pits for food storage, as well as house patterns, which indicate residential stability or even sedentism (Kraft 1975:85; Stewart, Hummer, and Custer 1986:83).

Ceramics tend to become more refined and recognizable as local products, with designs that suggest technological traditions based on kinship (McCann 1950:315; Mounier 1991:VI:6-11; Morris et al. 1996:25-31; Stewart 1998:75-77, 98, 111-112; Kraft 1974:33-

46, 1975:59-61). These changes suggest a trend towards settlement in permanently occupied territories by a number of distinct bands. The hinterlands remain thinly settled.

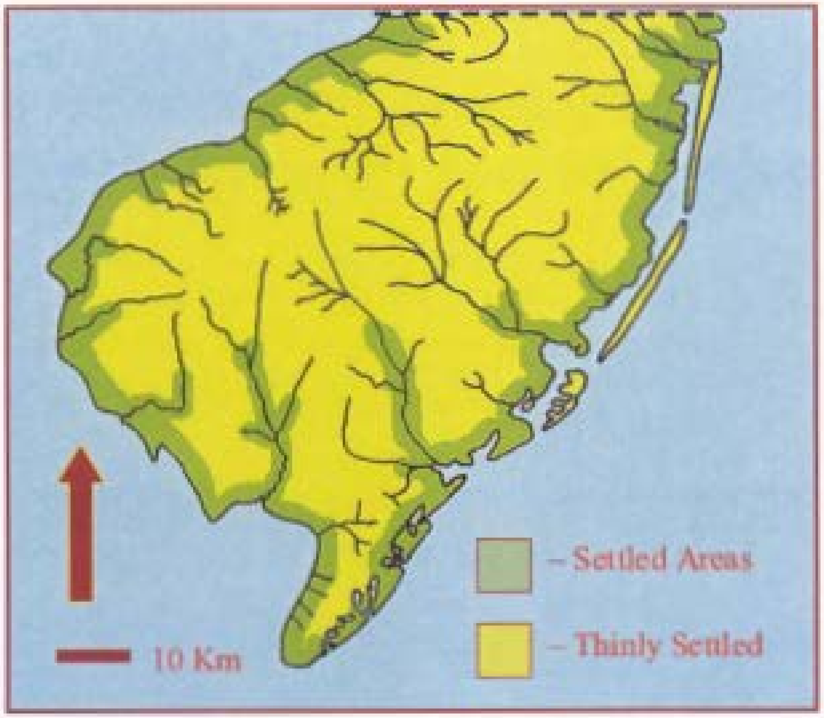


Figure 2.2: Late Prehistoric Settlement (1500-500 B.P.)

While the ceramic arts became more refined, stonework in general declined. The earlier knapping traditions—based on carefully prepared quarry- or cobble-preforms and flake blanks—were supplanted by a simple technology based on the expedient, almost haphazard, flaking of common pebbles.

The appearance of small triangular arrowheads is generally taken to mark the introduction of bow hunting (Kraft 2001: 30; Ritchie 1965:passim, but see Odell 1988; Shott 1993; Nassaney and Pyle 1999 for different points of view). As shown experimentally

(Chapter 6), these arrowheads could be fashioned quickly from cryptocrystalline pebbles that are ubiquitous on the coastal plains.

Downscaling in the size of bifaces is matched with concomitant size reductions in other implements, such as woodworking tools, which could also be made from locally gathered materials. Small celts and adzes—rarely more than a few centimeters long—replaced the cumbersome tools of earlier epochs. By Middle Woodland times, the widespread acceptance of smaller bifacial types—and of lithic technology in general—correlates with the sharp decline in the use of Cuesta quartzite. These changes appear to be tied to the recognition of locally available pebbles as acceptable raw materials.

2.2) Physiographic Provinces

New Jersey has five major physiographic provinces, all of which are part of larger regions with similar geological structures and histories (Figure 2.3). These regions extend well beyond the borders of New Jersey in a northeast to southwest trend along the eastern seaboard (Kümmel 1941; Widmer 1964; Robichaud and Buell 1973; Wolfe 1977). These provinces include the Ridge and Valley, the Highlands, the Piedmont, and the Inner and Outer Coastal Plains. The last two have critical importance with respect to the study at hand, and are the only ones treated in detail below.

2.2.1) The Coastal Plains

The coastal plains cover about 3/5 of the land area of New Jersey, including all of Cape May, Cumberland, Salem, Gloucester, Camden, Atlantic, Burlington, Ocean, and

Monmouth Counties. The combined total size of the coastal plains is 19,210km^2 (7,417 square miles). This expansive region consists of geological formations that include large deposits of clay, silt, sand, and gravel. The surficial geological formations are of Quaternary or Tertiary age. The most important from the standpoint of the present research is the Bridgeton Formation, which is described in more detail elsewhere in this document.

The region is commonly divided into two districts—the Inner and Outer Coastal Plains—because of differences in geological history, soil development, associated biological communities, and human settlement (Widmer 1964:90-91; Wolfe 1977:207-208).

Not more than 24km (15 miles) wide, the Inner Coastal Plain is a relatively narrow band that skirts the southeastern edge of the Piedmont from the Raritan Bay to Trenton, thence along the Delaware River into Salem County. The Outer Coastal Plain is a much broader district. The geological boundary between the two is marked by a band of hills or cuesta caps, which are crowned with relatively hard, consolidated limonitic sandstones and gravels (Cook 1868:286). North of this line of cuesta caps, the land drains into New York Bay and the Raritan River, while to the west the drainage runs to the Delaware River. The Outer Coastal Plain, on the other hand, drains southward and eastward respectively into the Delaware Bay and the Atlantic Ocean. Elevations across the coastal plains range from sea level to somewhat more than 61m (200 feet) above sea level. Much to the mirth of highlanders everywhere, the highest peaks are known locally as mounts (e.g., Mount Laurel) or mountains (e.g., Forked River Mountains).

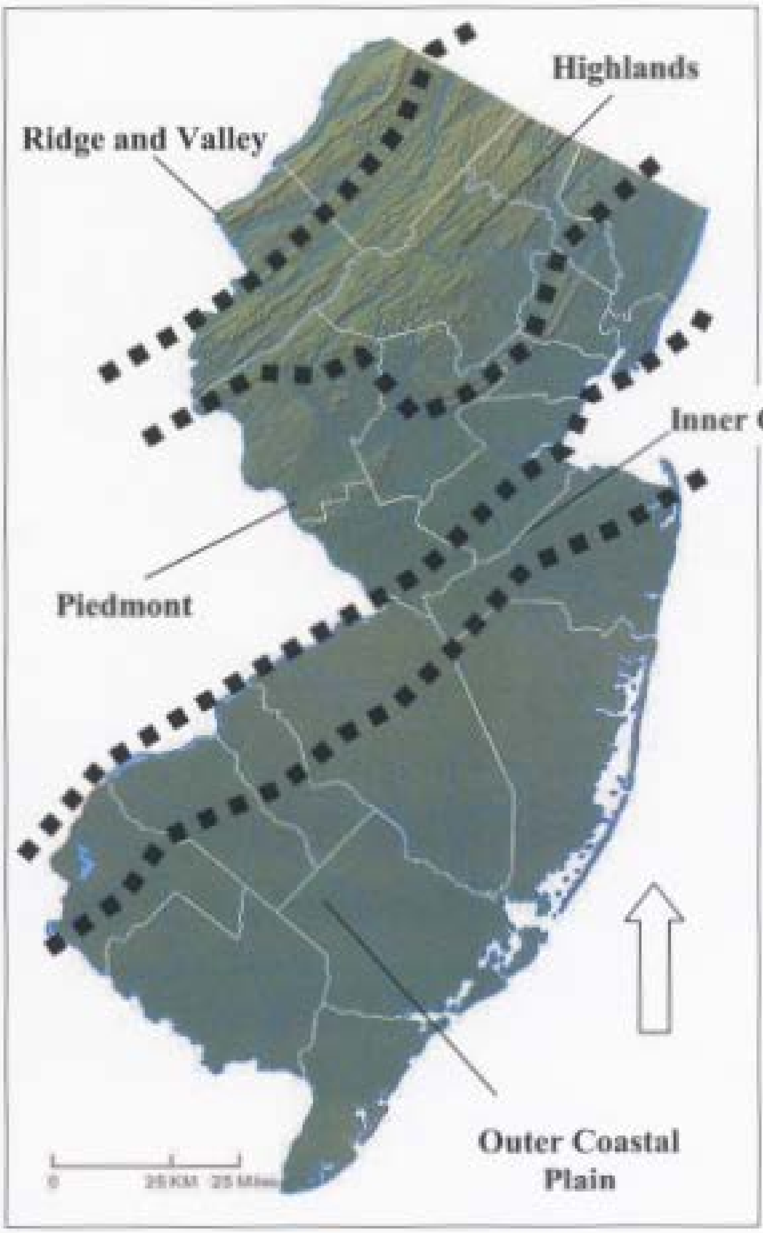


Figure 2.3: Physiographic Provinces of New Jersey
(Source: New Jersey Bureau of Topography and Geology)

The Inner Coastal Plain contains unconsolidated deposits of clay, sand, and gravel of Pleistocene age (up to 1 million years old) superimposed upon beds of Cretaceous marl and related strata (dating between 135 and 70 million years ago), whereas the Outer Coastal

Plain is composed of deep deposits of quartz sand, gravel, and clay of Tertiary (70-1 million years ago) and Quaternary age (1 million to 100,000 years ago).

As compared to the soils on the Outer Coastal Plain, the Inner Coastal Plain soils possess generally finer textures, and owing to higher clay fractions, tend to retain moisture for longer periods of time following precipitation. Largely because of the presence of marly deposits, the Inner Coastal Plain soils also have a greater natural fertility than those on the Outer Coastal Plain.

2.3) Geological Framework

The geology of New Jersey is quite complex and still incompletely understood. Because Cuesta quartzite occurs solely upon the coastal plains, the recounting of geology will focus on that portion of the state. Historically, geologists have identified four principal post-Cretaceous formations that comprise the coastal plains of New Jersey. From most ancient to most recent, these formations include the Beacon Hill, Bridgeton, Pensauken or Pennsauken, and the Cape May Formations (Salisbury and Knapp 1917; Widmer 1964:133-134). All of these formations consist principally of quartz sand, with variable amounts of other cryptocrystalline rocks, sandstones, quartzites, and conglomerates. Dissolved iron is a major constituent, which gives the formations a yellow cast. Consequently, these four formations are often called the "yellow gravel formations" (Widmer 1964:133). Of the four, the Bridgeton Formation is of particular interest to the present study, because it contains the principal deposits of Cuesta quartzite.

2.3.1) The Bridgeton Formation

The Bridgeton Formation consists of an unconsolidated mantle of highly weathered sand, clay, and gravel, up to 18.3m (60 feet) in thickness. This formation covers much of the surface of the coastal plains of New Jersey, particularly on the uplands overlooking the lower ground along the Delaware River (Salisbury and Knapp 1917:12). More sporadic exposures occur in diverse locations upon the Outer Coastal Plain (Lutz 1934:404; Salisbury and Knapp 1917:31, 40; Wolfe 1977:286-287).

Like all formations on the coastal plains of New Jersey, the Bridgeton Formation has a southeasterly dip, and strikes to the northeast-southwest. It outcrops along its strike in an eroded asymmetrical ridge that stretches from Salem to Monmouth Counties. A relatively steep scarp faces the Delaware River, while the long, gentle slope overlooks the Atlantic Ocean. Geologists refer to ridges of this form as cuestas (Hunt 1967:50, 137; Thornbury 1954:133; Figure 2.4). Denotatively, cuestas are ridges having ridges that face up-dip and long, gentle slopes in the down-dip direction. Cuestas are characteristic of the Atlantic Coastal Plain physiographic province from the Gulf Coast to New England (Hunt 1967:50; Thornbury 1954:133). Erosion of cuesta scarps led to the formation of isolated remnants or outliers (Thornbury 1954:137). Representative examples in New Jersey include Arney's Mount, Mount Holly, Mount Laurel, Woodbury Heights, and Mullica Hill (Widmer 1964:91). In New Jersey, less prominent cuesta caps remain unnamed or have only local appellations (e.g., Signal Hill, Red Man's Hill, Stone Mountain [see Figure 4.5]).

Within the Bridgeton Formation are found boulders of shale and quartzite, the latter comprising what archaeologists now call Cuesta quartzite. These boulders were known among the country folk as "bullsheads," presumably because their size approximated that of a bull's head (Salisbury and Knapp 1917:13, 31). Often about 0.5m (1½ feet) in diameter, some of the boulders can measure up to 1.5-1.8m (five or six feet) in greatest dimension (Salisbury and Knapp 1917:20, 40; Wyckoff and Newell 1988:40). Salisbury and Knapp (1917: 31) and Friedman (1954:236-237) identified a concentration of quartzite boulders between Oldmans and Raccoon Creeks, particularly in the locale to the south of Swedesboro in Gloucester County. Wycoff and Newell (1988) reported a distribution from somewhat north of Swedesboro, southward to Mannington, in Salem County, a distance of some 13 miles (20.9km).

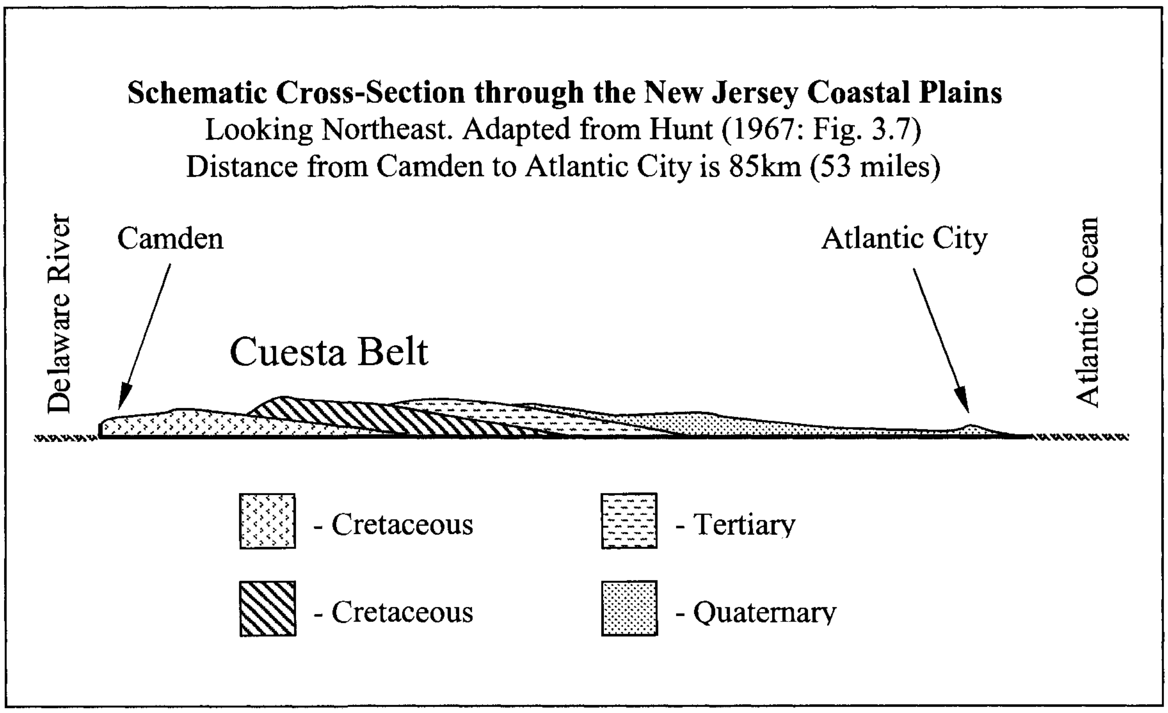


Figure 2.4: Schematic Cross-Section Showing the Cuesta

However, the distribution of quartzite boulders is far more extensive, reaching well into the center of the coastal plains, and in isolated locations within a few miles of the Atlantic Ocean (Salisbury and Knapp 1917:31, 40). To the north, the boulders extend well into Burlington County. Many geological outcrops are known from archaeological research in the vicinity of Evesboro, Medford, and Mount Laurel. At least sporadic distribution to the north and east into parts of Monmouth County has been observed in both geological and archaeological materials (Jack Cresson 1975, 1995a; Mounier 1990a).

Many quartzite boulders occur at or near the surface and erode out of exposed hillsides. As a consequence of farming and erosion, the boulders continually crop up in agricultural ground. Stone walls, fence lines, and building foundations attest to the removal of the rocks from farm fields.

Geologists have disparate views as to the processes that led to the formation of the quartzite boulders. Salisbury and Knapp (1917:31) thought that the quartzite had been formed by extensive weathering and erosion of indurated Miocene sediments. In order to explain the transportation of the largest of the quartzite boulders, Salisbury and Knapp (1917:13, 20) concluded that the rocks had been rafted on floating ice, a conclusion with which Wolfe (1977:137) concurred.

Wyckoff and Newell (1988:42) advanced the idea that the quartzite boulders previously attributed to the Bridgeton formation consist of orthoquartzite or silcrete (cf. Lamplugh 1902; Dixon 1994:93; Milnes and Twidale 1983). Orthoquartzites may be formed by cementation of sand or sandstone by the deposition of dissolved silica or other minerals under conditions of low temperature and pressure. If silica forms the cement, quartzites with relatively weak bonds between sand grains and cement are also sometimes called silicified sandstones (Skolnick 1965; Ebright 1978; Carozzi 1993; Howard 2005).

Wyckoff and Newell (1988:42) stated that the silcrete from New Jersey formed "within the shallow subsurface of a broad, vegetated valley bottom... with fluvial deposition during the late Miocene and early Pliocene." They further relate that "the silcrete probably formed during subtropical to warm-temperate climatic conditions, characterized by ample precipitation and leaching. . . [T]he silcrete was cemented during the Pliocene" (Wyckoff and Newell 1988:42). Through a series of erosional events over time, the landscape has experienced an inversion of topography so that the gravels and boulders deposited in the former valleys now cap the ridges (Widmer 1964:135; Wyckoff and Newell 1988:43).

2.4) Aboriginal Use of Lithic Materials

Aboriginal populations made extensive use of the cobbles, pebbles, boulders, and imbedded rocks that exist throughout the region (Didier 1975; Ebright 1987; Knowles 1941a; Richards 1941; Lavin 1983; Lavin and Prothero 1987, 1992; LaPorta 1989, 1994; Prothero and Lavin 1990; Lenik 1990, 1991). I am concerned principally with the lithic resources of the coastal plains—and especially with Cuesta quartzite—but will make passing reference here to the aboriginal exploitation of other rocks from more distant localities. As earlier noted, deposits of gravel, cobbles, and boulders cap the higher elevations upon the uplands. In some cases—and this is particularly true of Cuesta quartzite—the deposits consist of sizeable boulders. The deposition apparently occurred anciently, in Tertiary or Quaternary times (depending on locality). The position of the gravel caps on hilltops reflects an erosional history that has left a variety of refractory materials at high elevations.

Here and there, similar material from deeper deposits is exposed in valley slopes by fluvial cutting and on valley floors as a result of outwash. These beds contain lithic materials in a wide range of compositions and stone sizes. Quartz, quartzite, sandstone, cherts, and jaspers occur as pebbles, cobbles, and boulders.

Other cobble materials, traditionally associated with glacial outwash from sources in the Upper Delaware Valley, represent a portion of the stone procured for cultural purposes in prehistory. These materials include: granite, diabase, gneiss, felsite, siltstone, shale, argillite, hornfels, conglomerate, arkose, greywacke, and schist. This complement would also be expected to contain additional cryptocrystalline pebbles.

Certain of the distant primary sources are represented by the occurrence of argillite artifacts, along with argillaceous shale, derived from Triassic deposits in the Upper Delaware Valley (Mercer 1893; Schrabisch 1915:25-26, 1917; Richards 1941; Didier 1975). Evidence of distant argillite procurement and processing is reflected not only in the relative abundance of argillite tools but also in a relatively high incidence of flakes in this material. This association is usually attributed to quarry products.

Other primary source materials, also extensively utilized, are the so-called jaspers from the Reading Prong in Pennsylvania (Mercer 1894; Schindler et al. 1982; Hatch and Miller 1985). In numerous lithic assemblages across the region, a significant portion of the artifacts seems to pertain to the procurement of jaspers from the Pennsylvania sources, as well as possibly other sources. Flake samples often reveal distinctive colors, textures, or mineral arrangements, suggesting derivation from exotic sources.

Coarse-grained jaspers or chalcedonies from isolated locations in Delaware and Pennsylvania sometimes appear as raw material in archaeological deposits. Most notable of these are Newark Jasper from the vicinity of Iron Hill near Newark, Delaware (Custer, Ward, and Watson 1986), and Broad Run Chalcedony, which occurs in the vicinity of Landenberg, Pennsylvania and adjoining parts of Delaware and Maryland (Catts et al. 1988).

Certain orthoquartzites—notably, Cohansey and Cuesta quartzites—appear archaeologically at many sites. Both will be mentioned here briefly, with more details about Cuesta quartzite to be presented later on. Cohansey quartzite is a distinctive rock whose matrix is composed of fine sand and the fossilized remains of Miocene shellfish, cemented together by silica (Friedman 1954:238). In this respect it resembles Tallahatta quartzite from the southeastern United States (Dunning 1964; Ebright 1987).

A tabular orthoquartzite, Cohansey quartzite, occurs in very localized deposits in the valley of Cohansey Creek, in Cumberland County (Friedman 1954; Salisbury and Knapp 1917; Wyckoff and Newell 1986; Figure 2.5). Some pieces of Cohansey quartzite have been dredged from the river bottom while others have been exposed by digging for construction projects. Similar material, not well studied, has been reported conversationally from parts of Delaware—near Bombay Hook and Smyrna Beach—across the Delaware Bay from the mouth of Cohansey Creek.

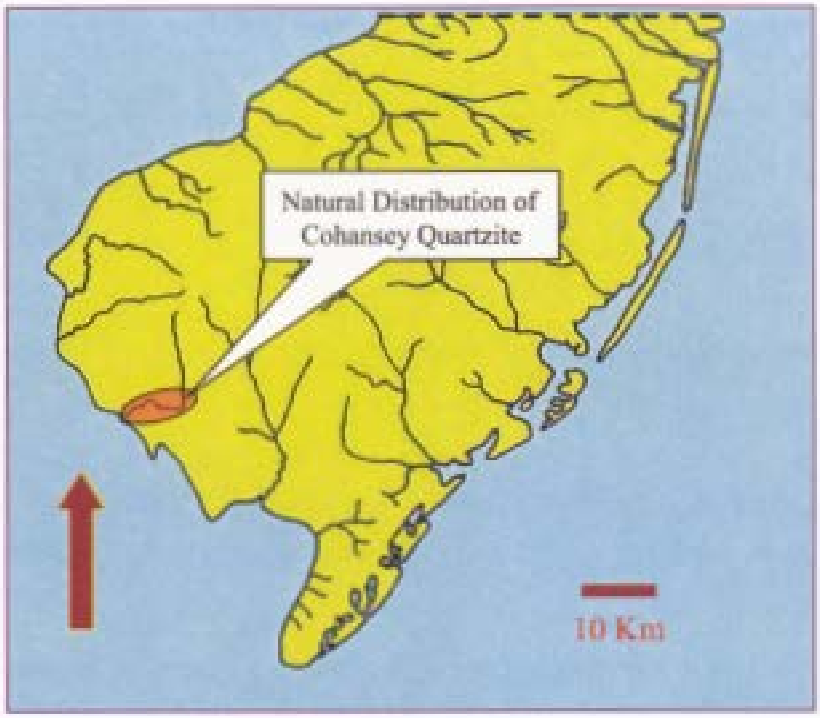


Figure 2.5: Distribution of Cohansey Quartzite

Because of very limited geological investigation, the sources of Cohansey quartzite, though apparently limited in locale, have not been determined to comprise either primary or secondary deposits. According to previous research, the quartzite derives from the cementation of sediments and the fossilization of calcareous remains in an ancient beach/shore environment (Richards 1935, 1941:211; Friedman 1954).

Near the source, the human use of Cohansey quartzite seems to span the broad range of prehistoric cultures; farther away, the material is consistently found with several cultural manifestations that are widely separated in time. The earliest general occurrence for the use of this material corresponds to the late Early Archaic or early Middle Archaic periods, with the appearance of bifaces having bifurcated hafting elements. The next extensive expression occurs in the Late Archaic and Early Woodland periods when broadspear and fishtail bifaces were introduced. The last major exploitation of Cohansey quartzite correlates with the Late Woodland period during which time the stone was rendered into the predominant triangular biface forms and related implements.

The second variety of quartzite that seems to be a sensitive indicator of cultural-temporal association is Cuesta quartzite, the subject of this thesis. This material appears to occur as deposits of cobbles in spot concentrations along the cuesta that separate the Inner and Outer Coastal Plains in New Jersey. These deposits frequently mantle the upland rises and the adjacent outwash fans and terraces associated with the cuesta. Such settings are known to contain very extensive local accumulations of cobbles and boulders and have been exploited in prehistory (and in more recent times for building material).

Although Cuesta quartzite does not have the highly restricted natural distribution associated with Cohansey quartzite, it is a fairly sensitive indicator of shifting patterns of lithic exploitation in the dimensions of culture and time. Until now, its spatial distribution in archaeological settings has not been well studied. Previously, the unpublished work of Jack Cresson (1975, 1995a, 2004) and my various reports in the field of cultural resource management (see Chapters 4 and 5) provide the most comprehensive view of the aboriginal use of this material.

While superficially similar, especially in very small samples, Cohansey and Cuesta quartzites are quite distinctive. In addition to its tabular form, Cohansey quartzite differs from Cuesta quartzite by reason of the inclusion of numerous fossils of ancient species of oysters, barnacles, gastropods, and scallops (Friedman 1954:238). Cohansey quartzite is generally lighter in color than Cuesta quartzite and usually has less polished surface textures. Like Cuesta quartzite, Cohansey quartzite was extensively exploited by aboriginal populations (Skinner and Schrabisch 1913:57; Kümmel 1941:154; Richards 1941:21; Kier 1949). A large depression along Molly Wheaton Run, near Greenwich, is said to have been an aboriginal quarry for Cohansey quartzite. So far as is known, aboriginal peoples never pursued Cuesta quartzite in open mine pits.

"Not all orthoquartzites are created equal." So says Jack Cresson (pers. comm., 04 April 2007), relating that Cohansey quartzite knaps as easily as cryptocrystalline materials, or more so. It also sustains "some very sharp, durable cutting and sawing edges" (Jack Cresson, pers. comm., 6 June 2007). This characteristic doubtless explains its popularity as tool-stone in antiquity. By contrast, modern knappers find Cuesta quartzite to be fractious—one of the most intractable materials known to prehistoric populations (Jack Cresson, pers. comm., 04 April 2007; William Schindler, pers. comm., 01 January 2007; Are Tsirk, notes of 11 January 2007; Scott Silsby, notes dated only June, 2007). Both Schindler and Silsby remarked that working untreated Cuesta quartzite was highly destructive of their percussors, especially antler billets. The flaking properties of this material—and, I would suggest, its appearance—improves with heat-treatment, which permitted extensive use by aboriginal knappers. I now turn to a more thorough description of Cuesta quartzite, its use by native populations in the region in space and time, and its natural distribution.

2.5) Cuesta Quartzite in Archaeological Context

Ancient people living in what is now New Jersey used quartzites of various compositions for the manufacture of flaked stone tools and rough service implements at least from Early Archaic times. The parent sources included pebbles and cobbles gathered from widespread gravel deposits and boulders from the flanks of the cuesta (Cross 1941; Knowles 1941; Mounier 2003a:157). By the early 1970s, recognition of the patterned exploitation of the quartzite cobbles that occur along the cuesta belt spurred the archaeologist, Jack Cresson, to coin the term, "Cuesta quartzite," for this suite of materials (Cresson 1975). Since then, the name has gained currency among archaeologists in the region (Clark and Halsall 1999). Cuesta quartzite, or something closely resembling it, has been reported at the Hickory Bluffs site (7K-C-411) in Kent County Delaware (Liebeknecht et al. 1997). Artifacts attributed to this material include flakes, thermally altered rock, and "points" (i.e., bifaces) in a variety of typical stemmed forms. The descriptions sometimes note "Cuesta quartzite-like," indicating that the material has not been geologically linked to outcrops in New Jersey.

Reference to Cuesta quartzite or similar materials in archaeological contexts beyond the borders of New Jersey suggests that the material may have a wider natural or cultural distribution than is currently known or that it has cognates of similar lithology in other regions (Liebeknecht et al. 1997). The following pages discuss the aboriginal use of Cuesta quartzite in New Jersey in a detailed cultural-historical perspective.

Although Cuesta quartzite was occasionally rendered into bifacial forms that are typical of Paleoindian and earlier Archaic contexts, the material first saw sustained use during Middle and Late Archaic times (Cresson 1975, 1995a). Contracting stemmed bifaces—reminiscent of the Morrow Mountain I and II types (Coe 1964:37-43)—seem to be the most common styles. Evidently, some small points, roughly bifurcated, appear in private collections without good provenience (Jack Cresson, pers. comm.). According to Cresson, these specimens resemble Early or Middle Archaic points similar to the Kanawha or LeCroy styles described by Broyles (1966, 1971) in the Middle South and dated in New Jersey to 6,560 B.P. (Mounier 2003a:202). I have seen none in any of the collections that I have personally surveyed.

Narrow stemmed bifaces become common in Cuesta quartzite and other materials by Late Archaic/Early Woodland times (Cresson 1975, 1995a; Chapters 4 and 5, this thesis). These bifaces appear with a variety of stem forms, including contracting, straight, and moderately expanded styles (Plate 3.4). These points resemble the Morrow Mountain II (Coe 1964:37-43), Poplar Island, Rossville (Ritchie 1961:44-46), and Lackawaxen (Kinsey 1972:337, 408-411) types. Evidence from experimental archaeology indicates that the broad and narrow forms are very likely to be contemporaneous in most archaeological situations (see Chapters 3 and 6). A similar range of stemmed styles occurs in Delaware in Cuesta quartzite or a physically similar quartzite (Liebeknecht et al. 1997).

Some artifact collections from southwestern New Jersey contain Cuesta quartzite in generalized side-notched styles of uncertain date and cultural association. The longer, more slender varieties resemble the Fishtail points, generally associated with Late Archaic or Transitional cultures (Ritchie 1959, 1961). When found under controlled circumstances, generalized side-notched bifaces in a variety of materials most often appear in Late Archaic and Early Woodland assemblages (Kinsey 1972: 443-444; Mounier 1974a, 2003a:214-215). In the absence of definitive data, one can only suppose that this temporal association holds true for generalized side-notched specimens in Cuesta quartzite.

A triangular specimen (C-2388) from the Carman collection, now housed in Greenwich, N.J., probably relates to Archaic biface technology, either as a finished piece, or possibly, as a preform for a notched or stemmed point. Less likely is its origin in a later prehistoric context. A convex-based "Teardrop point" of Cuesta quartzite (NJSM-24656) was found during the Indian Site Survey. Such forms, never before seen in this material, seem to have either Late Archaic/Early Woodland or Middle Woodland associations (Cross 1956; Kraft and Blenk 1974; Mounier 2003a:158-159, Mounier and Cresson 1988, Mounier and Martin 1994).

The use of Cuesta quartzite is linked to a remarkable degree in time and cultural associations with the exploitation of argillaceous shale. Argillaceous shale, sometimes called "indurated shale" (Cook 1868:384-386), is a form of metamorphosed sediment of Triassic age, occurring in deposits in the piedmont of New Jersey (Richards 1941:19). Typical bifacial products in argillaceous shale include the longer stemmed forms—Poplar

Island, Morrow Mountain, Lackawaxen, and Rossville styles—that often form parts of Cuesta quartzite assemblages.

Experimentation by Cresson has shown that argillaceous materials, such as argillite and argillaceous shale, respond nicely to knapping with hammers formed from Cuesta quartzite (Cresson 1995a.). This observation helps to explain why knapping stations that contain substantial amounts of argillaceous shale are often accompanied with specialized, faceted flaking hammers of Cuesta quartzite.

Cuesta quartzite is often found as mundane hearth rock and in other expedient forms as choppers, cutting tools, anvils, and so forth in later Woodland episodes, especially in locations that contain an abundant natural supply of the material. For example, unpublished excavations by Jack Cresson and Anthony J. Bonfiglio at the Gruno Farm, a Middle Woodland site in Mount Laurel Township, Burlington County, N.J., revealed numerous hearths and pit features that were lined with Cuesta quartzite (Jack Cresson, pers. comm., 30 April 2006).

Biface production started with the reduction of boulders, using direct percussion when possible, or heat from open fires, when the boulders were too large to penetrate otherwise. The thermally spalled pieces were subsequently flaked into manageable blocks or ideal flake blanks. Cresson (1995c) further noted that "the production of specialized hammerstones is attributed to this stage of [the] production process. The heat-shattered cobble residues leave abundant sub-spherical or blocky pieces [that are] ideal for hammerstone blanks. Evidence of this production was uncovered at Darnell Farm thirty years ago."

Opportunistic processing also employed smaller, more manageable pieces, which naturally existed in a range of round, tabular and lenticular forms, at any number of sites (e.g., the Riding Run site in Evesham Township, Burlington County, N.J.). At extensive and dense deposits, both flake blanks and blocky cores were prepared to make bifacial products. Heat processing and multiple episodes of thermal alteration were part and parcel of the processing trajectory.

Early-stage production proceeded by a reduction sequence, using hammerstones followed by billets of wood or antler (see Chapter 6). The process involves removing cortical residues along with naturally rounded or square edges, then proceeding to remove prominent ridges or humps. This knapping is akin to "edging" and "primary thinning" in Callahan's (1979, 1989) terminology. The resulting early-stage bifaces are typically ovate sub-triangular forms that superficially resemble first Abbevillian and then Acheulean hand axes. This grouping shows a high frequency of manufacturing failures. These inchoate bifaces often served as choppers and heavy-duty cutting implements. With additional percussion thinning, the early-stage bifaces would be reduced to semi-finished forms, akin to the biconvex pieces that Callahan (1979, 1989) referred to as Stage 3 bifaces. The intent is to produce a regularized form upon which flakes extend from the biface margin to a point beyond center of each face. The circumferential edge is relatively straight, rather than scalloped, and lies centered between the two faces.

The subsequent bifacial form is a much thinner, more refined biface with higher width-to-thickness ratios in elongated ovate and lanceolate configurations in what may be considered "preforms". Generally the width to thickness ratio approximates 4:1, but sometimes ratios of nearly 5:1 are achieved. Secondary thinning flakes are diagnostic artifacts from this level of work. The formalized bifaces for the most part are contracting stemmed forms, with a minority representation in generalized side-notched pieces, as noted earlier.

The reduction of Cuesta quartzite by knapping is closely associated with thermal processing. Research has shown that heat-treating was conducted repeatedly at different stages of cobble reduction in the process of biface manufacture (Mounier 1990b). Experimental knapping indicates the value of repetitious heating to bifacial knapping of Cuesta quartzite (see Chapter 6).

In addition to bifaces, hammerstones were also produced from Cuesta quartzite. Cresson (2004) has noted that hammerstone production was also related to thermal processing: "Data from a quarry workshop in Mt. Laurel, N.J. has revealed evidence of heat-spalling and percussion activities in a sequence of manufacturing processes that reduced large blocks and boulders to smaller, blocky, cubic forms of varying sizes, which served as hammerstone blanks."

In the historic era, quartzite boulders served various functions. Near sources of supply, they were used often for building foundations and for making stone walls, which sometimes served as boundary markers. More often, the latter constructions merely reflect the removal of boulders from farm fields, where they posed hazards to cultivation. In certain Quaker cemeteries, small boulders or cobbles of Cuesta quartzite served without engraving or other ornamentation as grave markers.

2.6) Cuesta Quartzite in Radiometric Context

This section conflates data from a variety of carbon-dated contexts (also see entries for the indicated sites in Chapters 4 and 5). Generally, the presentation proceeds in chronological order, but some sites have yielded divergent data, which will be presented together. After considering the validity of the assays, the presentation ends with an interpretive summary. The accompanying table and graph show the data schematically (Table 2.1, Figure 2.6). When present, calendrical calibrations follow the INTCAL 98 Radiocarbon Age Calibration technique.

2.6.1) Site 28-GL-45 (Mounier 1975a, 2000b)

Wood charcoal associated with Cuesta quartzite debitage in a feature was dated to 1600±60 B.P. by the Beta Analytic Laboratory in Miami, Florida (Beta-139737). The 2-sigma calibration of the radiocarbon age coincides with the calendrical range of A.D. 340 to A.D. 600 (1610 – 1350 B.P.) Another nearby feature contained a dense accumulation of Cuesta quartzite debitage (over 900 flakes and fragments), 20 unfinished or broken bifaces in the same material as well as a Fishtail variant biface in argillite. This association makes the otherwise late date sensible in terms of traditional culture-history. Evidently, the use of Cuesta quartzite persisted beyond the limits suggested by its more common cultural diagnostics.

2.6.2) Baseman Site: 28-BU-475 (Mounier 1998b)

Two charcoal samples were submitted to the Beta Analytic Laboratory in Miami, Florida for radiocarbon age determination. Both samples were composites of wood charcoal and carbonized nut shells (probably, hickory). The apparently associated cultural diagnostics included bifaces and debitage of Morrow Mountain, Poplar Island, and Lackawaxen typology. The inferred age, based on typological considerations, is approximately 6000 to 4500 years (4000 - 2500 B.C.).

Table 2.1: Radiocarbon Age Assessments

Site	Years B.P.	Sample #	Associated Remains
28-GL-45	1600±60	Beta-139737	Debitage (Cuesta quartzite)
28-BU-475 (Baseman)	1670±80	Beta-125252	Debitage (Cuesta quartzite)
28-GL-33	1890±60	Beta-104884	Bifaces (Cuesta quartzite)
28-MO-134 (Abature Site)	3010±80	Beta -24154	Debitage (Cuesta quartzite)
28-BU-129 (Geni-Koppenhaver)	3030±80	Dicarb-2947	Early Pottery in Cuesta quartzite hearth
28-BU-90 (Evesham Corp. Ctr.)	3840±60	Beta-154402	Debitage (Cuesta quartzite)
28-BU-475 (Baseman)	3990±60	Beta-125251	Bifaces, debitage (mixed materials)
28-BU-226 (Highbridge)	4010±60	Beta-143127	Bifaces (Cuesta quartzite)
28-BU-403 (Kings Grant)	4240±70	Beta-40164	Biface (Cuesta quartzite)
28-BU-407 (Troth Farm)	4380±70	Beta-116126	Biface and debitage (mixed materials)
28-BU-456 (Northside School)	4520±50	Beta-203253	Argillaceous bifaces w/ Cuesta quartzite hammers
28-BU-403 (Kings Grant)	5980±70	Beta-40163	Biface (argillaceous shale)
28-GL-344 (Grande at Elk)	6640±50	Beta-222524	Biface (Cuesta quartzite)
Nominal Span: 5040 years. **Mean Deviation (±):** 65 years. **Median Deviation (±):** 60 years.			

The first sample returned an age estimate of 3990±60 radiocarbon years (Beta-125251). The data from this sample intercept the calendrical calibration curve at 2480 B.C. The calibrated results indicate a date between 2575 and 2455 B.C. (within 1σ, or 68% probability), or between 2610 and 2325 B.C. (within 2σ, or 95% probability). This assay has yielded an age determination that overlaps slightly with the recent end of the expected range and is considered to be valid.

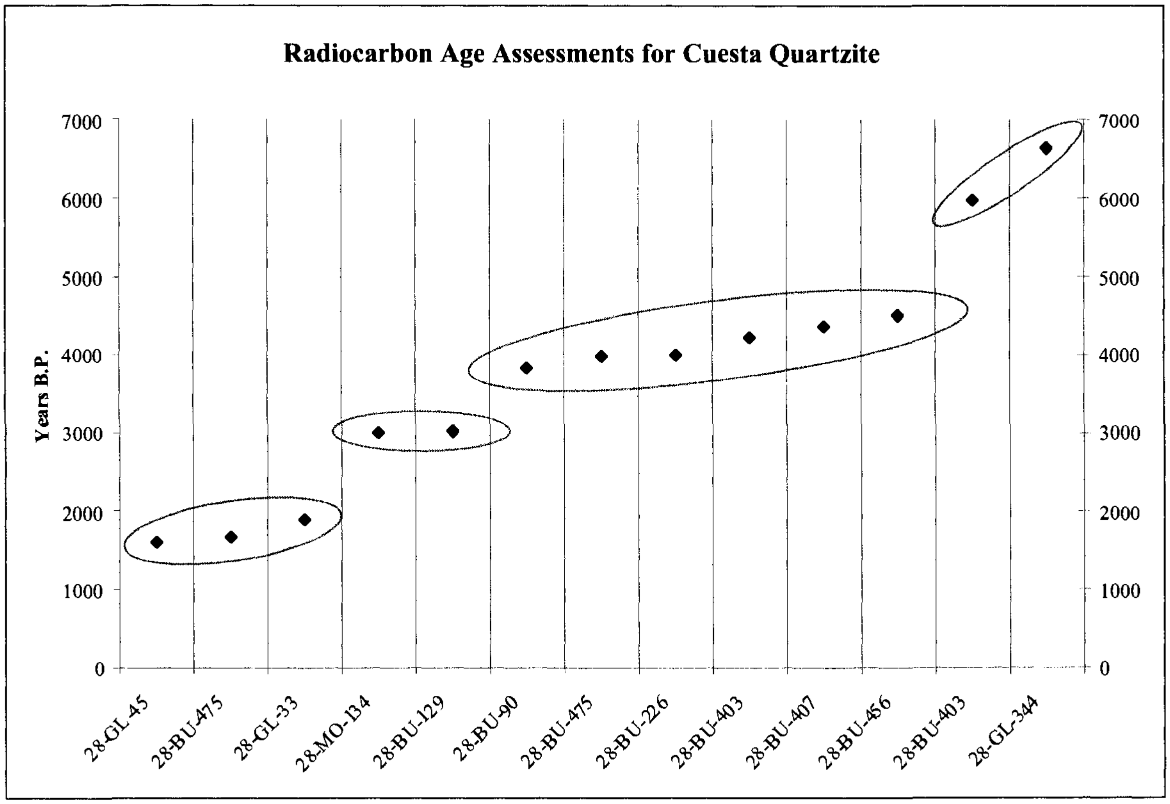


Figure 2.6: Graph of Radiocarbon Age Assessments
The ovals highlight loosely clustered dates.

The second sample yielded an age estimate of 1670±80 radiocarbon years (Beta-125252). The data from this sample intercept the calendrical calibration curve at A.D.

405. The calibrated results within 1σ, or 68% probability, indicate a date in two possible intervals: 1) between A.D. 265 and 290; and, 2) between A.D. 320 and 450. The calibrated results within 2σ, or 95% probability, indicate a date between A.D. 220 and 575. This assay has yielded an age determination that is far more recent than the expected range.

The discrepancy between expected and actual results can be addressed in one of four ways. First, the diagnostic artifacts may actually have a broader time span than previously recognized. Second, the sample may reflect more recent cultures, whose material remains are poorly represented in the site, possibly as a result of generations of artifact hunting on the property. Third, the sample inadvertently may have contained some carbonized matter of modern age (e.g., charcoal from brush fires). Finally, the results may simply be anomalous.

Considering the rather tight measures of error for this sample, this last interpretation is unlikely to be correct. Due caution was exercised in collecting carbonaceous materials for analysis. If error resulted from mixing of more recent materials, the contamination probably occurred by the tumbling of modern charcoal granules through worm tubes, root channels and the like. The notion that the diagnostic types have a broader than expected chronology cannot be dismissed out of hand, given the cultural conservatism that is manifested in the region generally, but confirmation must await further corroboration. It is entirely possible that the assessment accurately dates a more recent component, whose diagnostic artifacts remain indeterminate at this site. A similar date (1600±60 B.P.) applies at 28-GL-45, where Cuesta quartzite debitage was associated with stemmed points of the Transitional or Terminal Archaic phase.

2.6.3) Site 28-GL-33 (Mounier 1975a, 1997b)

Charred organic matter was submitted to the Beta Analytic laboratory for assay. Sample No.104884 returned an age assessment of 1890±60 B.P. The computed radiocarbon age of this sample coincides with the calibrated calendrical date of A.D. 120. The dates within one standard deviation range from A.D. 70 to A.D. 220. Within two standard deviations, the range is A.D. 5 to A.D. 250. The former range has a probability of 68% and the latter a probability of 95%. The reported date would be appropriate for a cultural setting between late Early Woodland and early Middle Woodland times. The expected age, based on cultural associations (particularly, the apparently simultaneous utilization of Cuesta quartzite and argillaceous shale), would have been a few hundred to a couple of thousand years earlier than reported. In other words, a date more consistent with the presently understood temporal limits of the Late Archaic/Early Woodland period was anticipated. Nevertheless, the date falls within the range associated with Cuesta quartzite usage on other sites within the region. Given the low calculated error, the date is assumed to be accurate.

2.6.4) Abature Site: 28-MO-134 (Mounier 1990a)

A feature that appeared to be a weathered pit at site 28-MO-134 contained a small piece of limonite and a small, but datable amount of wood charcoal. A core fragment of Cuesta quartzite and a fragmentary end-tool of chert were found nearby. Also found in adjacent parts of the excavation were stemmed bifaces in argillaceous materials and faceted hammers in Cuesta quartzite. An assay of this charcoal returned date of 1060 B.C. (3010±80 B.P. [Beta 24154]), which is consistent with the inferred Late Archaic/Early Woodland origin of the feature.

2.6.5) Geni-Koppenhaver Site: 28-BU-129 (Jack Cresson, pers. comm., 4 June 2007)

The Geni-Koppenhaver site lies near the Fairview neighborhood of Medford Township, Burlington County, N.J. A brief excavation in 1984 by the Southern New Jersey Chapter of the Archaeological Society of New Jersey led to the discovery of a hearth of Cuesta quartzite, which contained charcoal, along with early ceramics and contracting-stemmed bifaces of the Rossville type (Ritchie 1961:44-46) and other Late Archaic/Early Woodland forms (Fishtail, Susquehanna Broad, and Lackawaxen types). Analysis of the charcoal by the Dicarb Radioisotopes Corporation in Chagrin Falls, Ohio (Dicarb-2947), returned a date of 3030±80 B.P. (1060±80B.C.). A statistical evaluation of dates run by the Dicarb facility with respect to those of other laboratories suggests that the actual age of the sample may be somewhat earlier than indicated, but the degree of possible error cannot be ascertained (Reuther and Gerlach 2005). As a formal report of the excavation was not produced, I am indebted to Jack Cresson for the information provided.

2.6.6) Evesham Corporate Center: 28-BU-90 (Mounier 2001)

A composite sample of charred nut shells, associated with Cuesta quartzite artifacts from Locus A-2 was submitted to the Beta Analytic Laboratory in Miami, Florida for an assessment of age by radiometric dating. The sample (Beta-154402) returned an age of 3840±60 radiocarbon years ago. The result intercepts a calendrical calibration curve at 4240 B.P., equivalent to a date of 2290 B.C. There is a 68% probability that the actual date falls between 2200 and 2430 B.C. (4380 to 4150 B.P.) and a 95% probability of falling between 2470 and 2130 B.C. (4420 to 4080 B.P.). This chronology is entirely in keeping with expectations based upon typological considerations involving the use of Cuesta quartzite for tool manufacture.

2.6.7) Highbridge Site: 28-BU-226 (Mounier 2000e)

The site yielded charcoal and charred nut fragments in association with a broad-bladed, contracting stemmed biface in argillaceous shale. A flaking hammer of Cuesta quartzite was found nearby. The Beta Analytic Laboratory in Miami, Florida performed the determination of radiocarbon age (Sample No.143127). The results of analysis accord well with expectations concerning the chronology of the associated cultural material: 4010±60 B.P. Within two sigma (95% probability), this sample intercepts the calendrical calibration curve at two locations, respectively relating to the following periods: 2845–2820 B.C. and 2670–2395 B.C.

2.6.8) Kings Grant: 28-BU-403 (Mounier 1990b)

Wood and nut charcoal from 28-BU-403 was submitted to the Beta Analytic Laboratory, in Miami Florida, for radiocarbon age determination. The samples returned two dates as follows: For Sample No. 40163, the laboratory found the age of charcoal associated with a stemmed biface in Cuesta quartzite to be 4240±70 B.P. The age of the charcoal associated with a stemmed biface in argillaceous shale was determined to be 5980±70 B.P (Beta 40164).

2.6.9) <u>Troth Farm: 28-BU-407</u> (Mounier 1998d)

A carbon sample was submitted to the Beta Analytic Laboratory in Miami, Florida for age determination. The sample consisted of charred organic material: wood charcoal and charred nut fragments from Activity Area 1 (Locus A, Units 3, 5, 6, and 8). The sample was deemed too small for confident standard radiometric analysis and was subjected to extended counting. The results of analysis satisfy expectations concerning the chronology of the activity area, which contained a variety of stemmed bifaces (including Rossville, Teardrop, Lackawaxen, Fishtail variants, and Koens-Crispin types); debitage in argillite and cuesta quartzite, and petrified wood. The sample, No. 116126, returned an age assessment of 4380±70 B.P. This sample intercepts the calendrical calibration curve at 2930 B.C. Within 1 sigma (68% probability), the calibrated results place the sample between 3085 and 2905 B.C.

2.6.10) <u>Northside School: 28-BU-456</u> (Mounier 2005)

A sample of wood charcoal and carbonized nut fragments was submitted to the Beta Analytic Laboratory in Miami, Florida for determination of radiocarbon age. The laboratory reported a measured radiocarbon age of 4470±50 B.P., and a conventional radiocarbon age of 4520±50 B.P. (Beta-203253). Calendrical calibration places the date of the specimen between 3370 and 3030 B.C. (or from 5320 to 4980 B.P.). The result accords with expectations given the cultural content of the site. That is, the occurrence of narrow-bladed and stemmed bifaces in argillite and argillaceous shale, along with faceted hammers of Cuesta quartzite is definitive for Late Archaic/Early Woodland occupations.

2.6.11) Site 28-GL-344 (Mounier 2006b)

A Cuesta quartzite knapping feature at site 28-GL-344 (Locus B2) yielded a small amount of charcoal, which could be evaluated by the accelerator mass spectrometry technique. Beta Analytic Laboratory in Miami, Florida reported an assessed age of 6640±50 B.P. (Beta-222524). This date is particularly interesting because it applies to a diagnostic form—a broad-bladed, contracting stemmed biface—and represents the earliest benchmark for the type in the region.

2.6.12) Evaluation of Carbon Dates

The C^{14} dates have a nominal spread of 5040 radiocarbon years from the most ancient to the most recent assessed ages (from 6640 to 1600 radiocarbon years B.P.). If the calculations of error are taken into consideration then the span is 5150 years (6690 to 1540 radiocarbon years B.P.). All of the assays carry relatively minor error intervals. Of the battery of 13 dates, none has a calculated error greater than 80± years. The average deviation is 65 years, while the median is 60 years. None of the assessments appears to be aberrant (Table 2.1).

As graphed, the data points show a fairly linear arrangement between the extremes. The assessments form four clusters; or to put it the other way around, there are three gaps in the plot (Figure 2.6). The four clusters occur: 1) between 1600 and 1890 B.P. (a range of 290 years); 2) between 3010 and 3030 B.P. (a range of 20 years); 3) between 3840 and 4520 B.P. (a range of 680 years); and 4) between 5980 and 6640 B.P. (a range of 660 years). The three apparent gaps in the sequence occur: 1) between 1980 and 3010 B.P. (a range of 1120 years); 2) between 3030 and 3840 B.P. (a range of 810 years); and 3) between 4520 and 5980 B.P. (a range of 1460 years). The general sense of linearity from the graph suggests that the gaps represent unsampled potential as much as errors in age assessment.

The first clustering series includes three assays, two from nearly adjacent sites, 28-GL-33 and -45. These sites would seem to be closely related in time as well as in space. The second cluster happens to have two nearly identical age determinations, but the sites are widely separated, and there is some question concerning the accuracy of the date evaluated by the Dicarb laboratory for site 28-BU-129. If the date for this site should prove to be earlier than indicated (see Reuther and Gerlach 2005; and page 62 above), the gap between 3030 and 3840 B.P. would be reduced. The third cluster consists of six determinations from as many Burlington County sites, each within a day's travel of the others by foot or canoe. This series appears to have a high degree of internal consistency. The last cluster represents widely spaced sites in Gloucester and Burlington Counties. The dates indicate an early origin for the use of Cuesta quartzite in noncontiguous territories.

The persistence of Cuesta quartzite use into relatively recent times was surprising, mostly because it did not square with expectations based on the known strong association of the material with bifaces of earlier form. There is no reason to suppose that, once having accommodated to this difficult material, knappers would soon reject its use, especially on sites where it is readily available. Indeed, the lack of continued use in the face of an established cultural tradition would be the harder argument to make. The augmentation of the demonstrated period of use is in itself a contribution to knowledge.

2.7) Cuesta Quartzite in Geological Context

Many geologists have noted the presence of quartzite boulders on the coastal plains of New Jersey. Among them are Cook (1868), Salisbury and Knapp (1917), Friedman (1954), Minard (1965), as well as Wyckoff and Newell (1988). Popular geological accounts make only passing reference to these boulders (Widmer 1964; Wolfe 1977). Until recently, the geologists have only categorized the quartzite deposits in general terms, the principal distinctions being the presence or absence of index fossils.

Cuesta quartzite occasionally occurs in slabs or tablets, but more commonly as cobbles and boulders, mostly about 30cm in diameter. Examples up to a meter in major dimension are not uncommon (Plate 2.1 and 2.2). However, much larger boulders have been observed (Salisbury and Knapp 1917: 20, 40; Wyckoff and Newell 1988:40). Cresson (1995b, 1995c) has stated that some Cuesta quartzite boulders are "as large as small automobiles," meaning up to the size of a Volkswagen Beetle (Cresson, pers. comm.) The external surfaces of these rocks are mostly smooth, often bearing a polished appearance as though tumbled in water or burnished by aeolian abrasives. Often the surface is knobby, faceted, and perforated with irregular pits, tubes, or vugs (Friedman 1954:236). When examined closely, some silcrete boulders exhibit soil-like structures (Wyckoff and Newell 1988:40).

Cuesta quartzite consists of several varieties of silica cemented sandstones or conglomerates. The major constituent is weathered quartz sand of variable sizes, usually cemented with gray, tan, brown, or pink silica. There can be rather extreme variability in particle size within individual samples. Microscopic examination distinctly shows quartz grains well under 0.25mm in greatest dimension, while grains of 3mm or more are sometimes seen in flaked bifaces, and even larger pebbles can be found in the field as constituents of larger masses (Plate 2.3).

The colors show a range of variation, which Salisbury and Knapp (1917:13) identified as "pink and purplish." Wyckoff and Newell (1988:40) reported that the constituent quartz grains ranged from yellowish gray (5Y 7/2 on the Munsell Soil Color Charts of 1975) to grayish orange (10YR 7/4) with pinkish-gray (5YR 8/1) and light gray (N7) mottles.

Plate 2.1: Cuesta Quartzite Boulder in situ
(Darnell Farm, Mount Laurel Township, Burlington County, N.J.)

Plate 2.2: Jack Cresson with Cuesta Quartzite Boulder
(Site 28-BU-90, Evesham Township, Burlington County, N.J.)

Plate 2.3: Variable Texture of Cuesta Quartzite
(Particle sizes range from aphanitic to more than 15mm in greatest dimension.)

Cresson (pers. comm., 30 April 2006) has noted that color "varies from location to location. But on the whole, the lower cuesta reaches exhibit colorations in the tannish, light yellowish red [to] pale greyish brown [range]. As the formation trends north, cooler, darker colors prevail. These are dark, greyish blues, light greyish mauves, and even dark brownish greys. When some of these are heat treated, they turn dramatically to a deep purple, liver-colored appearance that is quite stunning." The ordinary color shift is "from grey and bluish brown to dark red and maroon" (Cresson 2004). Upon heating, the entrained quartz grains become highly reflective, giving the thermally altered pieces an attractive, sparkly appearance. The effects of thermal exposure must have been well known to aboriginal people.

In samples that I recently gathered from nine locations in Burlington, Gloucester, and Salem Counties, the following range of colors was noted by reference to the Munsell Soil Color Charts (Munsell Color 1988, 1992): 1) Swedesboro vicinity, Gloucester County: Very pale brown (10YR 7/3-7/4), pale brown (10YR 6/3) to brownish yellow (10YR 6/6); 2) Woodstown vicinity, Salem County: Very pale brown (10YR 7/3) , pale brown (10YR 6/3), light brown (7.5YR 6/4) and reddish yellow (7.5YR 6/6); 3) McCann Farm, South Harrison Township, Gloucester County: Pale brown (10YR 6/3) to light gray (10YR 7/2), some with strong brown iron (7.5YR 5/6-5/8) accumulations; 4) Site 28-BU-407, Evesham Township, Burlington County: Light brownish gray (10YR 6/2), pale brown (10YR 6/3), gray brown (2.5Y 5/2), dark gray (2.5Y 4/1) and grayish brown (2.5Y 5/2); 5) Site 28-BU-90, Evesham Township, Burlington County: Pale brown (10YR 6/3) to brown (7.5YR 5/2) and pinkish gray (7.5YR 6/2); 6) Site 28-BU-475, Evesham Township, Burlington County: Pale brown (10YR 6/3) to grayish brown (10YR 5/2), brown (10YR 5/3) and light grayish brown (10YR 6/2); 7) Evesboro vicinity, Evesham Township, Burlington County: Light gray (10YR 7/2) to very pale brown (10YR 7/3); 8) Medford vicinity, Evesham Township, Burlington County: Brown (10YR 5/3); 9) Darnell Farm, Mt. Laurel Township, Burlington County: Brown (10YR 5/3 and 7.5YR 5/2) to grayish brown (10YR 5/2) and pinkish gray (7.5YR 6/2); Finally, from additional, miscellaneous samples of uncertain provenience: Gray brown (10YR 5/2), pale brown (10YR 6/2) and brown 7.5YR 5/2).

I determined the density of Cuesta quartzite, using both geological and archaeological specimens. In each case the weight of the sample was determined by direct measurement in grams or kilograms. Then, the volume of the sample was measured by the displacement of water, and finally the density was determined by calculating the weight per unit of volume. For geological specimens, the density ranged from 2.6kg/l (162.3 lbs/ft^3) to 3.1kg/l (193.5 lbs/ft^3). The mean density for the geological samples was 2.8kg/l (174.8 lbs/ft^3). These findings accord well with Goodman's (1944:432) calculations, based on quartzite samples of unspecified composition. Her data returned densities in the range of (2.63 – 2.69kg/l), with a mean value of 2.66km/l.

For artifacts, the density ranged from 1.7kg/l (106.1 lbs/ft^3) to 2.7kg/l (168.6 lbs/ft^3). On average the density for the archaeological samples was 2.3kg/l (142.2 lbs/ft^3). Because of the relatively small size of the artifacts and the simplicity of the measuring devices, the associated calculations are likely to be somewhat less accurate for the artifacts than for the geological samples. Still, both samples have statistically significant Pearson's correlation coefficients (***r***) for weight arrayed against volume. For artifacts, $r(7) = 0.989232$, $p < 0.001$); for rocks, $r(8) = 0.99797$, $p < 0.001$.

2.8) Results of Petrological Analysis

I presented samples of Cuesta quartzite for petrological analysis to Pamela King of the Earth Sciences Department at Memorial University of Newfoundland. I am indebted to Ms. King for her guidance and assistance in this phase of the research. The samples included both archaeological and geological specimens, some from the same sites. The study had two principal goals, first to determine the mineral and trace element content and, second, to ascertain whether archaeological and geological samples from the same site could be closely matched.

Geological samples included specimens from the following sites: 28-BU-475 (Baseman site); the Darnell Farm; 28-BU-90 (Evesham Corporate Center site); 28-BU-437 (Riding Run); the vicinity of Swedesboro; and the vicinity of Woodbury Heights. Several flaked artifacts were provided from the following archaeological sites: 28-BU-475 (Baseman site: 2 flake blanks); 28-BU-277 (Elmwood Estates site: one early-stage biface and one large flake fragment); 28-BU-403 (Kings Grant site: one large flake); 28-BU-407 (Troth Farm site: one early-stage biface); 28-BU437 (Riding Run site: one flake blank); 28-BU-104 (Sagemore site: one core); 28-GL-33 and 28-GL-45 (one core each).

The following description of analytical procedures and results has been abstracted from information provided by Pamela King (pers. comm., 26 April and 14 May 2007). The staff of the Earth Sciences Department prepared thin sections for purposes of quickly determining the mineralogy and structure of the quartzite samples. As expected, this effort demonstrated a very high proportion of silica, both as quartz grains and as a cementing agent.

Then, the samples were prepared for X-ray Fluorescence Analysis (XRF). This technique is based on the principle that minerals bombarded with X-rays will emit characteristic secondary X-radiation fluorescence, which can be detected, measured, and associated with particular elements (Barclay 2001:20-21). X-ray fluorescence yields very detailed information about elements that are present. The test is generally non-destructive, so long as the surface layer is considered to be representative of the sample as a whole. Since fluorescence occurs only at the surface of the sample, to a depth of less than 0.01 mm, the technique cannot interpret the core without destructively clearing away patination or weathered layers or crushing the sample.

In order to analyze the Cuesta quartzite specimens, the samples were crushed to a fine powder and pressed into pellets. Technicians prepared four samples, two from geological specimens (from 28-BU-475 and Darnell Farm), and two from archaeological objects (from 28-BU-475 and 28-GL-45). For unknown reasons, the sample from 28-GL-45 would not form a usable pellet. The remaining samples were pelletized and run on the XRF, using trace element software. The results showed no significant differences between the geological samples—all were predominately composed of silica—but not enough similarity in substances other than silica to link the geological and archaeological samples from 28-BU-475.

Samples were then dissolved in hydrofluoric acid ($HF[H_2O]_x$) and nitric acid (HNO_3). The resultant solution was analyzed by means of laser ablation microprobe-inductively coupled plasma mass-spectrometry (LAM-ICP-MS). The procedures for LAM-ICP-MS are as follows: Samples are positioned in a gas-tight chamber, where they can be viewed through a UV-transparent quartz glass window. Using a microscope, the sample is placed under a laser, which delivers light energy (normally 1 to 2.5 mJ) in pulses (1 to 20 Hz) at a wavelength of 266 nm. The laser pulses ablate a small amount of the sample into a very fine powder or aerosol, which is transported in a stream of inert gas (helium and/or argon) into the ICP-MS. The device then interprets elemental data with respect to background signals and external calibration standards. For reasons already cited, this effort also demonstrated no significant correlation between the geological and archaeological samples.

The composition of the Cuesta quartzite samples, as determined by XRF testing, is shown in Table 2.1, which contains a transcription of the data presented by the Earth Sciences Department. As an aid to interpretation, Pamela King (pers. comm., 14 May 2007) has stated the following: "Standard reporting for chemical composition of geological materials has major elements—those that compose the bulk of the sample, as % oxides of the elements such as Na, Mg etc., all the elements in the top half of the XRF data. Trace elements are reported as ppm (parts per million). For comparison's sake, 10,000 ppm = 1%. When we get a negative percent, that means the value is less than the detection limit of the instrument for that particular element. You would report it as <LD [below the level of detection]."

Further, she added that "The SiO_2 is high because, for the light major elements (Na, Mg, Al, Si, P, K), the pressed pellets are considered to be semi-quantitative. With quartzite samples, we are so close to the high end of the calibration range that you can expect some error. The error is <10% which is the best we can do using pressed pellet for the SiO_2" (Pamela King, pers. comm., 15 May 2007).

If normalized to 100%, the samples are found to be composed on average of 97.0% silica (SiO_2), 2.1% titanium (TiO2), 0.76% iron (Fe2O3), and small amounts of other elements and compounds (Table 2.2, Figure 2.7). There is a very high correspondence with the composition of related stones from various parts of the Inner Coastal Plain of New Jersey. Wyckoff and Newell (1988:42) reported that, "Preliminary chemical analysis using X-ray fluorescence spectrometry . . . shows that the silcrete [from the Woodstown vicinity] contains about 97% silica, 2.5% titanium, and less than 0.5% iron, aluminum, and other elements. Previous studies have shown similar values for silica and titanium [in silcrete from South Africa] (Summerfield 1983)."

Thus, our data on Cuesta quartzite compare closely to the sample reported by Wyckoff and Newell (1988), varying principally in the concentrations of titanium, iron, and other elements. As many as 50km (31 miles) separate our sample locations from those reported by the authors just cited.

Table 2.2: XRF Values Normalized to 100%			
Constituent	**M28492M (*G*) 28-BU-475**	**M28494F (*A*) 28-BU-475**	**M28493I(*G*) Darnell Farm**
Na_2O	<LD	<LD	<LD
MgO	0.0284%	0.0000%	0.0716%
Al_2O_3	<LD	<LD	<LD
SiO_2	97.9464%	96.6237%	96.5172%
P_2O_5	0.0000%	0.0000%	0.0000%
S	0.0405%	0.0128%	0.0225%
Cl	0.0018%	0.0010%	0.0015%
K_2O	0.0190%	0.0182%	0.0179%
CaO	0.0190%	0.0182%	0.3489%
Sc	0.0006%	0.0008%	0.0001%
TiO_2	1.6121%	2.5616%	2.1560%
V	0.0027%	0.0045%	0.0039%
Cr	0.0653%	0.0576%	0.0560%
MnO	0.0057%	0.0145%	0.0089%
Fe_2O_3	0.5405%	0.8539%	0.8946%
Ni	0.0185%	0.0141%	0.0142%
Cu	0.0019%	0.0011%	0.0012%
Zn	<LD	<LD	<LD
Ga	0.0002%	0.0005%	0.0003%
As	0.0012%	0.0015%	0.0011%
Rb	0.0001%	0.0000%	0.0001%
Sr	0.0011%	0.0014%	0.0027%
Y	0.0005%	0.0008%	0.0012%
Zr	0.0340%	0.0739%	0.0752%
Nb	0.0031%	0.0043%	0.0040%
Ba	0.0035%	0.0033%	0.0098%
Ce	0.0042%	0.0034%	0.0048%
Pb	0.0006%	0.0011%	0.0008%
Th	0.0003%	0.0004%	0.0003%
U	0.0004%	0.0003%	0.0004%
Total	100.0000%	100.0000%	100.0000%

Notes: Appended letters indicate geological (*G*) or archaeological (*A*) specimens.
<LD denotes, "below the level of detection."

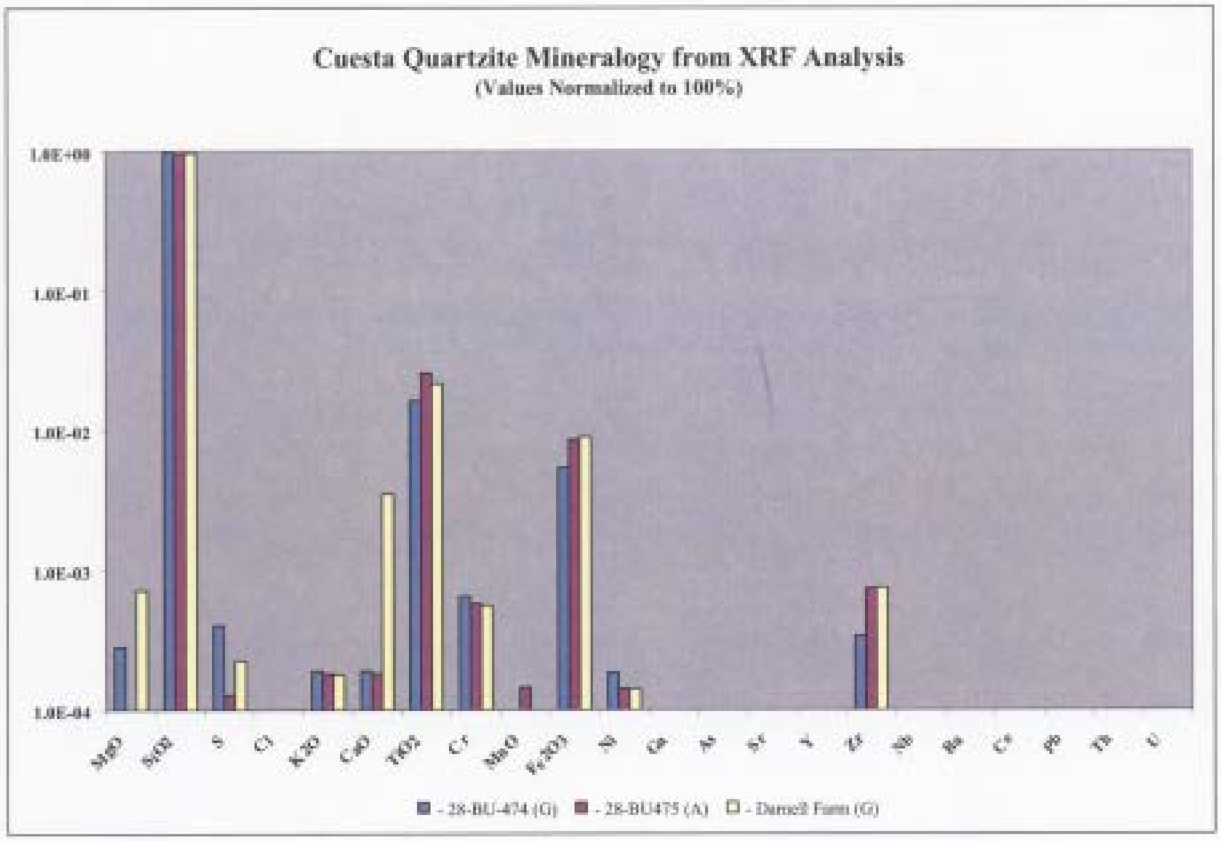


Figure 2.7: Graph of XRF Values

The measured values indicate a general similarity between archaeological and geological specimens from the same site. However, there is insufficient similarity to warrant a claim of identity between archaeological and geological specimens, even when both occurred on the same site. Pamela King summarized the situation as follows: "We could not see any clear differences between the geological samples, and no clear relationship between the geological sample and archeological sample from the same site" (Pamela King, pers. comm., 26 April 2007).

Table 2.3: Results of ICP-MS Analysis of Cuesta Quartzite Samples

(All values are stated as ppm)

Elements	M28492M (G) 28-BU-475	M28404F (A) 28-BU-475	M28493I (G) Darnell Farm	M28495B(A) 28-GL-45
Li	7.558	9.160	7.276	23.964
Rb	0.495	0.554	0.988	0.415
Sr	11.140	15.430	27.680	18.020
Y	3.726	5.545	8.578	5.767
Zr	95.876	147.012	127.350	155.526
Nb	17.616	33.115	37.333	46.138
Mo	15.757	15.315	17.340	24.438
Cs	0.176	0.167	0.115	0.123
Ba	56.540	55.100	144.540	72.540
La	7.715	11.850	16.304	14.455
Ce	15.291	22.045	35.929	26.211
Pr	1.943	2.675	4.241	3.051
Nd	6.742	0.105	16.056	10.494
Sm	1.413	1.760	2.758	1.809
Eu	0.201	0.262	0.542	0.300
Gd	0.422	0.654	1.386	0.699
Tb	0.087	0.114	0.230	0.149
Dy	0.732	0.938	1.615	1.108
Ho	0.156	0.225	0.324	0.245
Er	0.700	0.804	1.018	0.936
Tm	0.265	0.312	0.167	0.246
Yb	0.847	1.004	1.138	1.146
Lu	0.119	0.173	0.205	0.175
Hf	3.085	4.773	4.406	3.694
Ta	2.236	2.030	5.629	2.751
Tl	0.171	0.207	0.670	0.122
Pb	4.204	10.001	9.309	5.774
Bi	0.248	0.327	0.196	0.293
Th	2.422	3.447	3.341	3.891
U	1.512	2.022	2.525	3.205

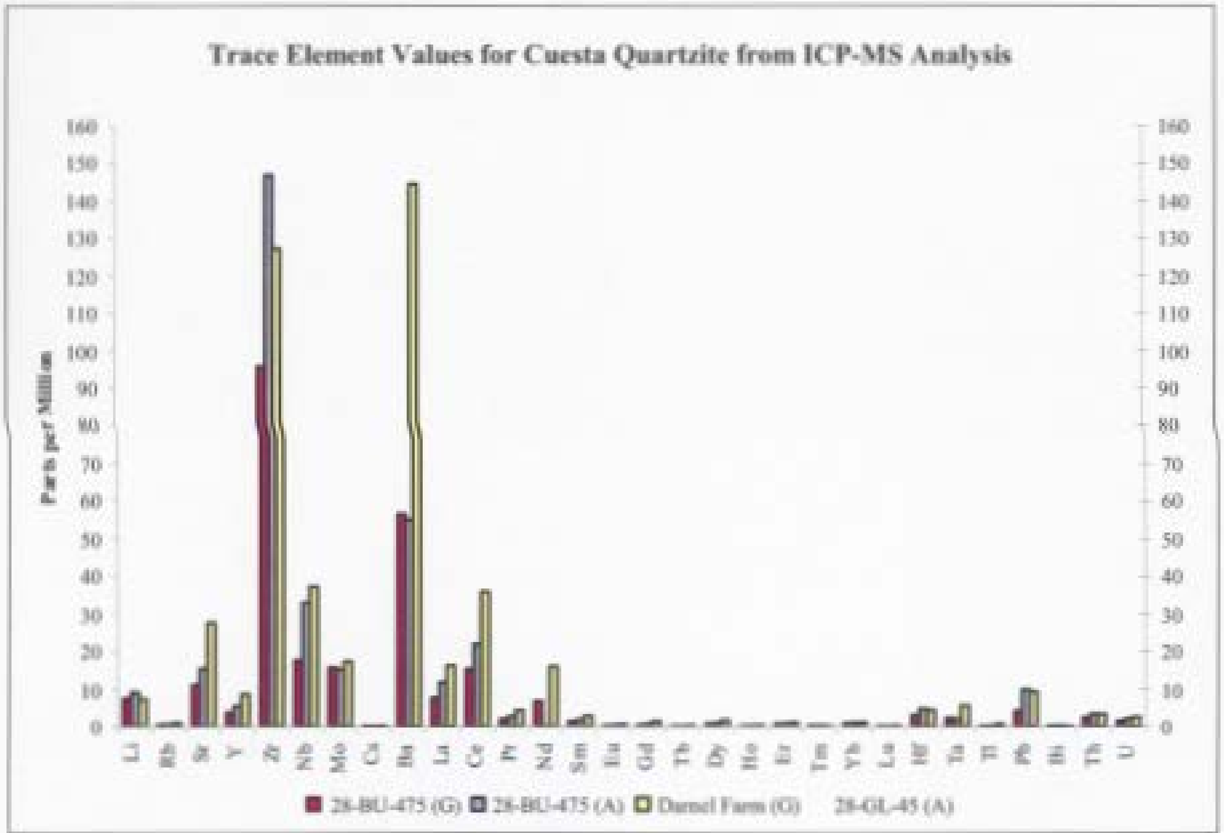


Figure 2.8: Graph of ICP-MS Values

The LAM-ICP-MS analysis of trace elements shows the same situation: All of the samples show similar mineralogy, but the discrepant values for suites of elements do not allow matching archaeological and geological specimens to single sources. Table 2.3 and Figure 2.8 present the LAM-ICP-MS data.

In addition to the article cited by Wyckoff and Newell, other research by Summerfield (1981:20, 26) in Africa generally has demonstrated a very high concentration of silica, as would be expected, as well as oxides of titanium, iron, and other elements, comparable to the New Jersey samples. The latter associations would not be intuitively obvious. This is not to say that the composition of silcretes or orthoquartzites can be said to be uniform, but there is a remarkably good fit among the analyses of the silcretes from widely divergent places.

The results lead to the conclusion that exhaustive testing for the purpose of matching archaeological remains with geological sources would be unprofitable for the purposes of the present research. Following the general tenets of optimal foraging or "mini-max" economic constructions (Becker 1976; Schelling 1978; Byrne 1980; Orlove 1980; Cooper 1998) one is left to assume that archaeological populations made use of materials that were near at hand. This interpretation makes sense considering that all known archaeological examples of Cuesta quartzite occur within easy travel distance of the natural sources.

2.9) Summary

This chapter has summarized the physiographic and geological framework in which archaeological cultures operated. The paleogeographic contexts have been presented, along with information concerning the aboriginal use of Cuesta quartzite and other lithic materials. I have explored the cultural and geological contexts of Cuesta quartzite and presented data concerning its geochemical composition. The limited sampling conducted so far suggests that Cuesta quartzite is very similar in composition to other orthoquartzites or silcretes from various places in New Jersey, and, indeed, from around the world. With respect to samples gathered from geological sources in southern New Jersey and from nearby archaeological sites, its mineralogy shows no major differences from place to place, yet its composition is too varied to permit linking archaeological remains with geological sources.

Chapter 3: Artifact Descriptions

This chapter will deal with the description and analysis of Cuesta quartzite artifacts. The classes of artifacts to be considered are bifaces, debitage (flaking debris), and hammerstones. In each case, as appropriate, the presentation will include a general description, along with a listing of linear dimensions, relational measures (such as length-to-width ratios), mass, and color. Statistical indices will be noted along with commentary concerning their implications. Specimen identification numbers are provided when reference is made to particular items. The following prefixes indicate specimens from collections: C- for Carman collection, W- for Woodruff collection, and NJSM- for New Jersey State Museum. Individual artifacts from my own research are identified by site number. A brief comment concerning the known geographic distribution of bifaces will be offered. The treatment of each artifact category will end with an interpretative discussion. The chapter concludes with a general summary.

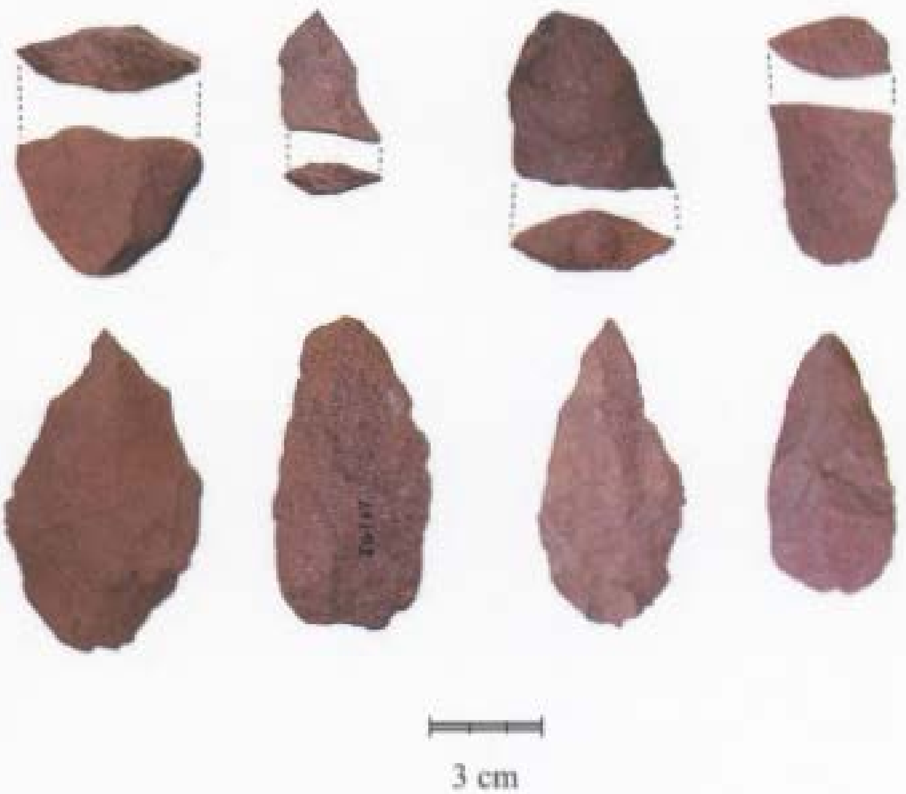
3.1) Bifaces

As a general class, bifaces frequently show a reduction trajectory from cores, or flake blanks to early-stage bifaces; thence, to more refined pieces—mid-stage or late-stage bifaces—and finally to formalized specimens. As used here, formalized bifaces are finished items that appear to satisfy a conscious design intended to serve a particular purpose or a set of functions.

A biface core represents the nucleus of a lithic mass that has been bifacially reduced from a cobble or a bedrock source. As Cuesta quartzite does not occur in bedrock per se, all cores in this material derive from cobble fields. These cores denote either initial tool fabrication or flake procurement activities, or both.

Incompletely formed bifaces, lacking refinements in edge-finish, hafting elements, or other details, are called early-stage bifaces (Plate 3.1). The general stages of reduction employed here follow those established by Sharrock (1966:43ff) and refined by Callahan (1979:9-13; 1989:6). Bifaces that have been completed to some conceptual design are known as formal bifaces. Formal bifaces may include objects of specialized or unspecialized function, whether or not intended for use in a haft. Items representing this class are projectile points, knives, and cleavers. Forms that are intermediate to early-stage and formalized bifaces may be called mid-stage bifaces.

In order to produce a formal biface the knapper must thin the work piece to appropriate proportions by the systematic removal of flakes. Usually, thinning is intended to reduce the thickness of the mass being worked, while maintaining as much length and breadth as possible. Biface preforms are bifacially reduced artifacts that have been successfully thinned or exhibit manufacturing failure during the process of thinning. Preforms usually possess regular, fairly refined shapes and may only need to have the hafting elements completed to be classified as formal bifaces. Flake blanks are derived from initial flake removals from a core, usually representing either decortication or primary flake types. The parent cores may or may not be specially prepared by preliminary knapping to control the size and rough shape of the flake blanks. These blanks are potentially useful as tools, given reshaping, but as blanks usually only show minimal reduction or evidence of use. In Cuesta quartzite, flake blanks often serve as the starting forms for bifaces, small untrimmed flakes, rarely so.



Upper row shows early-stage fragments in plan and section. Bottom row, left to right: early-stage biface, mid-stage biface, flake blank, preform.

Plate 3.1: Unformalized Bifaces

Formal bifaces were subject to breakage, use-wear, and reshaping, all of which could materially change the form and appearance of the pieces. The blades became shorter and often asymmetrical, while the basal portions generally retained their original formal configurations. Many worn specimens evidently were reworked into smaller functional implements (such as reamers or drills) until they reached a point of technological exhaustion and were discarded. However, some non-functional pieces might have been held subsequently for reasons having nothing to do with practicality.

The present sample of Cuesta quartzite bifaces numbers 170 formalized bifaces, of which 116 are stemmed, and 27 notched. A final, miscellaneous category includes another 27 specimens, which comprise early-and mid-stage bifaces, biface fragments, and tools, as well as two formalized bifaces that do not conform to the stemmed or notched categories. The sample is a composite that derives from a variety of sources, including museum and personal collections, and my own research.

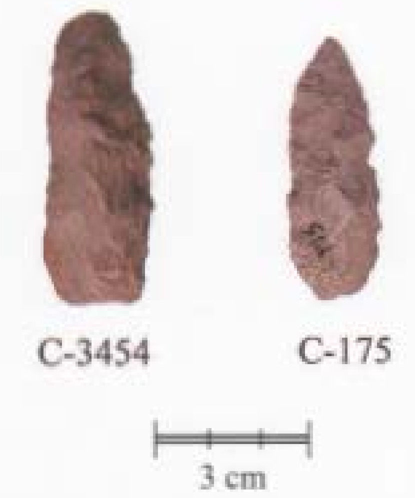
Virtually all Cuesta quartzite bifaces exhibit evidence of thermal alteration, which is usually expressed in two ways. First, most of the pieces show a distinct reddening or darkening of the stone in relation to the colors of the unmodified rock. Second, the surfaces of heated artifacts have a glossy, almost waxy appearance and feel, which is not found on broken surfaces of the material as it occurs in nature. In addition, the imbedded quartz grains become very clear and reflective upon exposure to heat. In these respects the thermal treatment of Cuesta quartzite is similar to that observed in other materials (Crabtree and Butler 1964; Crabtree 1972; Griffiths et al. 1987; Hester 1972; Luedtke 1992:91-92; Purdy 1984:122-123; Schindler et al. 1982; Silsby 1994:323-326).

Shifts in color and luster have been replicated in multiple thermal alteration experiments, which are treated in detail elsewhere in this document (Chapter 6). The effects of heat appear to be essentially surficial, and renewed exposures to fire seem to accompany each stage in the reduction sequence. In its native contexts, this continual repetition of the heating and knapping cycle was certainly intentional and may well have carried symbolic meaning in addition to practical implications.

The distribution of color within individual specimens can be recorded with respect to the extent of expression, either as background colors or highlights. Background or base colors are the predominant colors of the biface, whereas highlights are streaks or zones of color that contrast with the background. Colors were recorded for 24 stemmed bifaces, representing a judgmentally representative sample. The Munsell Soil Color charts (Munsell Soil Color Company 1988, 1992) provide the standard color classification scheme. In the text and illustrations, the Munsell soil color names, rather than their technical designations, are used, because the names are the more intuitively evocative. Also, multiple designations are classified under a single descriptive name. For example, an even dozen color notations qualify as "weak red," another nine for "dusky red," and so forth. It is far simpler to use the names.

The background colors are mostly shades of brown, red, and gray. Predominant tones of gray come from the presence of many split, clear quartz crystals which reflect, but do not transmit, much light by reason of being surrounded by generally opaque silica cement in tones of gray, yellow, or pink. The finer and more numerous the crystals, the grayer the sample appears. Items that are composed of more widely dispersed quartz grains have a browner or redder appearance, depending upon the color of the cement. The cement evidently contains traces of iron compounds which take on a red or yellow cast when heated. Apparently, the zones of iron concentration are mechanically weaker than the silica matrix, since conjoining specimens occasionally have fractures that correspond with reddened iron-oxide bands (Plate 3.5, left).

All of the bifaces were formed by a combination of percussion and pressure flaking. Artifacts in an unfinished state show relatively bold, deep flake scars, which are remnants of percussion flaking (Plate 3.2). The finished reduction of these pieces would proceed by the creation of a hafting element and trimming of the flake scar ridges to produce a less rugose surface texture.



Unfinished bifaces, showing deep flake scars from preliminary thinning. Hafting elements have not been created at this stage.

Plate 3.2: Bold Flaking on Unfinished Bifaces

Experimentation shows that creating the haft might likely occur earlier rather than later in the reduction process, because knapping on the ends of bifaces poses a high risk for biface fracture (Cresson, pers. comm. and experimental observations). Most of the later stage reduction (i.e., from mid-stage and preform bifaces to formal items) is accomplished by pressure flaking, as suggested by the quality of the flaked surface, the corroborative ratios of flake type, and the known behavior of the stone with respect to knapping techniques.

In this study, the bifaces have been divided into four categories, according to form. The groupings are: 1) early- and mid-stage bifaces and flake blanks; 2) stemmed bifaces; 3) notched bifaces; and 4) miscellaneous bifaces. Each group will be described in turn. The presentation will then turn to a discussion of the relationships between the various classes of bifaces.

3.1.1) Early- and Mid-Stage Bifaces and Flake Blanks

Flake blanks in Cuesta quartzite are generally large primary flakes, which have been tentatively reduced by preliminary trimming. They are inchoate forms, which have not advanced to the point of being classifiable as true bifaces.

Whether starting from cobbles or flake blanks, early-stage bifaces have been reduced to rough, but true, bifacial forms by a technique that experimental knappers call "edging." This technique, most often accomplished with hammerstones, removes cobble cortex and the natural or rough broken edges of the core. When knapping with a stone percussor results in very thin or weak edges, they are removed with soft hammer techniques, which may involve soft stone or organic percussors. Irregular surface masses behind the edges, often called stacks, can be (and evidently were) detached with strikes of an organic billet. Each face contains multiple flake scars and a relatively rough, irregular edge, which appears crenellated (or even somewhat notched) in plan and sinuous in an edge-on view. Some flake scars may not reach to the midline of the broad face. Because of the thickness of the detached flakes, the surface topography is very uneven. Early-stage bifaces are intermediate between Callahan's (1979:9-10, 30-31, 1989:6) Stage 2 and Stage 3 bifaces. In Cuesta quartzite, typical examples have a width-to-thickness ratio of approximately 2.00:1 to slightly less than 3.00:1. These specimens are relatively thick in comparison to Callahan's framework, because of the refractory nature of the stone. Callahan (1979:9-10, 30-31, 1989:6) likens bifaces in this level of reduction to Abbevillian handaxes.

Mid-stage bifaces are more refined, having a straightened edge and a thinner cross-section, with a less pronounced surface topography produced by primary thinning, which involves the removal of ridges and humps from the faces of the work piece. The broad thinning flakes necessary to achieve this level of reduction are often removed by knapping with organic billets, as shown by experimentation and by the geometry of the flakes (Cresson 1990, 1994; Callahan 1989:6). Bifaces at this level of reduction resemble Acheulean handaxes; they are equivalent to the products of Stage 3 in Callahan's (1979:9-10, 30-31 1989:6) scheme. In Cuesta quartzite, the ordinary width-to-thickness ratio is in the range of 2.00:1 to 3:00:1.

With additional thinning, sometimes called secondary thinning, these forms become more refined and take on the general appearance of formalized bifaces prior to the creation of the hafting elements, achieved by removing the corners of the blank (Plate 3.3). Bifaces at this level of reduction—Stage 4 in Callahan's terms—assume what Callahan (1979:9-10, 30-31, 1989:6) calls "trade blank character."

Plate 3.3: Hypothetical Reduction of Preform

Few early- and mid-stage forms have been recovered from archaeological sites in unbroken or mendable condition, in consequence of which, the metric data are skimpy. Nevertheless, the maximum recorded dimensions are as follows: length, 87.9mm, width, 40.5mm, thickness, 23.5mm. The width-to-thickness ratios compute to a range of 2.14:1 to 2.70:1. A single example of a "trade blank" or preform (Specimen No. C-170) measures 67.1mm in length, 33.4mm in width, and 11.9mm in thickness. It is a leafshaped, stemless blank having a width-to-thickness ratio of 2.81:1. (Plate 3.1, lower right; Plate 3.3, background).

3.1.2) Formalized Bifaces

Formalized bifaces occur in stemmed and notched varieties, which will be discussed separately. Topics to be covered include dimensions, overall form, blade and stem elements, angular measurements, color expressions, and knapping techniques. These basic descriptors provide a basis for comparing artifacts of different form, for assessing their functions, and for relating them to a single cultural tradition. The sections that deal respectively with stemmed and notched bifaces will be followed by a general discussion that compares and contrasts the two forms.

3.1.2.1) Stemmed Bifaces: The stemmed bifaces are formed by removing the basal corners from preforms, thus resulting in the creation of stems or tangs. These bifaces vary with respect to basic dimensions, such as overall length, width, and thickness, as well as the form of the blade and stem (Plate 3.4). Many could be roughly classified within the morphological continuum defined by the Morrow Mountain (Coe 1964:37-43), Poplar Island, Rossville (Ritchie 1961:44-46), and Lackawaxen (Kinsey 1972:337, 408-411) types. The elemental forms are most reminiscent of the contracting stemmed bifaces that Joffre Coe (1964:37-43) called the Morrow Mountain I and II types. In Coe's typology the Type I form has a broad blade, while the Type II bifaces have a narrower blade in relation to overall length. One can select individual Cuesta quartzite specimens that satisfy the general configuration of both Morrow Mountain I and II bifaces. However, it appears that the quartzite bifaces really form a continuum which contains items of somewhat diverse form, resulting from vicissitudes of use, fracture, or accidents of manufacture. For now, the discussion will center on more elemental considerations, such as basic linear and angular dimensions, as well as the dimensional relations that define biface morphology. Table 3.1 lists these basic parameters and their related values.

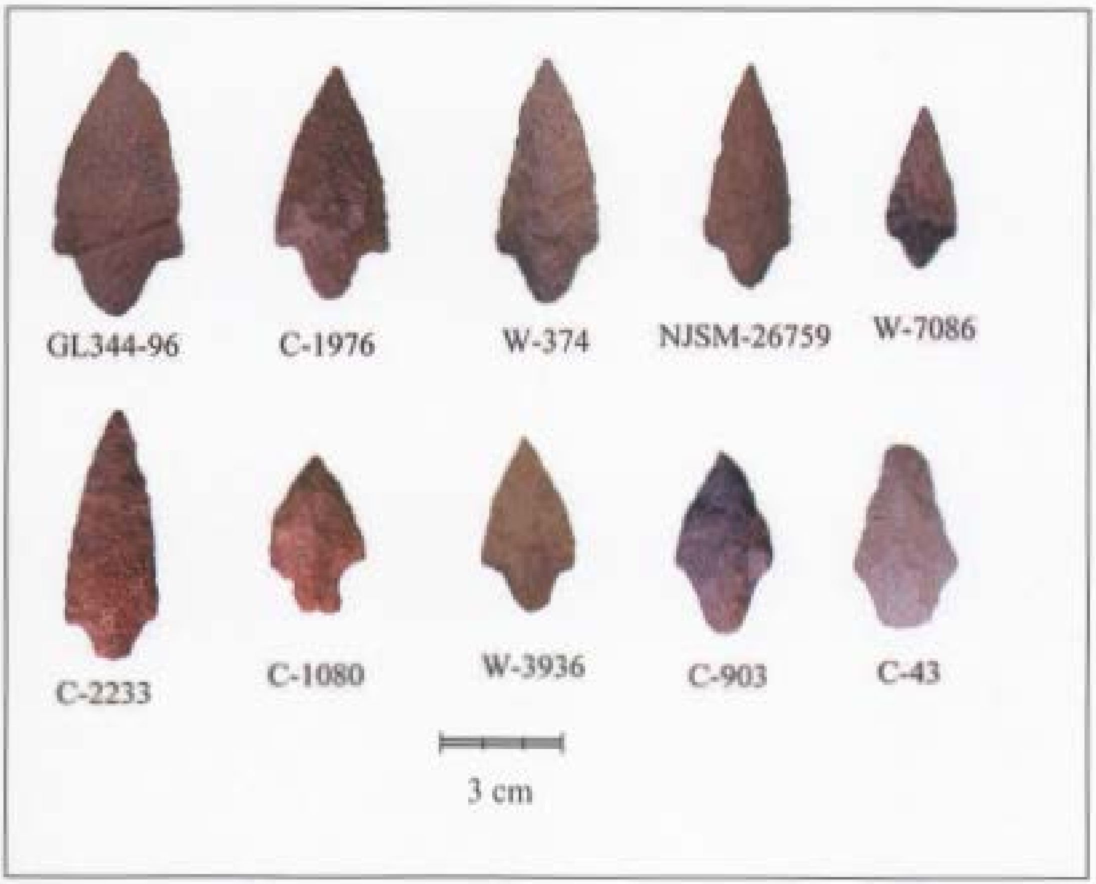


Plate 3.4: Typical Stemmed Bifaces

Excluding fragments, 109 specimens could be measured for length. All could be measured for width and thickness. The minimum length is 26.5mm, the maximum is

93.2mm, and the mean is 50.8mm. Widths range from 15.7mm to 32.6mm, with a mean of 23.5mm. Thicknesses vary from 5.0mm to 16.0mm. The mean thickness is 9.7mm. These values, plus those for the median, mode, and standard deviation appear in Table 3.1. That table also relates variability about the mean (within one standard deviation) and dimensional ratios, as well as angular measurements.

Table 3.1: Dimensions of Stemmed Bifaces

(N = 116) Parameter	L	W	T	W/T	L/W	Min. Edge Angle	Max. Edge Angle	Blade Angle	Tip Angle
Minimum	26.5	15.7	5.0	1.35	1.26	27	40	28	22
Maximum	93.2	32.6	16.0	4.20	3.56	73	108	72	144
Mean (μ)	50.8	23.5	9.7	2.49	2.18	45	67	44	67
Median	50.2	23.4	9.5	2.38	2.14	46	68	43	66
Mode	44.0	24.0	11.0	2.91	1.96	38	56	41	78
Std. Dev. (σ)	10.2	3.6	2.0	0.50	0.39	8	12	8	21
$\mu - \sigma$	40.6	20.0	7.8	1.99	1.79	37	55	35	46
$\mu + \sigma$	61.0	26.9	11.5	2.88	2.53	53	79	51	87
σ / μ	0.20	0.15	0.21	0.20	0.18	0.18	0.18	0.18	0.31

For the *population of stemmed bifaces* as a whole, the coefficient of variability (standard deviation divided by mean) indicates that width is the least variable dimension (0.15), followed by length (0.20), and finally by thickness (0.21). However, replicative knapping shows that thickness, which is established early in manufacture, is the least variable dimension in *individual bifaces*, while both length and width can witness much greater changes as a result of reworking during maintenance or repairs.

The stemmed forms vary from 1.26 to 3.56 times as long as broad. The mean length-to-width ratio is 2.18:1. Among these bifaces, length and width have a moderate positive correlation, which is statistically significant. The correlation coefficient is: $r(107) = 0.5502$, $p < 0.01$.[1] Figure 3.1 graphs the relationship of lengths to widths among stemmed bifaces, with a linear trend line. In this and other scatter plots, the trend line charts the linear regression between the subject variables.

The ratios of width to thickness range from a minimum of 1.35:1 to a maximum of 4.20:1. The mean value is 2.49:1. Width and thickness in stemmed bifaces have a moderate positive correlation, which is statistically significant. The correlation coefficient is: $r(123) = 0.4229$, $p < 0.01$. Figure 3.2 shows a scatter plot of width and thickness in stemmed bifaces with a linear trend line. Figure 3.3 illustrates both the length-width and width-thickness relationships in stemmed bifaces. Both indices show similar reduction patterns.

Edge angles vary along the length of a biface blade because the cross-sectional configurations vary with respect to micro-topography. Lower edge angles usually exist where one or both of the broad surfaces of a biface are concave, as, for example, in the

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[1] Here, and elsewhere in this document, r represents the Pearson's correlation coefficient. The number in parenthesis denotes the corresponding degrees of freedom, and p is the associated probability of random occurrence.

bottom of flake scars. In such situations the relative thickness of the biface at the point of measurement is less than it would be if measured along flake scar ridges, and the angular relationship between the opposite faces is correspondingly reduced. Higher angles usually exist if the measurement follows a flake scar ridge or occurs at a stack (i.e., a stone mass not removed during reduction), in which case, the biface thickness is greater, and the resulting angle more obtuse.

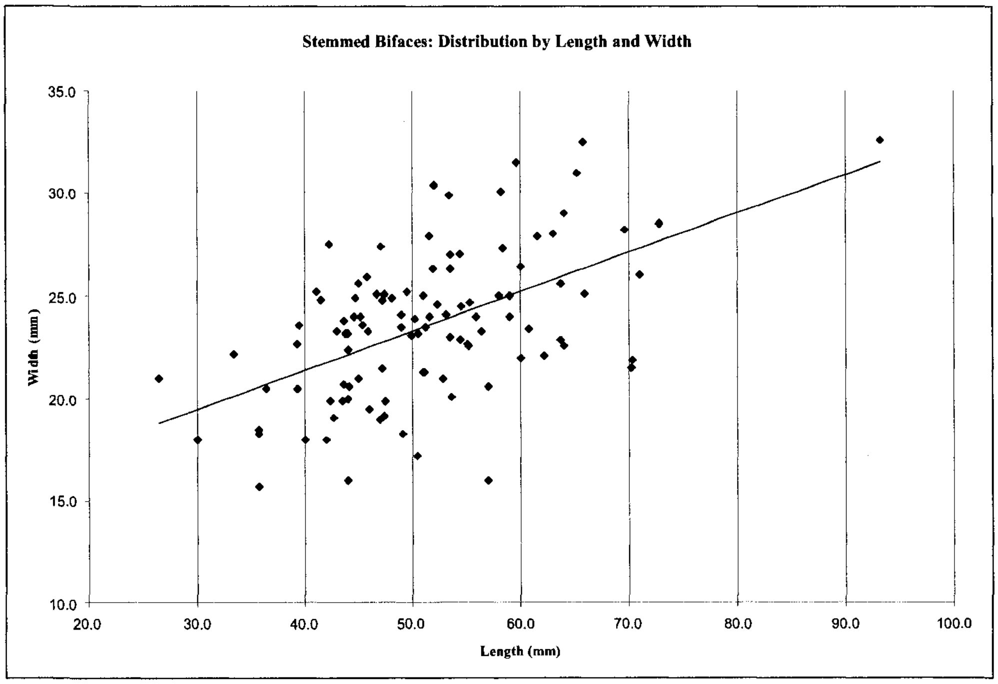


Figure 3.1: Stemmed Bifaces by Length and Width

In stemmed bifaces, the mean edge angles range from 33° to 90.6°, with a mean value of 56°. As would be expected, edge angles have a fairly strong inverse correlation to width-to-thickness ratios. As width-to-thickness ratios increase, the corresponding edge angles decrease as shown in the cross-sections of the bifaces in Plate 3.5. The correlation coefficient for this relationship in stemmed bifaces is: $r(123) = -0.9730$, $p < 0.01$. Conversely, as thickness increases, the corresponding edge angles also increase. The correlation coefficient for this relationship in stemmed bifaces is: $r(123) = 0.7041$, $p < 0.01$. Both of the foregoing correlations are statistically significant.

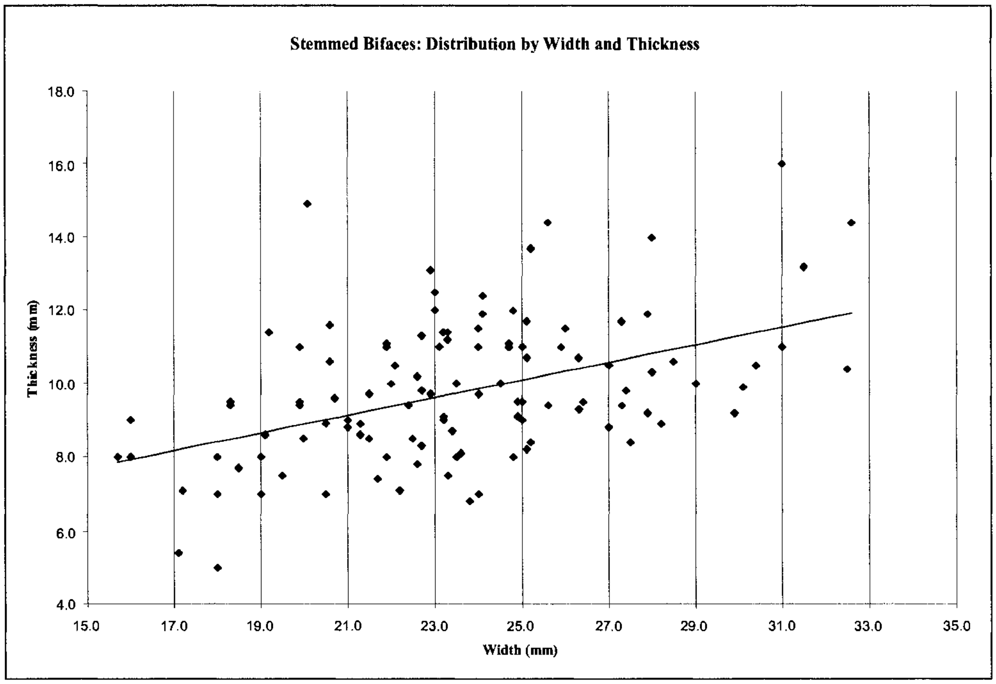


Figure 3.2: Stemmed Bifaces by Width and Thickness

Naturally, the higher width-to-thickness ratios also correspond to thin, generally lenticular cross-sections, while the lower ratios are characterized by round, nearly round, or rhombic cross-sections. Plate 3.5 illustrates two typical examples, showing composite views of bifaces in plan as well as in cross-section.

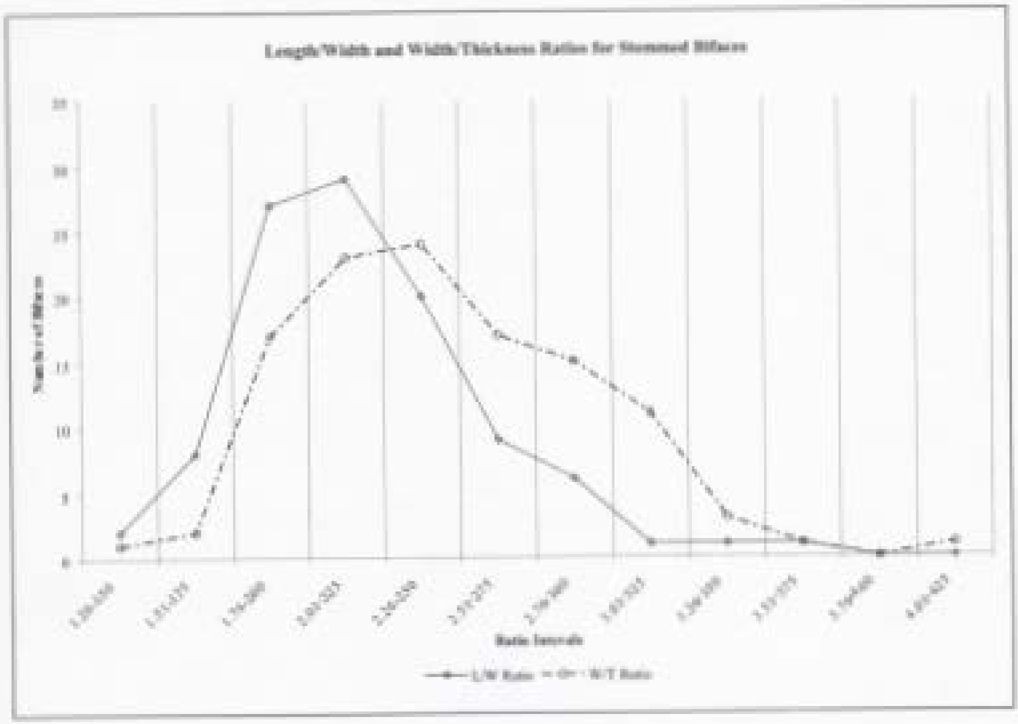


Figure 3.3: Dimensional Ratios for Stemmed Bifaces

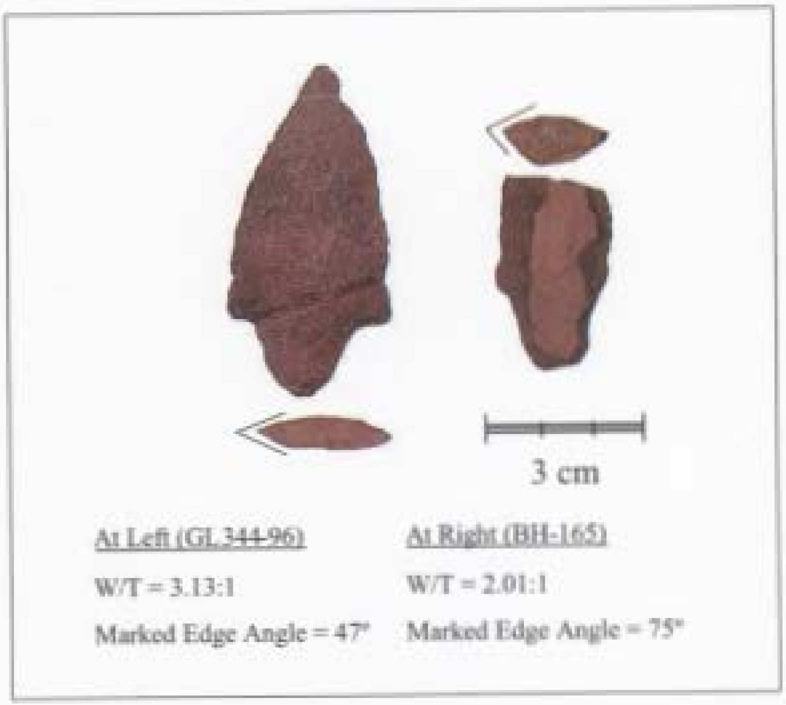
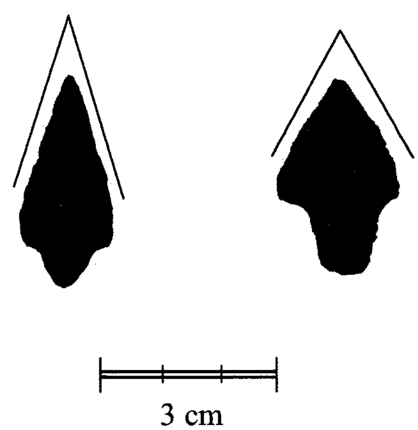


Plate 3.5: Outline and Cross-Section of Bifaces

Generally, the blades have slightly excurvate sides. The blade form can be characterized in simple terms by the "best-fit" blade angle. This angle gives a measure of the extent of blade attrition (see Plate 3.6). It describes the distal end of the blade, from the tip to the first major departure, if any, from a linear configuration along the blade edges. If the blade outline is basically linear from the tip to the shoulders, the angle simply follows the blade edges. The apex of the angle lies along the centerline of the biface, and the arms of the angle follow the blade so that as much of the blade edge lies upon one side of the line as the other. This procedure takes into account the fact that the biface edges are irregular or wavy. Bisecting the high points and hollows generates lines that are "best-fit" with the biface edge configuration.



Relationship between Blade Form and Best-fit Blade Angle.
The angles have been separated from the bifaces for clarity.
Left (W-7086): Angle = 36°, Right (W-2331): Angle = 63°

Plate 3.6: Best-Fit Blade Angle for Bifaces

Blade angles that are acute describe blades that have relatively straight edges and relatively high length-to-width ratios, a common attribute among bifaces without extensive wear (Plate 3.6, left). More obtuse blade angles correlate with blades that have markedly curved edges or short lengths relative to width. Often a low length-to-width ratio marks a heavily worn or reworked biface (Plate 3.6, right). As length and blade curvature increase, the blade angle tends to decrease. The correlation coefficient for the ratio of length and width to blade angle is: $r\ (107) = -0.5654$, $p < 0.01$, indicating statistical significance.

A sample of 92 bifaces was available for examination of blade angles. Artifacts from the Ware site, recorded by others, could not be used for want of pertinent data. Although the researchers recorded tip angles, the blade angles, as such, were not recorded. The best-fit blade angles range from 28° to 72°, with a mean value of 43.6°.

Tip angles vary from 22° to 144° with a mean of 67°. In almost all cases the tip angles are more obtuse than the

corresponding blade angles, although on severely reworked implements (drills, etc.) the reverse is true. The difference between the two gives a rough measure of wear or fracture at the distal end of the biface, which is more particularly shown by comparing tip angle and actual tip form (Figure 3.4). However, blade angle and tip angles are very weakly correlated: $r\ (90) = 0.0983$, $p > 0.01$). Evidently, the relationship is not statistically significant.

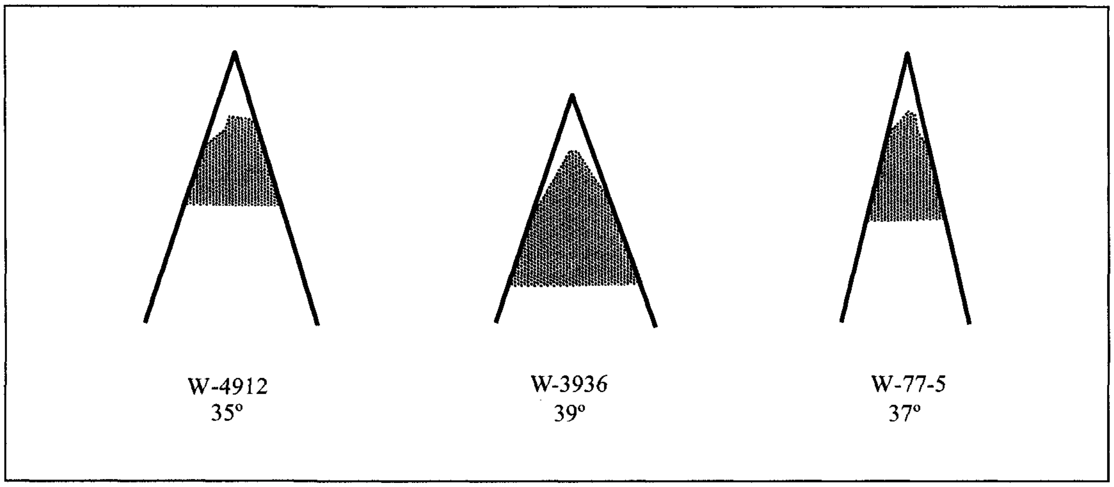


Figure 3.4: Tip Angles and Proximal Details in Bifaces

The 84 stemmed bifaces with complete hafting elements show a variety of basal configurations. Forty-two (50. 0% of the total) have rounded tangs, another five (6.0%) terminate in rounded, but somewhat pointed, bases, while 12 (14.3%) have rounded tangs with squarish corners. Twenty-four (28.6%) have square or predominantly squarish tangs. One biface (1.2%) has a stem that is irregular in form. Plate 3.4 illustrates typical stem terminations, and Table 3.2 shows the dimensions. A chi-square test of the distribution of stem forms shows it to be not significant in a statistical sense ($X^2 = 0$). From this evidence I infer that variability in terminal stem form was not highly patterned.

The overall length of any given biface consists of the blade length plus the stem length. The blade length may be defined as the measure of the biface from the tip (if present) to a line drawn between the widest points, at the shoulders (Plate 3.7). The stem consists of the element between the line just noted and the basal element (if present). The distinction between blade and stem length is important because blade length tends to change more over the use-life of an artifact than the basal element, which is often held in a haft and, therefore, not subject to as much reduction as the blade. Table 3.2 enumerates the values associated with blade and stem lengths in stemmed bifaces.

Table 3.2: Blade and Hafting Elements for Stemmed Bifaces

N = 84	Total Length	Blade Length	Stem Length	Stem Width	B/L Ratio [1]	S/L Ratio [2]	B/S Ratio [3]	S/B Ratio [4]
Minimum	33.4	21.2	7.4	8.9	0.57	0.15	1.30	0.18
Maximum	93.2	71.4	21.8	23.2	0.85	0.43	5.65	0.77
Mean (μ)	51.5	38.5	12.8	15.5	0.75	0.25	3.13	0.35
Median	50.3	37.6	12.5	15.3	0.74	0.26	2.91	0.34
Mode	35.7	31.6	12.2	15.7	0.72	0.28	3.96	0.39
Std. Dev. (σ)	10.0	9.1	2.8	2.9	0.06	0.06	0.94	0.11
$\mu - \sigma$	41.2	29.3	10.0	12.6	0.69	0.20	2.19	0.24
$\mu + \sigma$	61.3	47.6	15.6	18.4	0.80	0.31	4.07	0.46

— **Notes** —

[1] Blade Length / Total Length
[2] Stem Length / Total Length
[3] Blade Length / Stem Length
[4] Stem Length / Blade Length

The indicated ratios do not necessary compute across the table because the minimum and maximum values are spread across multiple specimens

In the present sample, blade lengths vary from a minimum of 21.2mm to a maximum of 71.4mm. The mean blade length is 38.5mm. Blade lengths variably comprise between 57% and 85% of overall biface length (Table 3.2 and Figure 3.5). The proportion of blade length to biface length is 0.75, on average.

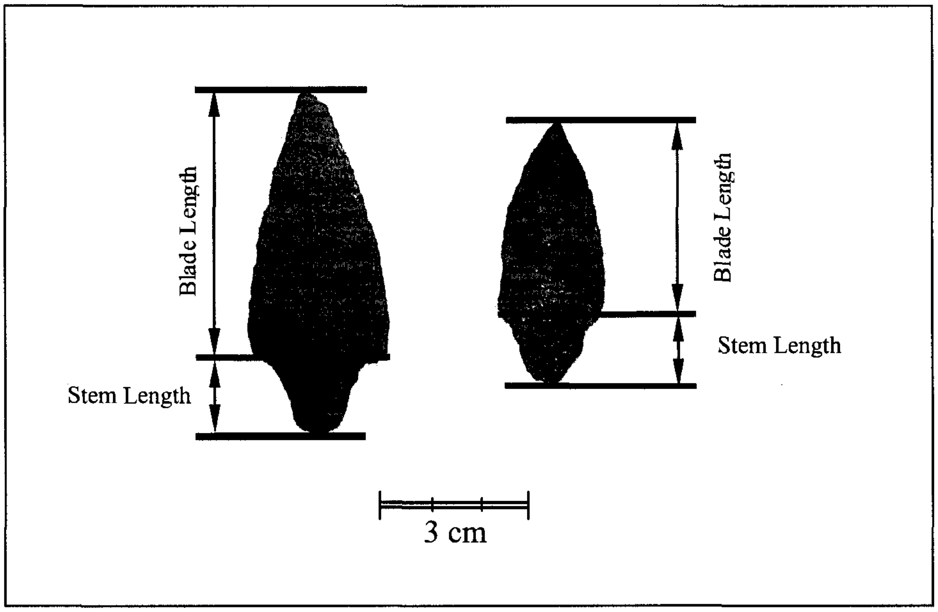


Plate 3.7: Blade and Stem Lengths in Bifaces

Stem lengths range from a minimum of 7.4mm to a maximum of 21.8mm. The mean stem length is 12.8mm. Stem lengths constitute between 15% and 43% of overall biface length. The ratio of stem length to overall length is 0.25, on average.

Stem widths were measured immediately beneath the shoulders or at a point midway along the stem-to-shoulder curvature, if the shoulders did not terminate in distinct tangs or barbs. The minimum stem width was 8.9mm, the maximum 23.2mm. The mean value computes to 15.5mm.

The blade length-to-stem length ratios vary from a low of 1.30:1 to a high of 5.65:1. In other words, the longest blades are almost six times longer than their stem elements; whereas the shortest are about 30% longer than the stem. The mean value is 3.13:1 (Table 3.2).

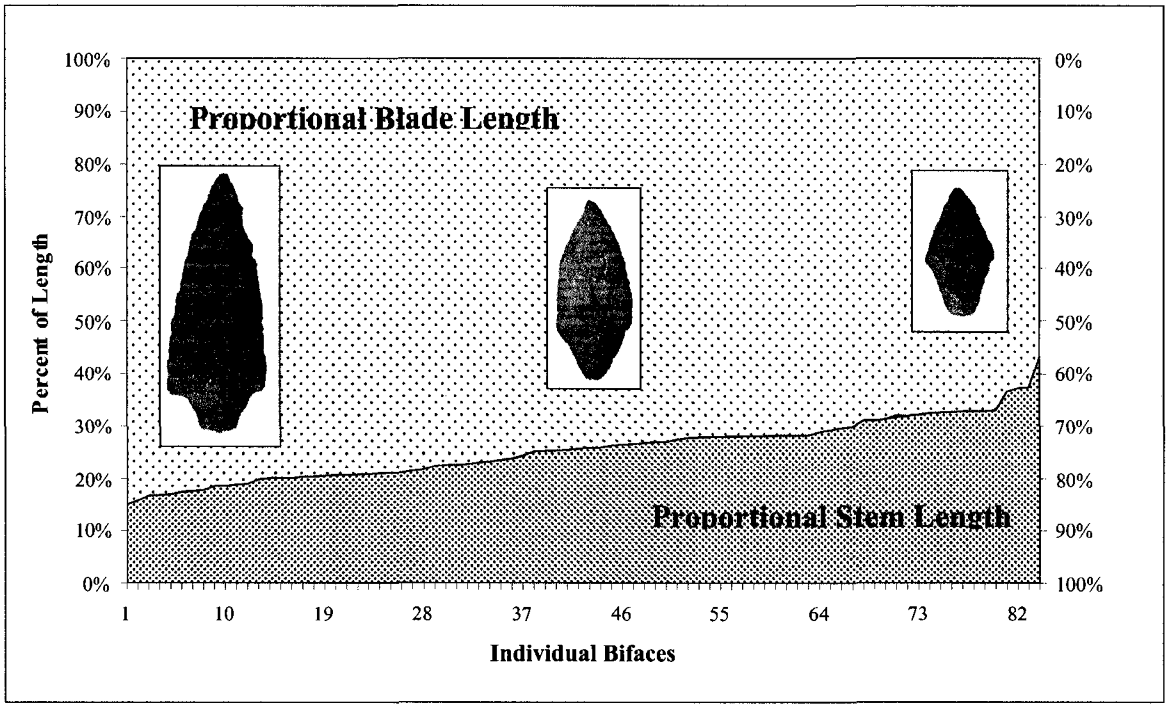


Figure 3.5: Blade and Stem Proportions for Stemmed Bifaces

Photographs illustrate extreme and median examples of blade and stem proportions.

Another descriptive index is the stem length-to-stem width ratio, which defines the proportions of the tang. Among stemmed bifaces, this ratio ranges from 0.55:1 to 1.41:1. That is, the shortest tangs are only about one-half as long as wide, while the longest are not quite 1½ times as long as wide. The mean is 0.83:1, or about 20% greater in width than in length.

In stemmed bifaces, the principal or base colors occur in shades of brown, gray, and red. In terms of the Munsell Soil Color charts, brown is represented by five shades, gray by seven, and red by one. The numerical and proportional expressions of these colors appear in the accompanying graph (Figure 3.6). Note that the graph presents the full range of colors observed on all bifaces, whether or not those colors find expression in the stemmed bifaces. This approach shows the manifestations as part of the color continuum for the entire biface assemblage.

Of the background colors, gray predominates. Gray is expressed in seven shades, which in the aggregate, account for two-thirds of the stemmed bifaces (N = 16). There are five variations of brown, which together comprise 20.8% of the specimens (N = 5). A weak shade of red finds expression in one specimen, representing 12.5% of the total.

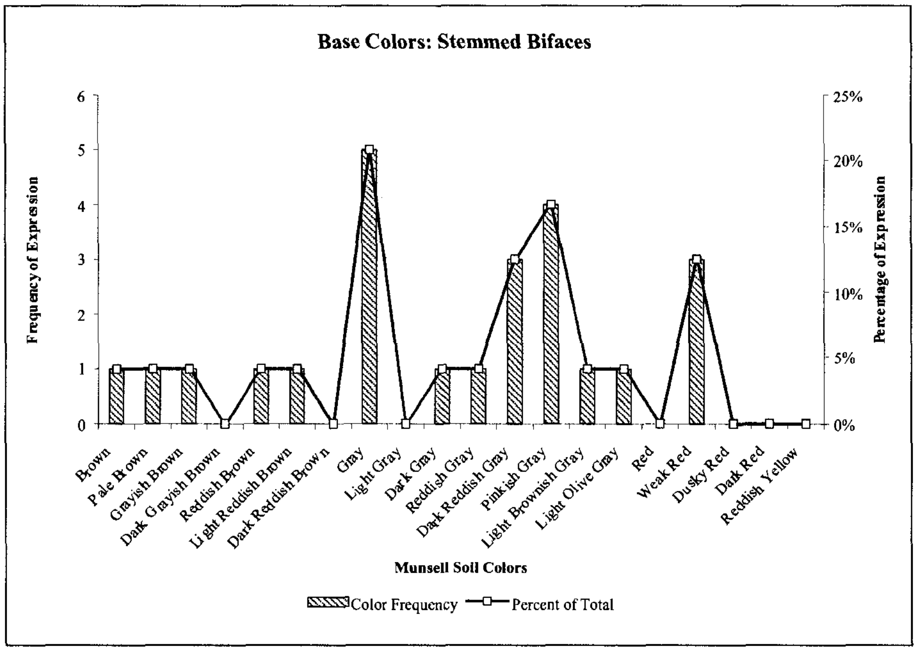


Figure 3.6: Principal Colors of Stemmed Bifaces

The highlight colors—the streaks or blotches of color that contrast with the background—are fewer than the base colors and usually reflect deeper shades or stronger colors of brown or red, and sometimes yellow (Figure 3.7). Gray does not appear as a highlight on any specimen. As already noted, the appearance of strong reddish or yellow highlights is an indication of thermal alteration of the bifaces.

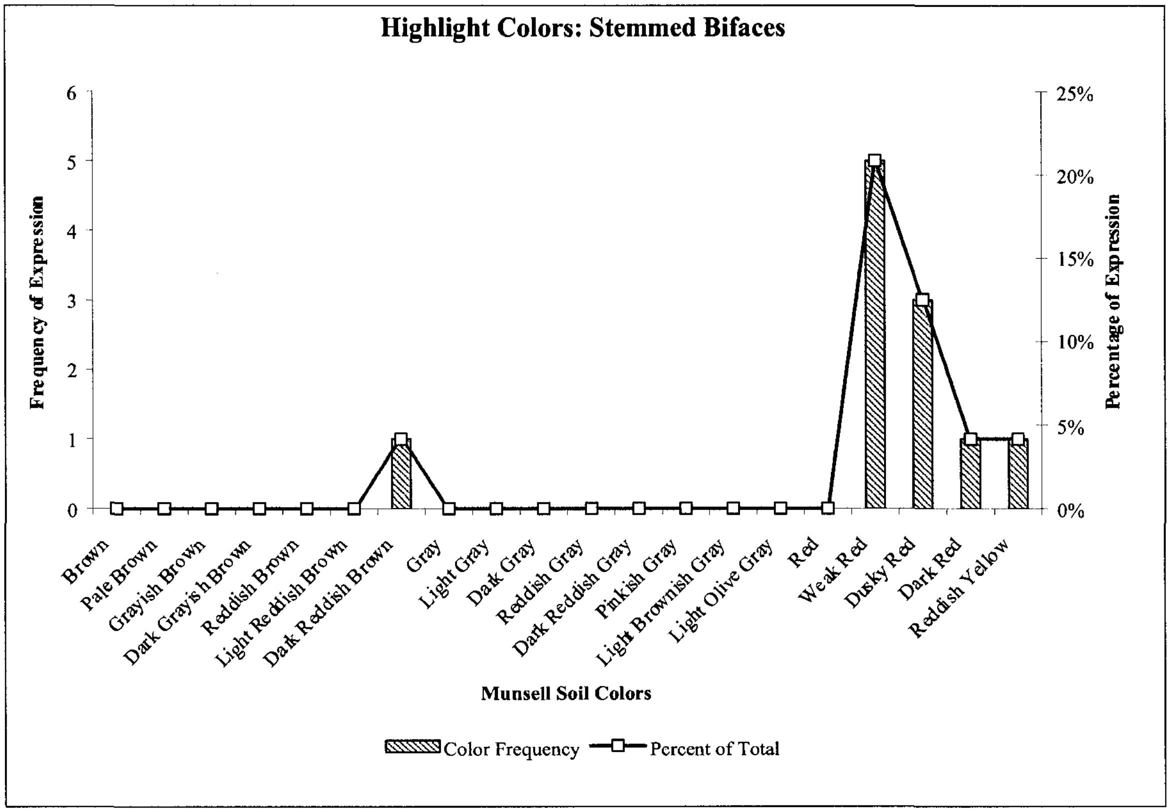


Figure 3.7: Highlight Colors for Stemmed Bifaces

Almost all of the finished stemmed bifaces show edge polish or dulling, especially on the shoulders and stems. This dulling is more pronounced than on the blade edges, indicating intentional blunting. Evidently, this action was taken to protect binding materials whose acquisition and preparation doubtless represented a significant economic investment. It probably also served to prevent the blade from loosening in the haft.

Rounding is visible under low-power magnification but is easily detected by touch. Running a finger tip along and across the edges readily distinguishes smoothed edges from sharp ones. Wear on the blade and flake ridges may be a function of use, but abrasion from contact with the soil after burial is certainly a contributing factor.

3.1.2.2) Notched Bifaces: Notched bifaces are formed by the removal of flakes above the basal corners of the preform, resulting in the creation of shoulders and an expanding tang (Plate 3.8). Similar bifaces occur on many sites in Late Archaic/Early Woodland contexts, but rarely in Cuesta quartzite (Kinsey 1972: 159-179; Mounier 1974a, 2003a:213-215).

The following paragraphs describe these bifaces with respect to overall length, width, and thickness. The ratios of length to width and width to thickness will be disclosed, along with angular dimensions respecting blade form, biface edges, and tips.

The notched forms vary from 1.63 to 2.74 times as long as broad. The mean length-to-width ratio is 2.04:1. Among notched bifaces, length and width have a moderate positive correlation, which is statistically significant. The correlation coefficient is: $r(25) = 0.5821$, $p < 0.01$. Figure 3.8 graphs the relationship of lengths to widths among notched bifaces, with a linear regression line. The plot points are more scattered than among stemmed bifaces, possibly because of the small sample size.

The maximum recorded length is 58.0mm, while the minimum is 33.4mm. The mean length is 45.9mm. The maximum recorded width is 30.6mm, the minimum is 17.0mm, and the mean is 22.7mm. The bifaces vary in thickness from 7.9mm to 12.6mm, with a mean of 10.3mm.

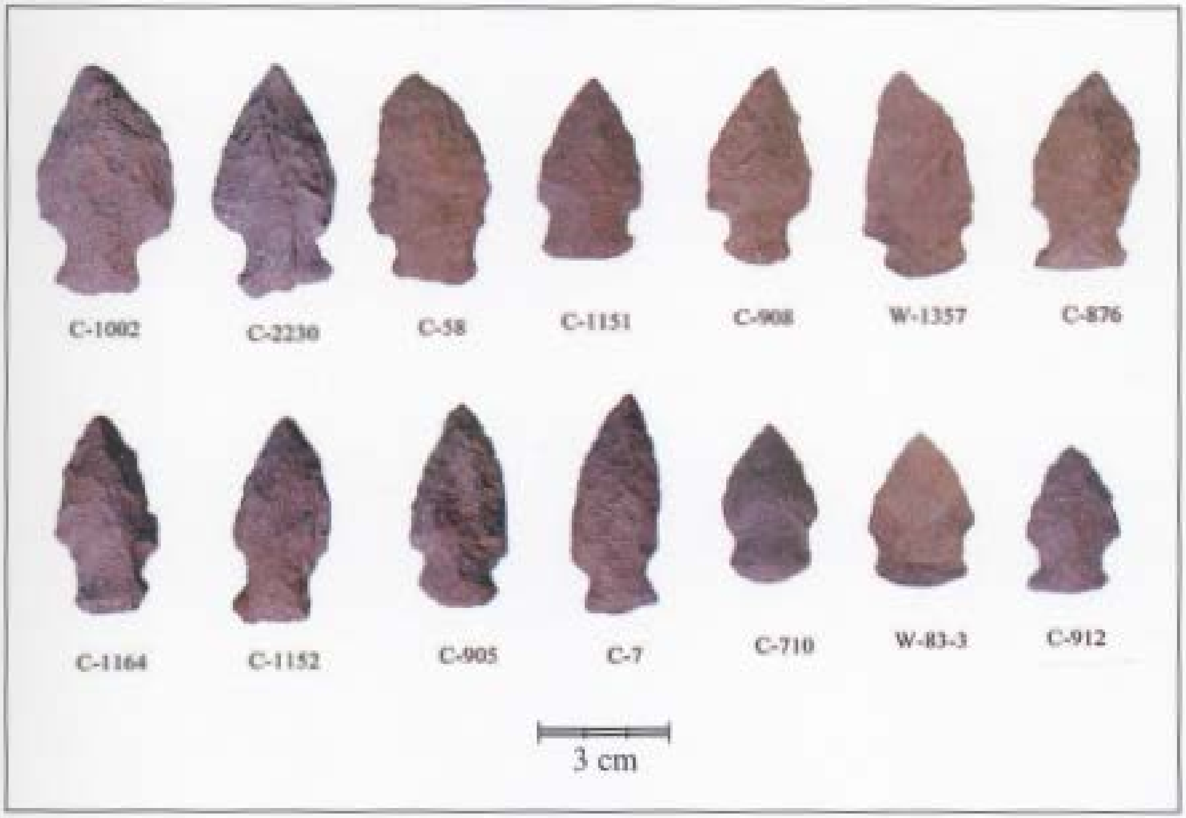


Plate 3.8: Typical Notched Bifaces

From the information presented in Table 3.3, it can be seen that among the notched bifaces thickness is the least variable dimension ($\sigma/\mu = 0.12$), followed by width ($\sigma/\mu = 0.13$), and finally, by length ($\sigma/\mu = 0.15$). In this instance, the biface population mirrors the variability expected among individual bifaces from an experimental perspective.

Table 3.3: Dimensions of Notched Bifaces									
N = 27 / Parameter	L	W	T	W/T	L/W	Min. Edge Angle	Max. Edge Angle	Blade Angle	Tip Angle
Minimum	33.4	17.0	7.9	1.73	1.63	37	55	38	51
Maximum	58.0	30.6	12.6	2.97	2.74	60	89	56	100
Mean (μ)	45.9	22.7	10.3	2.22	2.04	49	73	44	69
Median	47.9	22.6	10.5	2.19	1.98	49	73	44	68
Mode	47.9	24.9	10.8	2.01	2.04	49	66	66	60
Std. Dev. (σ)	7.1	3.0	1.2	0.33	0.29	6	9	4	10
$\mu - \sigma$	38.8	19.7	9.1	1.89	1.75	43.1	63.8	40.2	58.8
$\mu + \sigma$	53.0	25.6	11.5	2.54	2.33	55.4	82.0	48.7	79.2
σ / μ	0.15	0.13	0.12	0.15	0.14	0.12	0.12	0.09	0.14

The ratios of width to thickness range from a minimum of 1.73:1 to a maximum of 2.97:1. The mean value is 2.22:1. Width and thickness in notched bifaces have a weak positive correlation, which is not statistically significant. The correlation coefficient is: $r(25) = 0.2911$, $p > 0.01$. Figure 3.9 shows a scatter plot of width and thickness in notched bifaces with a linear trend line. Figure 3.10 graphs both the length-width and width-thickness relationships in notched bifaces. Both indices show similar reduction patterns, which approximate normal distributions.

In notched bifaces, the mean edge angles range from 49° to 101°, with a mean value of 72°. The edge angles on notched bifaces have a moderate inverse correlation to width-to-thickness ratios. The correlation coefficient for this relationship in notched bifaces is: $r(25) = -0.6576$, $p < 0.01$. Conversely, the correlation to thickness is positive; the correlation coefficient for the relationship between edge angles and thickness in notched bifaces is: $r(25) = 0.5541$, $p < 0.01$. These are statistically significant correlations.

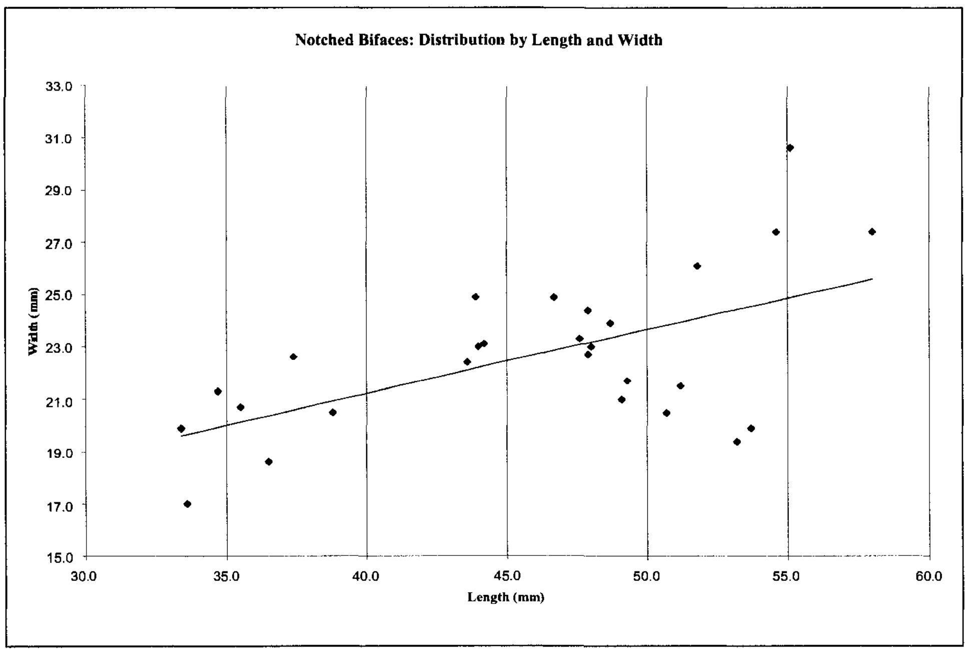


Figure 3.8: Notched Bifaces by Length and Width

As with the stemmed bifaces, the higher width-to-thickness ratios also correspond to relatively thin, generally lenticular cross-sections, while the lower ratios are characterized by round, nearly round, or rhomboidal cross-sections.

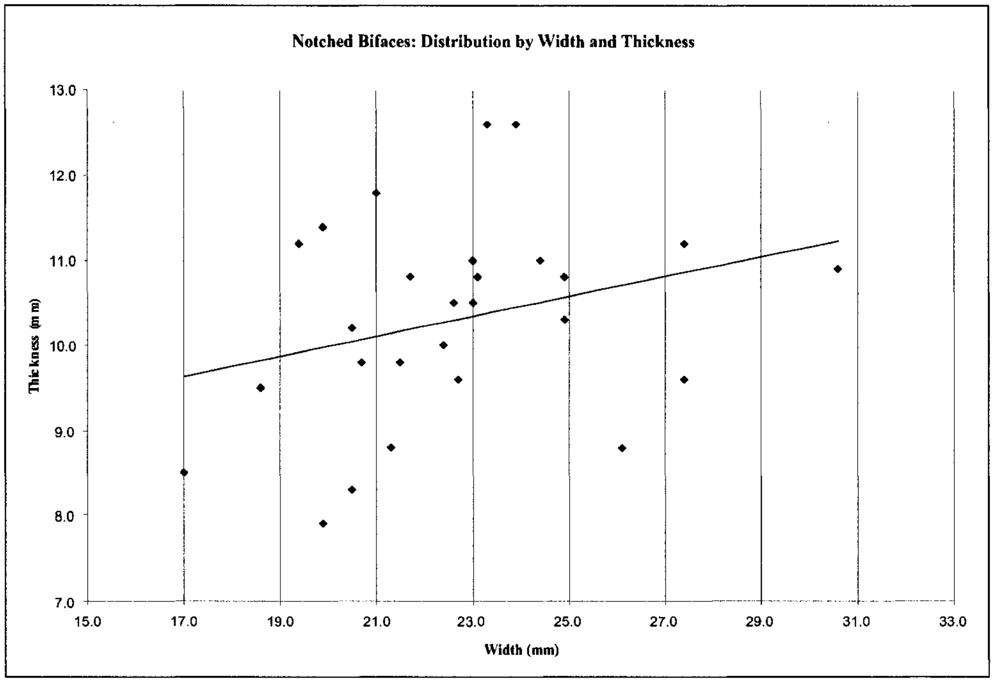


Figure 3.9: Notched Bifaces by Width and Thickness

Generally, the blades have slightly excurvate sides (Plate 3.8). One measure of blade form is the "best-fit" blade angle, whose characteristics have been previously noted. A sample of 27 notched bifaces was available for examination. As length increases and blade curvature decreases, the blade angle tends to diminish, and vice versa. However, in a statistical sense, this relationship may be more apparent than real. The correlation coefficient for the ratio of length and width to blade angle is: r (25) = -0.0790, p > 0.01, indicating a very weak, statistically insignificant correlation. The best-fit blade angles range from 38° to 56°, with a mean value of 44°.

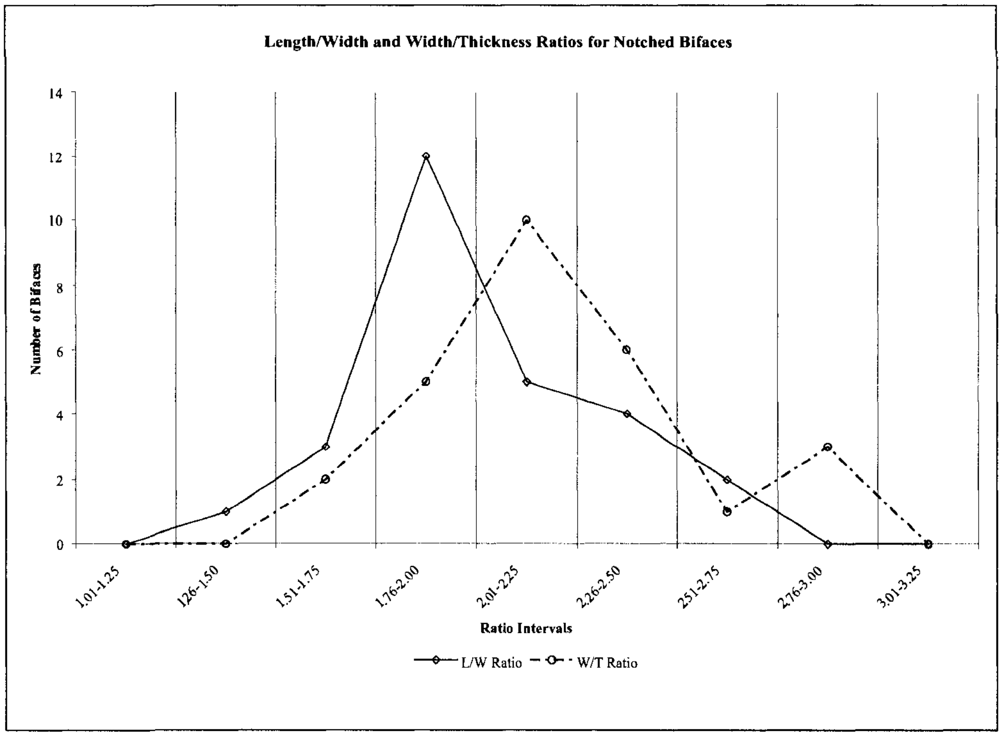


Figure 3.10: Dimensional Ratios for Notched Bifaces

Tip angles vary from 51° to 100° with a mean of 69°. In all cases the tip angles are more obtuse than the corresponding blade angles. As already noted, the difference between these angles gives a rough measure of wear or fracture at the distal end of the biface (Figure 3.4). The correlation coefficient for the relationship between blade angles and tip angles is stronger than in stemmed bifaces: r (25) = 0.4792, 0.02 > p > 0.01. Still, the one is not a particularly good measure of the other.

The 27 notched bifaces with complete hafting elements show a variety of basal configurations. Fourteen (51.9% of the total) have rounded tangs, and six (22.2%) have rounded tangs with squarish corners. Another six (22.2%) have square or predominantly squarish tangs with straight basal lines. One biface has a stem that is irregular in form (3.7%). Plate 3.8 illustrates typical stem terminations. A chi-square test of this distribution shows it to be not statistically significant ($x^2 = 0$); consequently, it seems likely that variability in terminal stem form was not highly patterned.

The hafting elements were formed by the selective removal of flakes from the sides of the stem, between the shoulders and the stem base. Though they vary somewhat in configuration, all of the notches are fairly shallow and more or less rounded. Mostly the opposing notches are comparable with respect to depth and width. Table 3.3 provides summary statistics for the dimensions of notched bifaces.

A visual scanning of artifacts indicates a general similarity in the form of the notches (Plate 3.8). However, the correlations range only from weak to moderate. The correlation coefficient of notch-depths is: $r(25) = 0.3625$, $0.05 > p > 0.01$ (not significant). The coefficient for notch-widths is: $r(25) = 0.6209$, $p < 0.01$. This value is statistically significant. The breadth of notching is more similar from one side of the sample bifaces to the other than the corresponding depth of notching.

The minimum stem width, measured at the full depth of the notches, ranges from a low of 10.9mm to a high of 17.1mm. The mean is 14.0mm. The maximum stem width, measured at the fullest extent of the tang, ranges from 12.4mm to 20.5mm, with a mean value of 16.8mm.

Table 3.3: Hafting Elements on Notched Bifaces

Parameters	Blade Length	Stem Length	Max. Stem Width	Min. Stem Width	Notch Depth (1)	Notch Depth (2)	Notch Width (1)	Notch Width (2)
Minimum	20.6	10.9	12.4	3.3	1.3	1.1	6.2	6.2
Maximum	42.2	18.1	20.5	17.1	4.3	8.8	15.3	15.4
Mean (μ)	31.3	14.6	16.8	14.0	2.5	2.6	10.3	10.3
Median	31.7	14.4	17.0	14.4	2.6	2.4	9.6	10.2
Mode	N/A	15.2	17	14.1	2.8	2.5	9.6	11.4
Std. Dev. (σ)	6.76	2.08	2.21	2.71	0.89	1.48	2.31	2.41
$\mu - \sigma$	24.5	12.5	14.6	11.3	1.6	1.1	8.0	7.9
$\mu + \sigma$	38.1	16.7	19.0	16.8	3.4	4.0	12.6	12.7

As would be expected, the minimum and maximum dimensions of the stem have a strong positive correlation, which is statistically significant. The correlation coefficient of these dimensions for the sample of 27 bifaces is: $r (25) = 0.7257$, $p < 0.01$.

Blade lengths vary from a minimum of 20.6mm to a maximum of 42.2mm. The mean blade length is 31.3mm. As shown in Table 3.4 and Figure 3.11, blade lengths variably comprise between 57% and 79% of overall biface length. The proportion of blade length to overall length is 0.68, on average.

Stem lengths range from a minimum of 10.9mm to a maximum of 18.1mm. The mean stem length is 14.6mm. The blade length-to-stem length ratios vary from a low of

1.32:1 to a high of 3.66:1. That is, the longest blades are almost four times longer than their stem elements; whereas the shortest are about 30% longer than the stem. The mean value is 2.19:1.

Table 3.4: Blade and Stem Ratios for Notched Bifaces						
Parameters	**S/B Ratio**	**B/S Ratio**	**B/L Ratio**	**S/L Ratio**	**SW/SL Ratio**	**SL/SW Ratio**
Minimum	0.27	1.32	0.57	0.21	0.87	0.65
Maximum	0.76	3.66	0.79	0.43	1.53	1.15
Mean (μ)	0.49	2.19	0.68	0.32	1.16	0.87
Median	0.46	2.15	0.68	0.32	1.14	0.88
Mode	0.39	3.32	0.72	0.28	1.07	1.07
Std. Dev. (σ)	0.13	0.60	0.06	0.06	0.16	0.12
$\mu - \sigma$	0.4	1.6	0.6	0.3	1.0	0.75
$\mu + \sigma$	0.6	2.8	0.7	0.4	1.3	0.99

The stems themselves tend to be wider than long. Almost 90% (N = 24; 89%) are relatively short and wide. Only three stems are longer than wide, with lengths exceeding widths by factors that range from 1.35 to 1.53. The summary statistics for the stem width to length ratio are as follows: The minimum is 0.87:1; the maximum is 1.53:1, and the mean is 1.16:1.

Colors were recorded for nine of the 27 notched bifaces, representing a judgmentally representative sample, using the Munsell Soil Color charts (Munsell Soil Color Company 1988, 1992). In notched bifaces, as with the stemmed, the principal or base colors are shades of brown, gray, and red (Figure 3.12). In terms of the Munsell Soil

Color charts, brown and red are represented by one shade each and gray by five shades. Reddish brown appears on one specimen (11.1% of the notched bifaces); gray, dark gray, dark reddish gray, and light brownish gray are represented by one example each (cumulatively accounting for 44.4%), while reddish gray occurs on two specimens (22.2%). Only one shade of red, known as "weak red," is present, being represented by two specimens (22.2%).

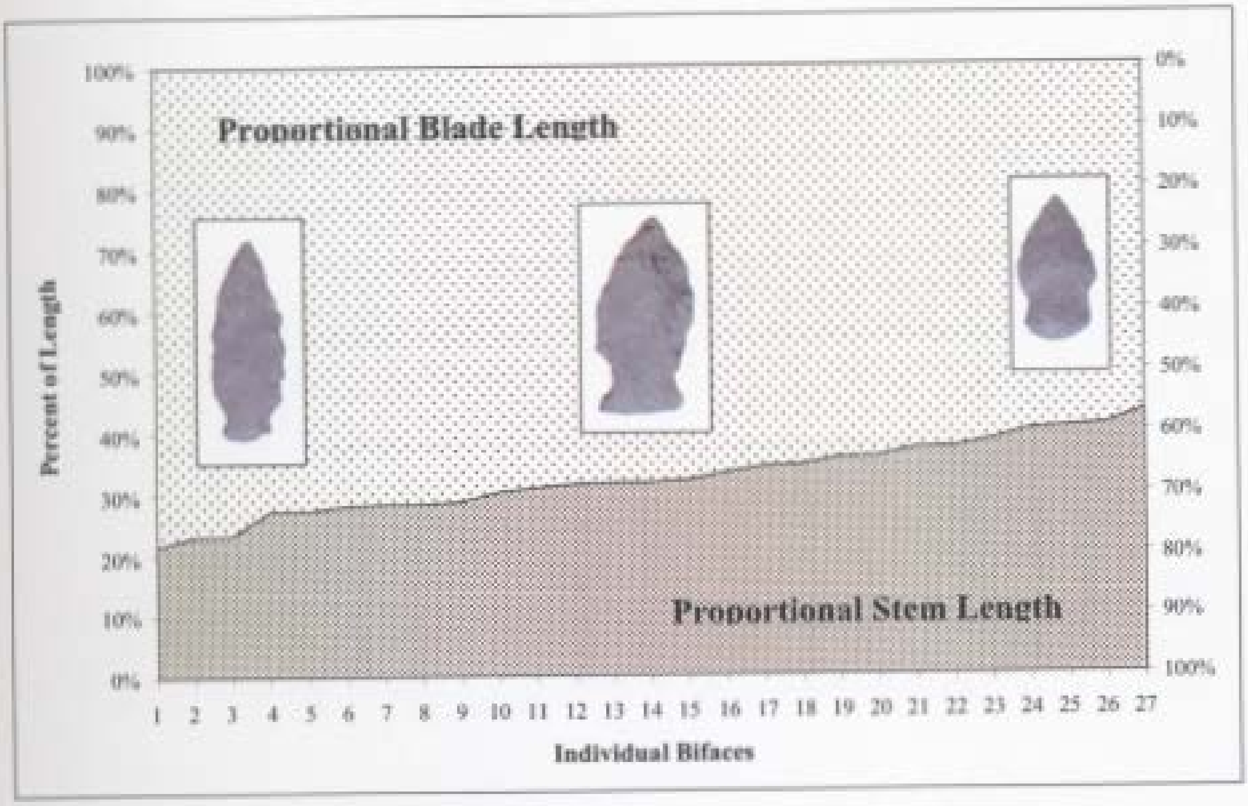


Figure 3.11: Blade and Stem Proportions for Notched Bifaces

Photographs illustrate extreme and median examples of base and stem proportions.

Very few of the notched bifaces show any color highlights (i.e., streaks or patches of color that stand in contrast to the background). As with the stemmed bifaces the highlight colors appear in various shades of red. Weak red highlights appeared on three specimens (11.1%) and another showed faint zones of dusky red. More than 85% of the bifaces presented generally uniform colors (Figure 3.13).

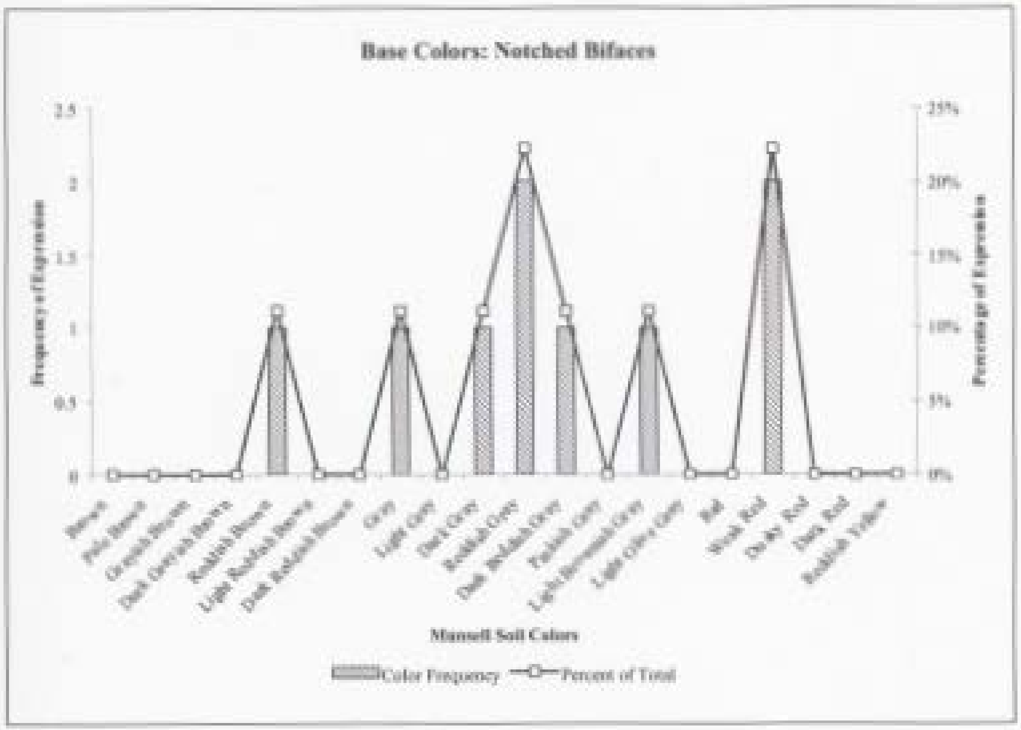


Figure 3.12: Principal Colors on Notched Bifaces

All of the notched specimens, like their stemmed counterparts, were formed by a combination of percussion and pressure flaking. Artifacts in an unfinished state show relatively bold, deep flake scars, separated by distinct ridges, which are usually remnants of percussion flaking (Plate 3.2). The finished reduction of these pieces would proceed by refining the hafting element and trimming the flake scar ridges to produce a smooth surface texture, and to even the lateral edges.

Almost all of the notched bifaces that are finished show some degree of edge rounding, which is especially prominent on the hafting element. As with stemmed specimens, intentional smoothing was undertaken to protect expensive binding materials and to stabilize the implement in the haft. The dulling of blade edges and flake ridges may be a function of use, but soil abrasion after burial cannot be ruled out as a contributing factor. Rounding is visible under low-power magnification but can be detected readily by touch, as previously noted.

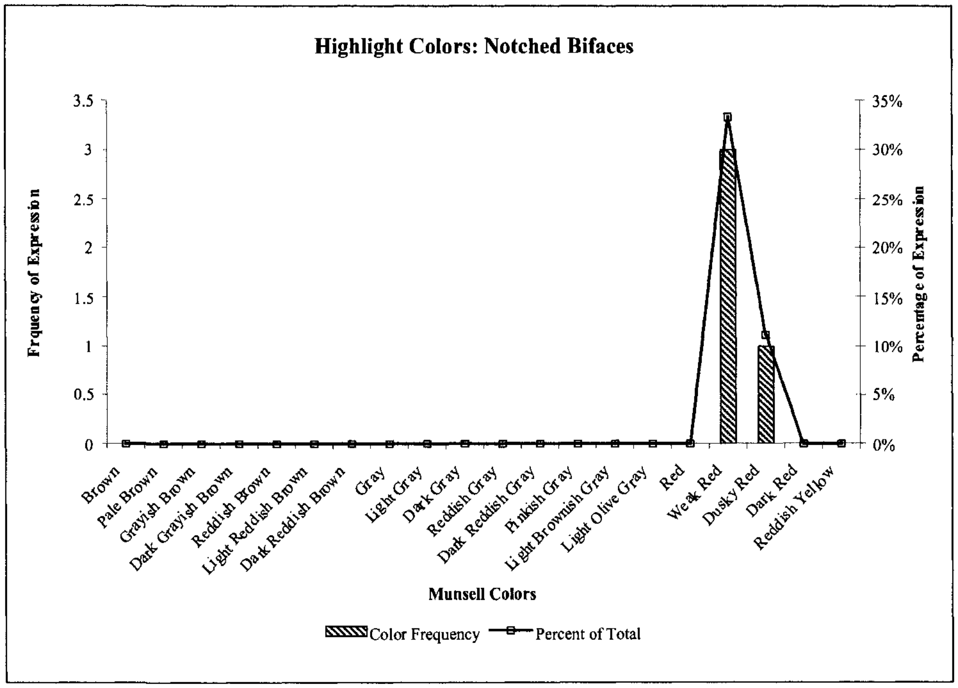


Figure 3.13: Highlight Colors on Notched Bifaces

3.1.2.3) *Miscellaneous Bifaces:* In addition to stemmed and notched forms, there is a small number of miscellaneous bifacial specimens. Three of these bifaces conform to styles that more commonly appear in cryptocrystalline materials (Plate 3.9). One fluted point, one triangular biface (C-2388) and one convex-based specimen (NJSM-24656) appear in collections. The fluted point is a version of the Clovis style (C-90), found by Alan Carman on the Harris Farm, near Salem, Salem County, N.J. The triangular biface, perhaps unfinished, has an isosceles form that could relate either to Archaic or late prehistoric expressions (Ritchie 1961; Mounier 2003a: 27-28). It was found by Alan Carman on the Glick Farm in the headwaters of the Maurice River, near Elmer, Salem County, N.J. Based solely on the setting, an earlier rather than a later origin is suspected, because by late prehistoric times, the headwaters of most coastal streams saw very sporadic occupation. Triangular bifaces ordinarily occur in jasper, chert, and other cryptocrystalline materials, and rarely in quartzite and argillite.

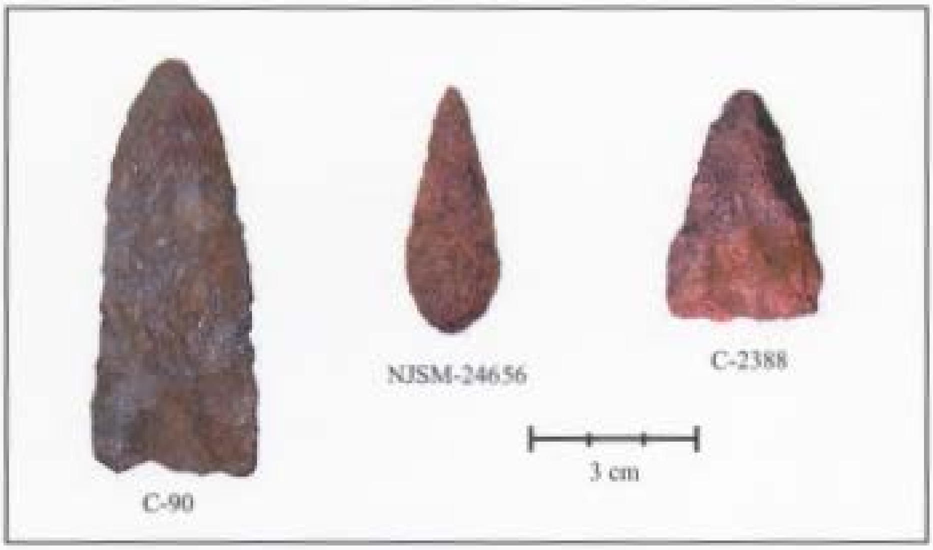


Plate 3.9: Fluted, Teardrop, and Triangular Bifaces

The convex-base biface comes from the Salisbury site, along the Delaware River in Gloucester County, where it was found during excavations by the Indian Site Survey (Cross 1941). This specimen conforms to a style locally known as the "Teardrop point" because of its mnemonic form. Like triangular bifaces, this style also seems to have multiple expressions in time. When they occur in good contexts in New Jersey, Teardrop bifaces either relate to the Late Archaic/Early Woodland period (Kraft and Blenk 1974; Mounier 2003a:158-159, Mounier and Cresson 1988, Mounier and Martin 1994) or to the

Middle Woodland period (Cross 1956). This form, like the triangular style, generally occurs in fine-grained stones.

Other bifaces in the miscellaneous assemblage do not conform to any recognized types. Several are neither stemmed nor notched and may be unfinished specimens. Two of these items can be classed as early- to mid-stage bifaces. Six are late-stage bifaces, whose trajectory towards formalization remains unrealized. One of these specimens—possibly a knife—has a thick stem, round in cross-section, and an asymmetrical blade. There is one well made preform (Plate 3.1, lower right; Plate 3.3, background), five small fragments, and nine miscellaneous specimens that cannot be classified more closely. Finally, two bifaces have blade configurations and wear patterns indicative of use as drills or reamers.

3.1.3) Discussion

The previous pages have dealt with the descriptive characteristics of various biface forms. This section will explore some of the relationships that exist within and between the biface types.

In most instances, the enumerations for formalized bifaces show a strong central tendency; that is, the means, medians, and modes tend to have very similar values, and standard deviations tend to be relatively small. For width, thickness, and their ratios, the differences between the mean and modal values are negligible. Lengths and angular measurements vary more strongly, because these dimensions are most heavily affected by events in the use-life of the artifacts. In general, departures from otherwise closely clustered central tendencies reflect the conditions of individual artifacts. Some are nearly pristine, while others have reached the point of exhaustion. Despite limitations in sample size, the linear dimensions for both stemmed and notched bifaces seem to approximate normal distributions. Usually, the distributions are well balanced around the mean. The graphs for distributions in length, and width share this similarity, as do the graphs for the ratios of length to width and width to thickness (Figure 3.14 – 3.19).

In scanning the assemblage of stemmed bifaces, one can envision two different groups or types, one following a broad-bladed template and the other a narrow-bladed pattern. Based on existing typologies, particularly Coe's (1964:37-43) Morrow Mountain I and II types, the discovery of two types was, in fact, expected. However, the data do not support this interpretation, particularly as there is a virtually complete absence of bimodality in the sample.

Irregularities in the curves can be explained by the relatively small sample sizes. For example, a "bump" in the curve for width-to-thickness ratios in the interval between 2.50 to 3.50 might represent the frequency sum of two overlapping normal distributions (Figure 3.17). However, the addition of only two specimens in the interval between 2.51 and 1.75 would normalize the curve. Accordingly, the data seem to represent a single, slightly ragged, frequency distribution. In other words, the data do not support the identification or creation of two discrete types; rather, it seems likely that the broad-bladed and narrow-bladed "types" represent nothing more than points on a continuum of related forms, as they are transformed from pristine to worn conditions. This is scarcely a new idea, as the venerable William Henry Holmes pointed out at the turn of the twentieth century (Holmes 1892, 1919).

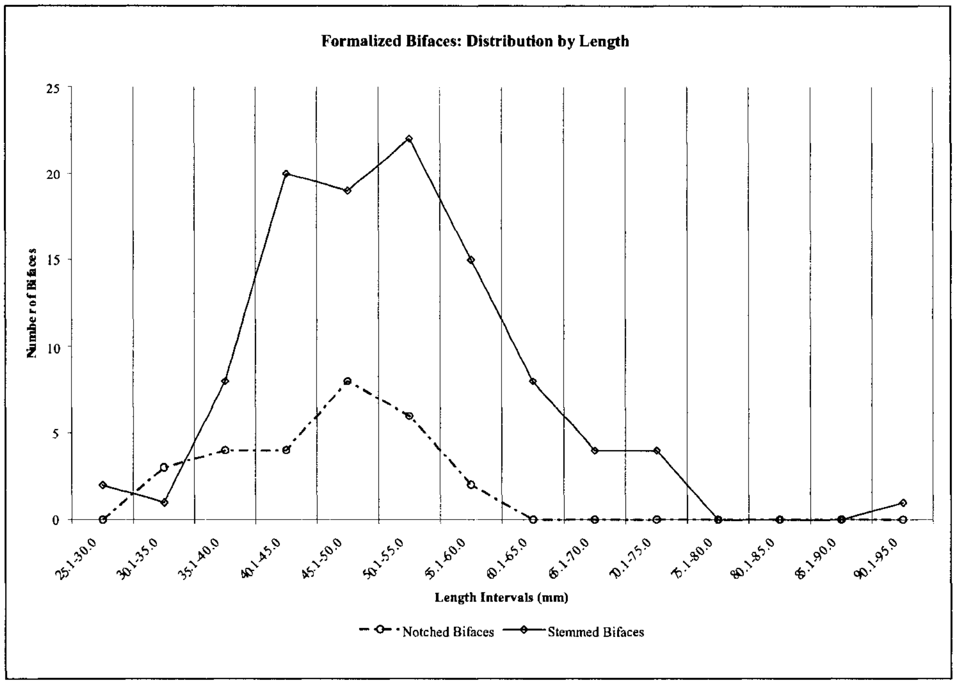


Figure 3.14: Formalized Bifaces, Frequency by Length

This view is consistent with both archaeological and experimental observations. One can see that the narrow-bladed form could derive from a process of reshaping the broad-bladed form, and there are numerous examples of reworked bifaces that might satisfy this scenario. Experimental knapping also shows that premature failure of broad, early-stage bifaces often creates an opportunity to salvage the blank by rendering it into a formalized, narrow-bladed biface (see Chapter 6). The stemmed forms, whether broad or narrow, are closely related.

In addition, the data strongly suggest that the notched specimens comprise a subset of the same population that contains the stemmed bifaces. Whether for linear or relational measures, all of the graphs show that the notched bifaces shadow the more numerous stemmed forms. This evidence indicates that the pattern of reduction in the principal linear dimensions was similar between the stemmed and notched varieties, and that the bifaces followed similar trajectories respecting the reduction in one dimension relative to reduction in another, as shown in the graphs that relate length to width and width to thickness (Figure 3.16 and 3.19).

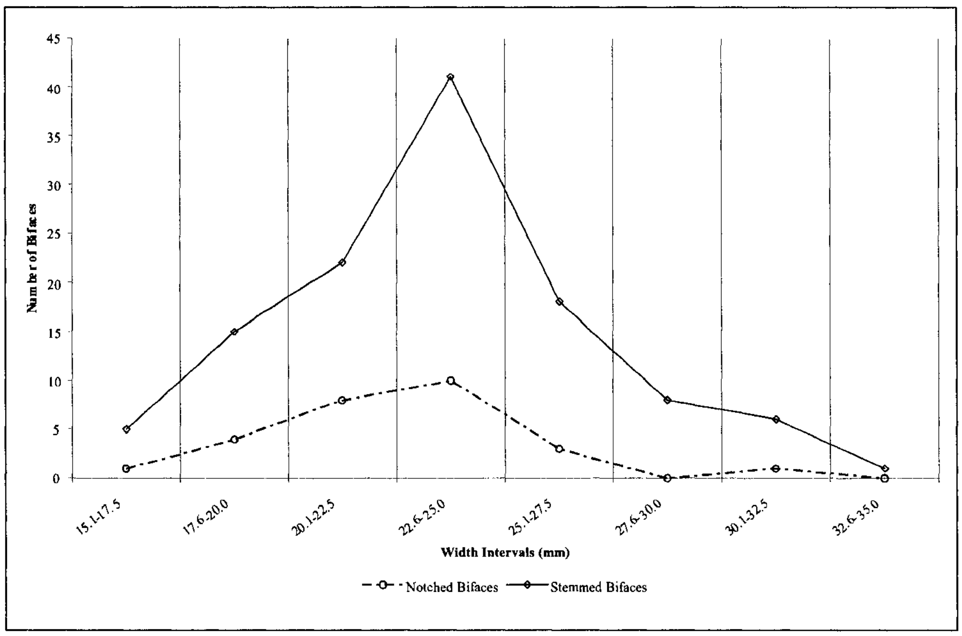


Figure 3.15: Formalized Bifaces, Frequency by Width

Chi-square (X^2) tests of stemmed and notched bifaces—arrayed with respect to lengths, widths, and thicknesses—result in an inability to reject the hypothesis that both sets were drawn from the same population; that is, that there is no difference between them with regard to the measured variables. In all cases, the values of X^2 were too small to have confidence in an alternate hypothesis at the 0.05 level.

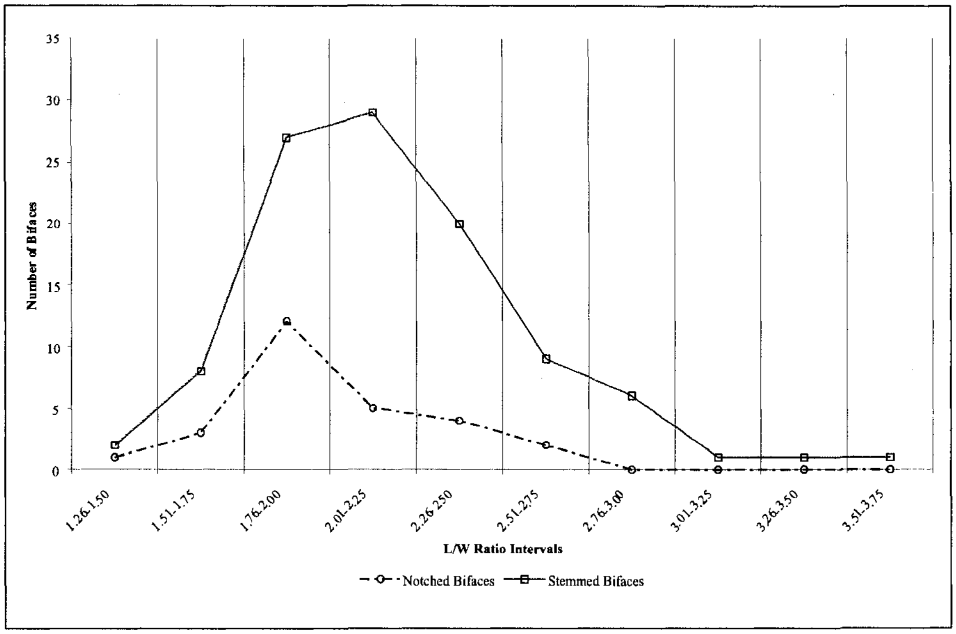


Figure 3.16: Length/Width Ratios for Formalized Bifaces

Furthermore, arraying randomly drawn samples of 27 stemmed bifaces (from a set of 116) against all 27 notched specimens with regard to length, width, thickness, and ratios of width to thickness as well as length to width, resulted in strong positive correlations in each category, as shown in Table 3.5. The table presents the results of three trials, each employing different random selections from the pool of stemmed bifaces. The degree of correlation indicates a close relationship between the two groups in all critical measures. One can conclude that the notched and stemmed bifaces derive from a single cultural-technological tradition.

Among individual specimens, blade length—and, with it, the length-to-width ratio—tend to vary more than the other measures. This variability results from repeated episodes of sharpening or reworking of the blade after fracture. In most cases, reshaping affects length more than width, while thickness is the least changed of all. Hafting elements tend not to be reworked unless necessitated by failure. In extreme cases, both with regard to stemmed and notched bifaces, the blade length has been reduced to approximately 130% of stem length from a maximum of 565% among the former and 366% among the latter.

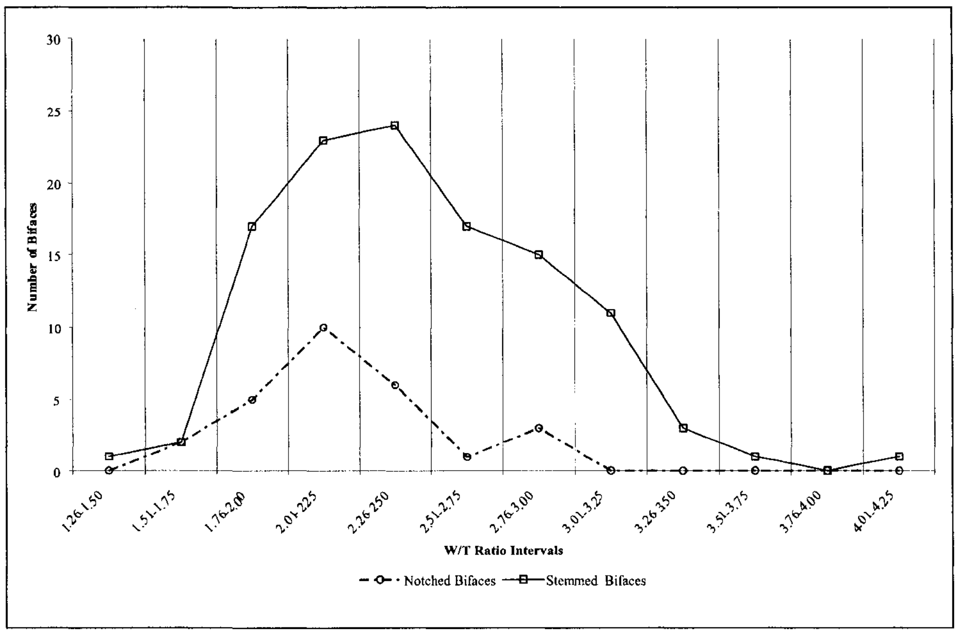


Figure 3.17: Width/Thickness Ratios in Formalized Bifaces

In stemmed bifaces, the maximum reduction in blade width is about 49%; that is, the smallest recorded width is approximately 51% of the greatest. In notched bifaces, the loss in width amounts to 64% of the maximum or a residual width of 44% of the largest specimen. In stemmed bifaces, the maximum reduction in blade thickness is about 31%; in other words, the smallest recorded thickness is approximately 69% of that exhibited by the thickest specimen. In notched bifaces, the loss in thickness amounts to 63% of the maximum or a residual width of 37% of the thickest specimen.

Table 3.5: Correlations of Stemmed and Notched Bifaces

Measure	Trial A	Trial B	Trial C	Mean
Length	0.9445	0.8708	0.9275	0.9143
Width	0.9795	0.9827	0.9857	0.9826
Thickness	0.9507	0.9436	0.9259	0.9400
W/T Ratio	0.9644	0.9788	0.9512	0.9648
L/W Ratio	0.8671	0.9402	0.8985	0.9019
Mean	0.9412	0.9432	0.9378	

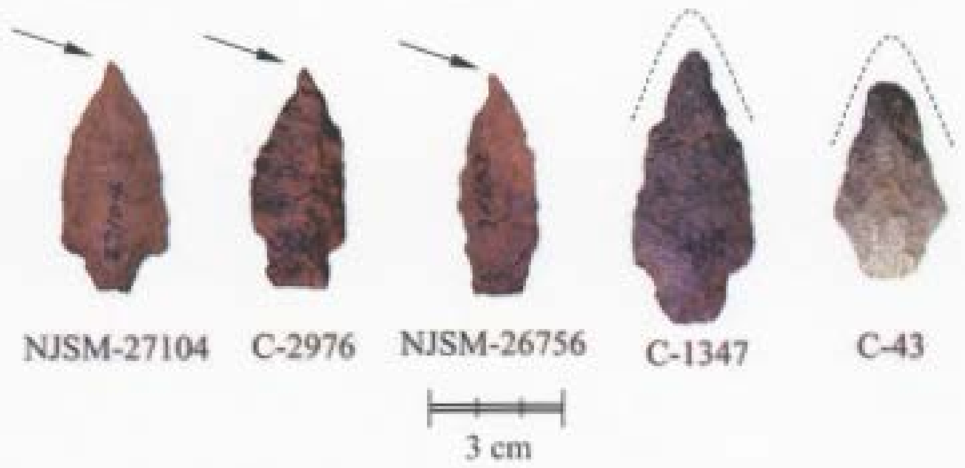
Note: In all cases, df = 25, $p < 0.01$

It is understood that comparative inferences about the whole assemblage based on individual artifacts are subject to error. However, there is no reliable method for reconstructing changes to specific bifaces between manufacture and discard. Those changes are subtractive and occurred anciently with no means of tracing individual reduction trajectories. Thus, I take recourse to an obviously flawed device.

One might argue that the linear and relational data used to show an association between stemmed and notched forms in Cuesta quartzite might yield similar results if compared to more diverse biface types, such as broadspears (Ritchie 1961:42-43, 53-54; Witthoft 1953), which are characteristically rendered in other materials. To the extent that such similarities could be said to exist, they can be attributed to technological modalities, which focus on staged biface reduction strategies, rather than to linked cultural traditions. The reduction trajectories of the stemmed and notched varieties of Cuesta quartzite bifaces cannot be said to be distinct on grounds of their physical dimensions, which are the only objective measures available for analysis.

The manner of hafting as well as the variability in the relative dimensions of blades and stems were almost certainly based upon technological imperatives. Notched hafting provides a very secure mount, which would be necessary for rough-service work, such as sawing and whittling. Notching implies the use of split- or composite fixtures. Stemmed hafting elements, particularly contracting stems, suggests the use of socketed hafts, which are secure against forces that are collinear with the long axis of the implement, especially if applied against the distal end. Such applications include piercing, planing, and unidirectional slicing.

Eighteen bifaces show terminal alterations that indicate either tip-wear or intentional reshaping for use as graving tools, perforators, and the like (Plate 3.10). Fifteen have distal spurs and three have the long, tapered outlines typical of perforators, drills, or reamers. Many more show attrition of blade length and an increase in tip angle as a result of repeated sharpening or reshaping.

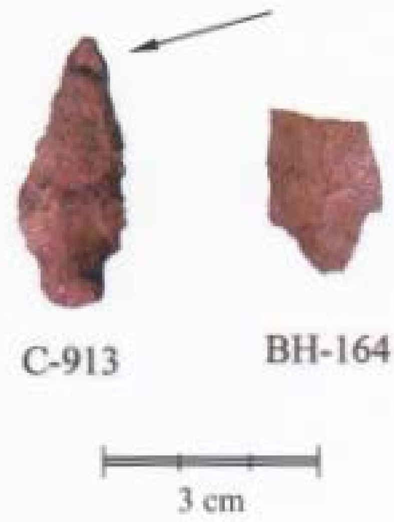


The three bifaces at left have distal spurs, possibly used for graving (arrows). The two at right have bilateral tip-wear suggesting use as perforators (Lines show extent of wear).

Plate 3.10: Bifaces with Specially Shaped or Worn Tips

Impact-fractured tips are relatively uncommon. Of the bifaces available for direct examination, six stemmed bifaces show transverse fractures at the tip, another three exhibit tip-crushing, and yet another three display burinated (step-fractured) tips (Plate 3.11). Cresson reported that the stemmed bifaces from the Ware site in the Howard Urion collection had 14 specimens with distal impact fractures of unspecified sorts (Jack Cresson, pers. comm., 18 February 2007). Thus, 26 bifaces (22.6% of all stemmed specimens) showed evidence of impact damage to their distal ends.

Tip burination is the most obvious, though not the only reliable sign, of damage from end-on impact (Truncer 1990:28). Other tip-fracture markers include transverse lateral edge clipping (edge burination) and certain kinds of hinge-fractures, as well as rebound fractures to the hafting element (Jack Cresson, pers. comm., 22 February 2007). These types of breakage do not exist in the sample available for study. However likely it may be, one cannot assume that tip damage reflects the practice of projectile hunting, as untoward contact of diverse sorts can lead to tip failure.



Left: distal impact fracture (burinated tip).
Right: transverse fracture at mid-blade.

Plate 3.11: Biface Fracture Types

Eight bifaces show snap-fractures in the mid-blade region (Plate 3.11, right). Ordinarily transverse fractures are attributable to non-projectile uses (Ahler 1971; Dunn 1984; Truncer 1990). Obviously, only those with proximal elements can be linked to hafting technique. In the present sample, four stemmed specimens show mesial transverse breakage. Four others are distal fragments.

None of the notched bifaces shows transverse fractures or severe distal end damage. On average, notched bifaces are about 90% as long as stemmed bifaces. The relative shortness of the notched blades would tend to protect them against untoward leverage that might otherwise lead to fracture. Nevertheless, because of sample bias, resulting from differential collecting by relic hunters, one cannot assess the significance of negative evidence respecting notched bifaces. That is, one cannot assert beyond cavil that notched implements were not used as projectiles or for tasks that could result in snapped blades; indeed, quite the reverse would seem to be true intuitively. Nevertheless, the lack of data prohibits definitive pronouncements.

In some Cuesta quartzite bifaces, material flaws rather than usage are clearly the most likely causes of failure. For example, the broad-bladed biface from 28-GL-344 illustrated in Plate 3.5 (left) broke along a transverse ferruginous vein, evidently weakened by thermal alteration. Another specimen (NJSM-26974), not pictured, fractured across the mid-section of the blade because of a crystal-filled void, which is visible only in the broken cross-section. Material flaws were a source of failure in replicative knapping experiments (see Chapter 6).

The edge angles for both stemmed and notched bifaces fall in the range that can best be attributed to general functions—such as cutting, scraping, shredding, and fleshing—on the basis of archaeological and experimental data (Wilmsen 1970:70-71; Keely1980; Cresson 1990). Compared to notched bifaces, the stemmed forms have a slightly greater range of variation in edge angles (40° - 106°) and somewhat more clustered measures of central tendency (with mean, median, and modal values separated by no more than five degrees). The range of variation for notched bifaces is 49° - 101°, and while the mean and median values are very close (72° and 71°, respectively), the mode, at 64°, lies eight units away from the mean.

The similarities in these distributions would seem to outweigh the differences. There appears to be no functional variation between the two, at least as expressed in edge angles. Both have edge angles appropriate to general cutting tasks, with the possible exception of fine incision or slicing, for which flakes were likely employed. Almost all archaeological bifaces show slight rounding or polish on the edges and on flake scar ridges. This polish appears not to be distinctive as to function. As already suggested, one might suppose that the size differential and hafting modes are more informative indicators of artifact function than edge angles.

Not seen either in archaeological samples or in collections are broken bifaces that have been rendered into dedicated end- or side-tools. Several examples show severe attrition to the blade, but in all cases, the tips of the blades remain somewhat pointed, and the bifacial character of the cross section has been preserved. The reworking of broken bifaces into beveled-edge scraping tools, often seen in other materials (Kraft 1990), has not been observed thus far in Cuesta quartzite, probably because finer-grained stones are better suited to this task.

Unifacial tools are almost entirely limited to simple, utilized flakes, which ordinarily exhibit little wear beyond minor edge polish or micro-flaking; that is, slightly chattered edges. Although three were found at site 28-GL-45, very few edge-retouched unifaces are known (Chapter 5). I have never seen any formalized, bevel-edged uniface tools (e.g., end-tools and side-scrapers) in Cuesta quartzite. Similarly, all perforators are derived from reworked bifaces. When present, unifacial tools generally occur in cryptocrystalline materials, probably because those stones can produce a sharper edge.

Table 3.6 shows the distribution of both stemmed and notched bifaces by drainage basin. Discounting specimens of unknown provenience, the data appear to show a clustering of stemmed bifaces at sites along the Salem and Maurice Rivers (N = 28 and 20, respectively) and along Cohansey Creek (N = 12). Other basins show only minor representations. The notched forms are most common at sites along the Salem River (N = 10) and the Cohansey Creek (N = 11). Sites along other streams produce few or no notched bifaces in Cuesta quartzite.

A chi-square test of this distribution shows it to be statistically significant. The computed value of X^2 is 27.99, with df = 8, and a probability of random occurrence of less than 0.001. However, because notched bifaces have no apparent representation in several stream basins, the Chi-square statistic yields weak results. Thus, one cannot vigorously reject the hypothesis that there is no difference in the distribution of the stemmed and notched bifaces between river systems. This hypothesis should receive additional scrutiny if future research provides additional data.

Table 3.6: Bifaces by River Basin								
Drainage Basin	**Stemmed**			**Notched**			**Total**	
	N	**% of Group**	**% of Total**	**N**	**% of Group**	**% of Total**	**N**	**%**
Cohansey Creek	12	10.3%	8%	11	40.7%	7.7%	23	16.1%
Delaware River	3	2.6%	2%	0	0.0%	0.0%	3	2.1%
Great Egg Harbor River	2	1.7%	1%	0	0.0%	0.0%	2	1.4%
Maurice River	20	17.2%	14%	2	7.4%	1.4%	22	15.4%
Oldmans Creek	3	2.6%	2%	0	0.0%	0.0%	3	2.1%
Raccoon Creek	4	3.4%	3%	3	11.1%	2.1%	7	4.9%
Rancocas Creek	7	6.0%	5%	0	0.0%	0.0%	7	4.9%
Salem River	28	24.1%	20%	10	37.0%	7.0%	38	26.6%
Unknown	37	31.9%	26%	1	3.7%	0.7%	38	26.6%
Total	116	100.0%	81%	27	100.0%	18.9%	143	100.0%

3.2) Debitage

Debitage refers to all of the waste created in the manufacture and maintenance of stone tools. Often, some of this debris was selected for expedient usage, but the majority was simply trash, which gives the archaeologist opportunities to study prehistoric manufacturing technologies. Experimental studies enhance the insights that archaeologists gain by the study of flaking debris.

Flakes comprise the single most numerous artifacts on most prehistoric sites (Bradbury and Carr 1999, 2004; Shott 1994), which is reason enough to consider them analytically. Sites that yield Cuesta quartzite are no exception. In the many investigations that I have directed, flakes of Cuesta quartzite cumulatively number in the tens of thousands. Moreover, interpretations of knapping processes cannot be accomplished without a consideration of debitage (Andrefsky 2001; Patterson 1990). The following is a brief categorization of the recognized flake types, which relate to the bifacial reduction of Cuesta quartzite from relatively large masses of stone.

The following characterizations follow from the method of flake identification and analysis that has been practiced in the Middle Atlantic Region for the past thirty years or so, largely as an outgrowth of the results of experimental knapping (Callahan 1974, 1976; Cresson 1997, 2000). This approach to debitage analysis is used here because it pervades all of my archaeological research in the field of CRM.

As to procedure, the analyst divides the flakes into types that are recognizable by size and form as they relate to different stages of bifacial reduction. After sorting, the flakes are counted by type. This method accords with "mass analysis" in that the flakes decline in size but increase in number as one works through the various stages of the knapping process (Ahler 1989; Ahler and Christensen 1983). It differs from that technique in that the flakes are visually sorted by size and attributes without physical screening or direct measurement of linear dimensions or weight. In this respect, the approach taken here is more like "individual flake analysis" in which the attributes of individual flakes—platform remnants, dorsal flake scars, and so forth—determine their position in the reduction sequence (Bradbury and Carr 2006:69: Magne 1985).

Jack Cresson performed the flake identifications with respect to all of the excavated and experimental assemblages of Cuesta quartzite debitage reported in this document. Cresson's long experience with Cuesta quartzite suits him to the task. As there were no other analysts, any biases are idiosyncratic and presumably minimal (Gnaden and Holdaway 2000). The flake types employed in this study are described in detail below.

3.2.1) Early-Stage Flakes

Early-stage flakes, sometimes called "edging flakes," are used to trim the square edges from blocky lithic masses. They tend to be short but wide, and carry remnants of the angular edge from the parent material (Plate 3.12, right). Flakes of this kind are most common when tabular stones rather than rounded cobbles constitute the starting forms.

3.2.2) Decortication Flakes

Decortication flakes are the first ones removed in the reduction of a cobble or pebble. By definition, they exhibit one or more remnants of the original cortical surface and relatively few scars, if any, from the removal of other adjacent decortication flakes. These flakes usually have a bulky form with irregular geometry characterized by thick margins adjacent to the bulb, markedly thin distal margins, and a lack of platform preparation. Flake curvature, following the convexity of the parent material, is pronounced. The size varies greatly depending on the dimensions of the parent rock, its form, and the energy involved in flake detachment. Some decortication flakes are larger than a large human hand, others no bigger than a thumbnail.

3.2.3) Primary Flakes

Primary flakes are removed early in the reduction of a lithic mass. In the case of reduction from cobbles, primary flakes are those removed after decortication has taken place (Plate 3.12, left). They result from preliminary shaping of the stone mass. Primary flakes represent the principal source of many chipped stone implements and expedient edged tools. With subsequent trimming, primary flakes may become flake blanks from which many bifaces are manufactured. Primary flakes are robust, with a rather irregular geometry. Flake curvature and bulbar pronouncement are less severe than in decortication flakes. There is little evidence on these flakes of specially prepared platforms. As with decortication flakes, the sizes vary with the nature of the stone being worked and the manner in which it is manipulated.

3.2.4) Thinning Flakes

As the name implies, thinning flakes result from the process of biface thinning (Plate 3.13, left). Generally, a fairly large, flat form is characteristic. Thinning flakes commonly exhibit a fairly regularized shape, which approximates the shape of a truncated triangle or trapezoid, usually measuring from 13mm to 5cm in greatest dimension. Because thinning ordinarily follows other flake removals, thinning flakes show multiple remnant flake scars on their dorsal faces. These flakes often possess evidence of specially prepared striking platforms, which may be isolated by discrete chipping and at least light abrasion to ensure good purchase by the percussor. These operations also serve "to pre-crack the location of intended flake detachment" (Jack

Cresson, pers. comm., 18 February 2007). In addition to their association with biface tool manufacture, thinning flakes are another source of expedient flake tools.

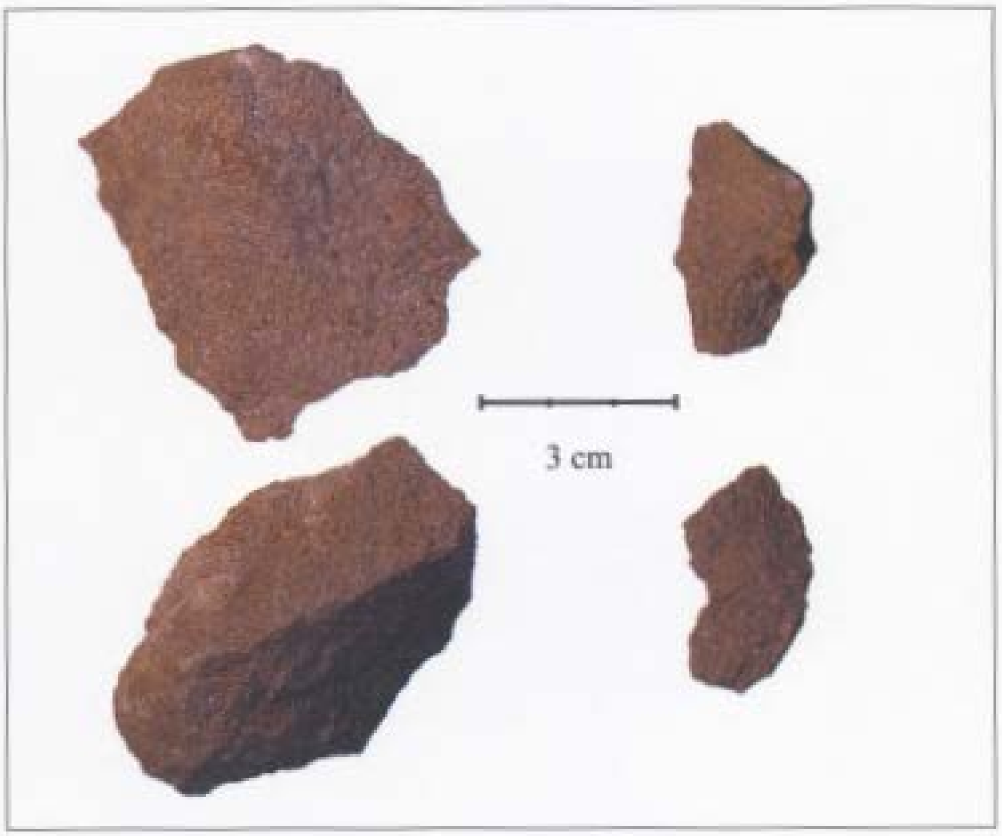


Plate 3.12: Primary and Edging Flakes
(Primary flakes at left; edging flakes at right.)

Experimental knappers visualize biface thinning as a multi-stage endeavor. Many recognize two principal stages of thinning, which they call, "primary thinning" and "secondary thinning" (Callahan 1979: 90-153, 1989:6). The associated flakes are called "primary thinning flakes" and "secondary thinning flakes." Because "primary flakes" already exists as a discrete category, a slightly different nomenclature will be followed here and elsewhere in this document. To avoid confusion, the earlier thinning flakes, when recognized, will be termed "initial thinning flakes," while all others will simply be called "thinning flakes."

Initial thinning flakes are generally much larger than those removed as a result of secondary thinning. The latter are shorter but proportionally longer in relation to width when compared with initial thinning flakes (Plate 3.13, left).

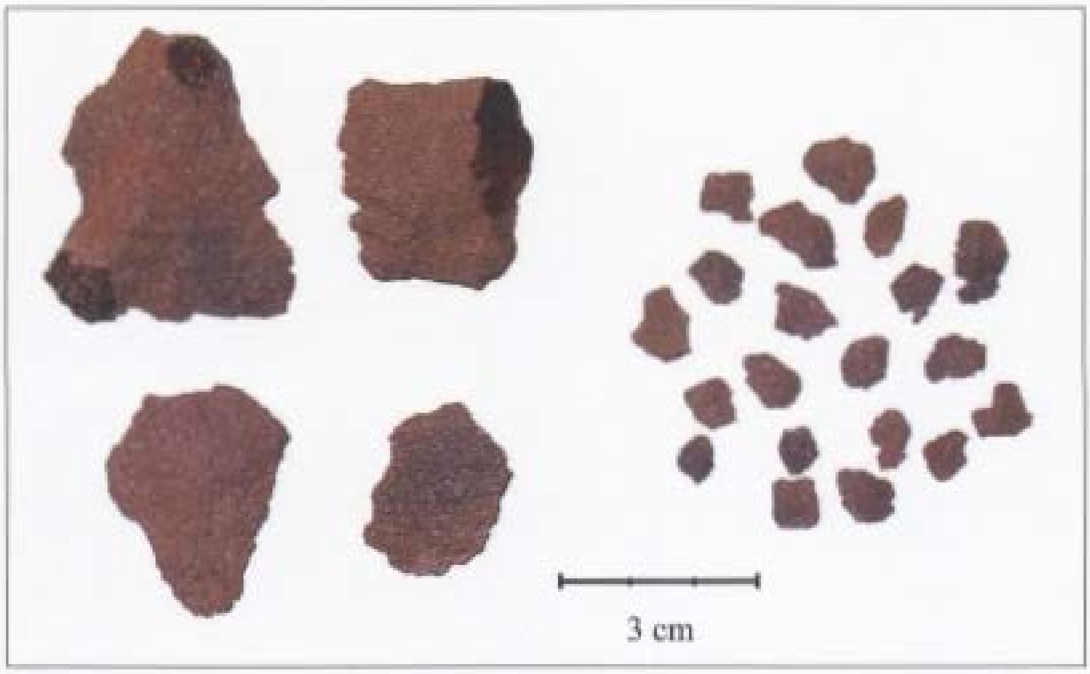


Plate 3.13: Thinning and Late-Stage Flakes
(Initial thinning flakes at top-left; thinning flakes at bottom-left; late-stage flakes at right)

3.2.5) <u>Late-Stage Flakes</u>

Late-stage flakes are so called because they ordinarily occur fairly late in the reduction sequence (Plate 3.13, right). However, similar flakes can be produced at any stage of knapping, particularly for platform preparation. This duplication of form can be difficult to discern archaeologically. Still, this sort of flake is far more common in late-stage flaking than earlier in the reduction process. Late-stage flakes are produced by edge shaping, functional edge preparation, and rejuvenation. They also result from general edge modification in the process of defining blade margins or surfaces, as well as from notching.

These flakes can be produced either by gentle percussion, including indirect percussion, or by pressure. Late-stage flakes are generally regular in form, having very thin concavo-convex sections, which superficially appear to be flat. Often resembling fish scales, most are small, with a maximum dimension of 15mm or less.

3.2.6) Flake Fragments

Fragmented stone pieces that can be identified as having been derived from any kind of flake are simply termed flake fragments. Hence, fragmentary flakes of recognizable form may be catalogued as, "primary flake fragments," "thinning flake fragments," and so on, as the case may be. Some are very small, grading from 15mm down to sandy or gritty particles, that nonetheless retain flake-like geometry (Plate 3.14).

3.2.7) Reduction Fragments

All pieces of knapping debris that cannot be assigned to specific flake types, or to the flake fragments category, are referred to as reduction fragments. Reduction fragments can be of virtually any size, including sandy, gritty, or dusty residues (Plate 3.14, right.)

Plate 3.14: Small Flake Fragments and Particles

3.2.8) Discussion

The ability to recognize flakes according to their form and position in a flaking hierarchy is critical to the identification of bifacial reduction strategies. Were it not for experimental archaeologists, it is likely that the "language of the flakes" would have remained unknown, as in former times, when archaeologists routinely treated flakes as inconsequential trash. It turns out that, as evidence of discrete stages of manufacturing processes, flakes in the aggregate are far more informative about production techniques than any finished implement. Finished artifacts only reveal the most recent events that gave rise to their final condition, whereas a good assortment of flakes can reveal the entire sequence of events in the production process (Crabtree 1972:3; Flenniken and Raymond 1986:604; Frison 1968; Ritchie and Gould 1986:35).

Replicative knapping by Jack Cresson shows that flake detachment by percussion leaves distinctive "signature" traces on the flakes themselves (Mounier 1998a). Analysis of these signatures can reveal the means and methods of tool production as well as indications of the technological sophistication and skill of individual knappers.

For example, hard stone hammers generally leave robust bulbs and flake scars that differ from the more subtle, often lipped, flake geometry resulting from the use of soft hammers or batons of bone, antler, or wood. The greater the incidence of hard-hammer processing, the more generalized and rudimentary the technique and process; conversely, the greater the incidence of soft-hammer percussion, the more specialized or sophisticated the technological process. Soft-hammer battery is associated with refined bifacial thinning that required the preparation of well planned striking platforms together with the use of specialized hammers.

The knowledge that flakes of different forms represent different stages in a production sequence permits the careful archaeologist to characterize, at least broadly, the sorts of knapping activities that transpired at any site that contains more than a handful of flakes. As previously indicated (Chapter 1), the calculated ratio of earlier vs. later stage flaking debris in an unbiased assemblage is a valuable indicator of knapping behavior. Comparing the percentages of primary, thinning, and late-stage flakes can yield nuanced insights concerning the nature of lithic reduction within and between sites.

In addition, when flakes and implements occur in the same materials on a site, the proportions of flakes to implements can give some indication of relative productivity, the nature of intended production, and the functions of the sites. For example, at site 28-GL-45, an extensive excavation yielded 4,445 flakes of Cuesta quartzite and 65 bifaces. Hence, the flake to biface ratio is 68.4:1, which indicates at least limited biface manufacture at this site (Mounier 2000b). Other examples of this sort of analysis occur elsewhere in this document.

3.3) Hammerstones

Cuesta quartzite finds expression in hammerstones as well as in bifaces. It was an important base material for knapping involving not only Cuesta quartzite itself, but also argillaceous materials, particularly, argillaceous shale. Examination of Cuesta quartzite hammerstones from archaeological excavations and from collections reveals two basic forms: tabular and spheroidal forms. Present evidence is that the tabular forms were used initially for rough service work. With continued exposure, and probably with deliberate shaping, the tabular hammers assume a spheroidal shape.

Hammers used for bifacial knapping can be distinguished from general-purpose percussors by the presence of discrete facets. The placement of the facets can occur on the poles, diameters, or (in elongated specimens) along the lateral margins. Specialized flaking hammers were formed by intentional chipping and abrading as well as by long term use. Such implements are not well known archaeologically. Indeed, they have been recognized almost exclusively on the Inner Coastal Plain of New Jersey in sites investigated by Cresson and myself, in individual and collaborative research.

Jack Cresson coined the term, "faceted hammerstones," for these specialized flaking hammers because of their characteristic shape. They represent a distinct cultural specialization and link the procurement and processing of Cuesta quartzite to certain Late Archaic/Early Woodland cultures that specialized in the use of argillite, and especially argillaceous shale, for flaked implements. Experimentation by Cresson shows that Cuesta quartzite is ideally suited to knapping these materials.

Cresson's (2004) research suggested to him that these hammerstones were probably first shaped into blanks by breaking cobbles of Cuesta quartzite by heat: "Data from a quarry workshop in Mt. Laurel, N.J. has revealed evidence of heat-spalling and percussion activities in a sequence of manufacturing processes that reduced large blocks and boulders to smaller, blocky, cubic forms of varying sizes, which served as hammerstone blanks." Some hammers show little or no evidence of thermal processing and may have been formed from large, percussion-derived spalls. Each of the blocky blanks was then trimmed to a somewhat rounded shape, which then progressively assumed the form of a multi-faceted spheroid by prolonged use in flaking.

The present study included a sample of 55 hammerstones from the collections of Jack Cresson, Milan Savich, and Ernest Stahl. The New Jersey State Museum acquired most of Mr. Stahl's collection after his death. The Museum collection had very few examples collected by others. Evidently, since the dawn of North American archaeology, hammerstones have attracted very little attention either from archaeologists or relic hunters (however, see M'Guire 1891 for an early treatise on hammerstones; also Sanger and Newsom 2000:6-7; Figure 4).

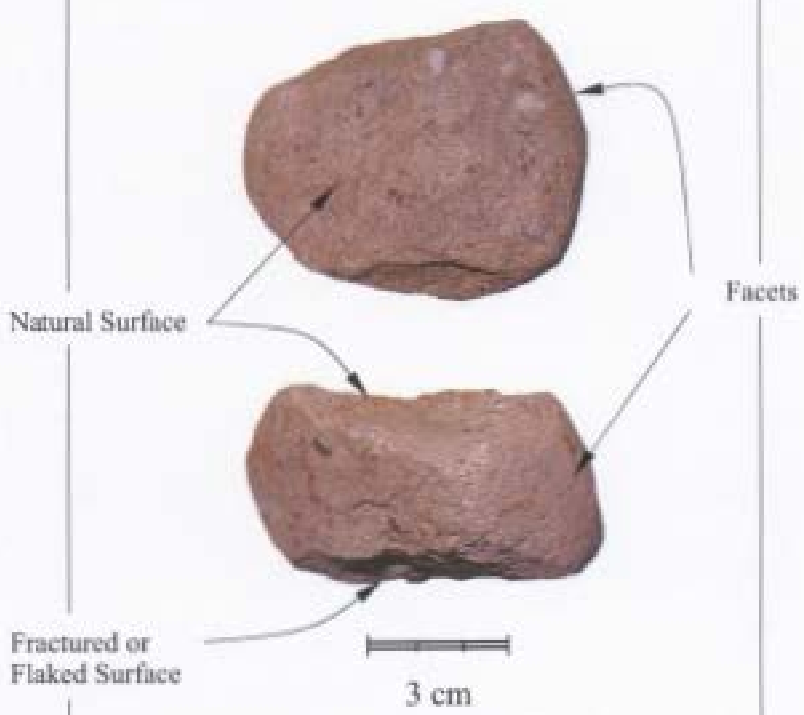
The examination of the presently available sample suggests that hammers of Cuesta quartzite take two distinct forms—tabular (meaning flat-sided) and spheroidal—which are related in form and function. Starting forms can be large spalls or blocky, cube-like fragments, derived from the fragmentation of large Cuesta quartzite blocks and boulders by fire. Some hammers clearly originated from flakes or chunks that were struck-off rather than thermally detached. The presence of residual patches of both natural and fractured or flaked surfaces on hammerstones vindicates these assertions (Plate 3.15).

In any case, blocky, angular blanks may have been roughly trimmed to facilitate their use as hammers. The incompletely formed hammers would have had an essentially tabular or cubical form, which eventually evolved into more refined shapes as angles wore to rounded edges and finally to facets. Thus, by stages, tabular hammers became spheroids, and the spheroids—at least sometimes—became virtual spheres (Plate 3.16).

I have no controlled data on this point, but on the basis of extensive knapping experience, Jack Cresson indicated that the facets can form quite rapidly. He further noted:

> Based on my observations, facets develop from the use of particular knapping techniques (e.g., sliding, brushing, or swiping) to more efficiently detach flakes, for the most part thinning flakes... The flatter the facets, the more advantageous [the] surfaces become for

> flaking, [because the facets present] larger areas with toothy, grabby surfaces. A broader area of contact is analogous to organic hammers that can disperse [the] striking load more evenly across the platform edge, resulting in larger, more controlled, [and] efficient flake detachments. Apex ridges between facets indeed are useful for certain, more precise, flake-removal tasks (Jack Cresson, pers. comm., 14 February 2007).



Tabular Hammerstone

Seen in plan (top) and profile (bottom). Note natural surface at top, fractured or flaked surface at bottom; also, facets and ridge angles, as well as large quartz grains.

Plate 3.15: Faceted Hammer, Tabular Form

As angles form between facets, they progress from relatively acute to increasingly obtuse configurations. In a sample of 20 hammerstones, the smallest measured facet angle is 70°, the largest, 145°. The mean angle is 121.6°, and the median and mode both stand at 125°. The standard deviation for this series is 15.72. Eventually, the facets become increasingly rounded and the angles between them so obtuse that accurate measurement is no longer possible.

The classification into tabular and spheroidal forms is strictly arbitrary, and perhaps not very imaginative, but it does seem to capture virtually the full range of shapes. On all pieces, the largest dimensions were measured and listed (in descending order) as length, width, and thickness. On slabs and more or less angular specimens, these dimensions are conventional, just as in measuring a board or a brick, because the planes of measurement have a more or less rectilinear arrangement. On the spheroids, the three largest dimensions were also recorded and arbitrarily called the major, intermediate, and minor diameters. The dimensions were logged into a spreadsheet, listing the largest under length, the intermediate under width, and smallest under thickness. This shorthand, though denotatively inaccurate, eliminated having to use three more categories, corresponding to the diameters just noted.

If the ratios of length to thickness and width to thickness both computed to 0.75 or greater, the specimens were classified as "spheroids." In other words, as length and width approach thickness, the piece becomes cubical, and with rounded corners, spheroidal (Plate 3.16). If either or both of these ratios computed to 0.74 or less, the piece was said to be "tabular." This classification resulted in two groupings, which visually correspond to their names. The tabular pieces numbered 35 specimens, the spheroids, 18.

As in most classifications, some things did not fit neatly in this scheme. One piece was discoidal; that is, it was tabular in section, but circular in plan, and another hammer was a squat cylinder, with a shallow groove pecked around its circumference. These two specimens were discounted from the ensuing analysis.

Spheroidal Hammerstone: Three Views

Note broad, round facets, generally smooth surface, and large quartz grains.

Plate 3.16: Faceted Hammer, Spheroidal Form

Table 3.7 shows the weights and cubes of Cuesta quartzite hammers. When plotted, these data form two closely aligned groups, with nearly parallel trend lines, which tend to close near the small ends of their respective distributions (Figure 3.18). From the graph, they could easily be considered to comprise a single group. Naturally, the relationship between the cube and weight is linear, because the parent material, though variable, has similar composition and density.

The tabular hammers exceed their spherical counterparts in both the minimum and maximum weights and cubes; however, on average, they weigh slightly less. This relationship is shown both in the mean and median values. Interestingly, the modal weights for both tabular and spherical hammers are identical, 141.7g. This coincidence may be nothing more than a fluke, considering the standard deviations.

Table 3.7: Weight and Cube of Hammerstones

Parameters	Tabular		Spheroidal	
	Weight (g)	Cube (mm^3)	Weight (g)	Cube (mm^3)
Minimum	56.7	46.5	53.9	40.2
Maximum	1060.3	888.2	567.0	417.5
Average	255.7	204.2	275.3	191.1
Median	201.3	162.3	260.8	185.6
Mode	141.7	N/A	141.7	N/A
Std. Dev.	209.9	169.4	141.0	108.7

Most hammers are not especially heavy, with the majority in the present sample weighing well under 300g (Figure 3.18). However, much larger hammers do exist. Jack Cresson informed the writer of a faceted hammer that weighed in excess of five pounds (2.27kg). A hammer of this size must have been used for rough service, as for example, fracturing large cobbles. The ordinary run of hammers, such as detailed above, can be assumed to have served as bifacial flaking implements, which undoubtedly were used in concert with organic hammers and billets. This assertion follows from a consideration of experimental knapping experiences and from an evaluation of flake morphology in archaeological assemblages.

Colors were observed on all hammers. Twenty-six of the hammers exhibited some degree of reddening, which is taken to be an indication of thermal alteration. Twenty-nine of the specimens, accounting for 52.7% of the sample, had Munsell Soil Color designations associated with shades of gray or brown. These colors are well within normal range for Cuesta quartzite in its natural state.

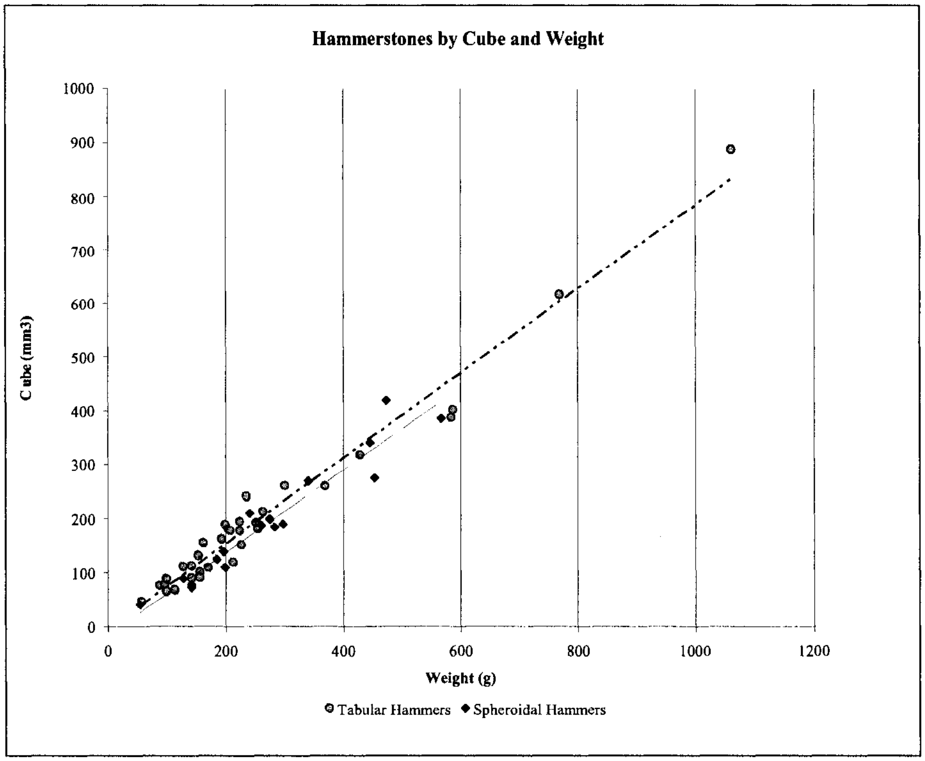


Figure 3.18: Distribution of Hammerstones by Weight and Cube

It seems likely that the some of the effects of thermal stress, as manifested by color changes, may have been masked on some specimens by subsequent activities. It is certain that abrasion removed the surficial layers that would have most dramatically witnessed the effects of fire. The depth of penetration of thermal alteration has not been determined on hammers, although experiments with bifaces suggest that it is not great.

3.3.1) Discussion

One might suppose that thermal alteration would be detrimental to percussion instruments inasmuch as it tends to weaken the fracture toughness of stones, as witnessed by any number of experiments (Crabtree and Butler 1964; Crabtree 1972; Domanski and Webb 1992:602; Domanski et al. 1994; Purdy 1973, 1981, 1984; Silsby 1994:323). However, differentially heating a suite of hammers would yield an assortment that varied in hardness. A percussor with reduced fracture toughness might possess better "tooth" than one in an unaltered state, and both may have been useful under different circumstances. It now seems likely that ancient knappers might well have regulated the toughness of their hammers to suit particular situations, depending upon the kind of material being worked and the nature of the flakes desired.

There is speculation that material fatigue brought on by prolonged use might weaken a hammer but also improve its suitability for certain kinds of knapping. Writing about his experiences with chert hammerstones from the Truman Reservoir in Missouri (Rodgers Shelter and Phillips Spring sites), Jeffrey Behm reported that he "observed many chert hammerstones. A well-used chert hammerstone is better than a new hammerstone. The many intersecting cones that cover the surface appeared to make the stone somewhat softer. While it didn't rival an antler billet for the ability to thin a biface, I was impressed [by] how much you could do with one of these softened chert hammers.

It reminded me of the way a soft sandstone hammer can be used to effectively thin an obsidian biface" (Jeffrey Behm, pers. comm. 30 April 2007). Reducing the hardness of a hammer by thermal-alteration may well have served the same purpose.

Although this aspect remains to be quantified, the materials selected for hammerstones seem to possess a high proportion of fairly coarse quartz grains, whereas finer-grained quartzites were typically selected for use as bifaces. This empirical observation is not universal, as some hammers consist of finer grained stones, and some bifaces occur in remarkably pebbly varieties of Cuesta quartzite. For instance, Biface No. W-9180 has many quartz grains in excess of 3.3mm in their largest measurable dimension. Coarse-grained quartzite may have been a superior medium for hammers because of the durability of the large quartz grains.

Experimental knapping gives a further insight. It seems certain that some hammers were particularly effective tools, had a comfortable feel in the hand, or had other qualities that endeared them to their knapper-owners. In any case, such characteristics often lead—and doubtless in the past, often led—to fairly intimate artisan-implement relationships. For this reason, Jack Cresson believes that many of the small, nearly spherical hammers were carefully husbanded, and may have been passed from one generation of knappers to the next (Cresson, pers. comm., 26 January 2007), to wit:

> Based on empirical inference, some of the more curated hammerstones have a very long use history. [Such items] were likely as much a part of "favored tool" ideology as today. It is not hard to deduce that some of these implements traveled around and may even [have] be[en] pan-generational. It is hard to compare,

> but based on archaeological residues, number of sites, [the] estimated age and longevity of prehistoric populations [, and so on], most modern knappers have well exceeded the production and processing of the past. In my own example, at 65 years, with a knapping history of 40 years or so, I have worn out many hammerstones, but also have many that have been in service for well over 25 years, and [are] still going.

There is good reason from modern experience to affirm the essential correctness of this "favored tool theory." Any "dirt archaeologist" has favorite tools and equipment. I still have several trowels and shovels that I keep for no practical reason, even though their usefulness has been entirely expended.

3.4) Summary

This chapter has provided descriptions, dimensions, and analysis of Cuesta quartzite artifacts including bifaces, debitage, and hammerstones. Although a variety of bifacial forms exist, the specimens share such strong similarities in form and reduction trajectories as to be reasonably considered to be the products of a single cultural tradition. Forms of hafting elements are as likely to signal functional differences as other criteria, such as edge angles. Debitage is fairly limited to a small number of definitive flake types. However, flakes themselves are often the most numerous artifacts in archaeological sites. The analysis of flakes—and particularly, their proportional frequencies—indicate the character of knapping that transpired at any given site. Likewise proportional representation of flakes and implements can inform on the nature of reduction strategies, and inferences drawn respecting the intended tool types can influence functional interpretations. Hammerstones were produced from fragments of Cuesta quartzite and witnessed a progressive utilization, materialized in a transition from a tabular or cubical form to a spheroidal, or even spherical, shape. Like bifaces, hammers in Cuesta quartzite were often heat-treated to modify their physical properties. The spherical hammers may reflect a long use-life, which implies the possibility of heirloom status and inheritance by succeeding generations of knappers.

Chapter 4: Burlington County Sites

This chapter deals with excavations at 11 sites in Burlington County, where I have discovered ancient utilization of Cuesta quartzite. These sites provide interesting points of comparison and contrast. So far as Cuesta quartzite knapping is concerned, all sites show evidence of intermittent occupation. As suggested by the generally limited numbers of flakes and bifaces, each component probably reflects the activities of individuals or at most a few artisans.

Figure 4.1 shows the site locations relative to state and county boundaries. The presentation follows the order noted below. Five sites lie in the vicinity of Pine Grove. These sites include the following: the Baseman site (28-BU-475), the Evesham Corporate Center site (28-BU-90), the Elmwood Estates site (28-BU-277), the Troth Farm site (28-BU-407), and the Ivins Farm site (28-BU-492). Figure 4.2 depicts these sites in relation to local topographic features.

Another four sites occur near Medford Village. These sites include: the Medford Park site (28-BU-466), the Riding Run site (28-BU-473), the Northside School site (28-BU-456), and the Mill Street site (28-BU-714). Figure 4.3 shows the locations of these sites in topographic context.

The Kings Grant (28-BU-403), and Highbridge sites (28-BU-226) are isolated expressions, whose locations are shown in relative detail in Figure 4.4 and 4.6, respectively.

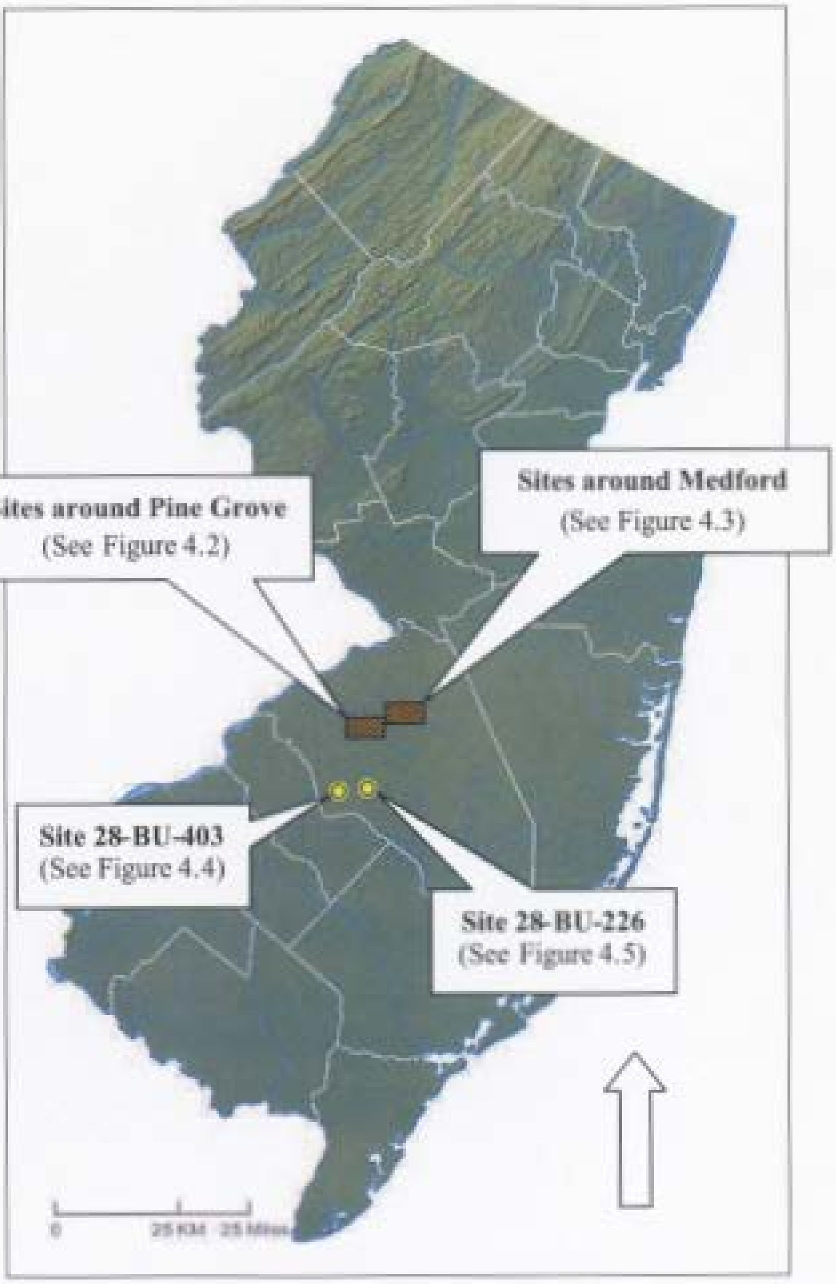


Figure 4.1: Archaeological Sites in Burlington County

The purpose of the excavations was to recover archaeological specimens and data sufficient to permit substantive archaeological interpretations in advance of residential or commercial development. In addition to artifacts, samples of organic material were collected when possible for radiometric analysis.

Sites that lie near geological sources of Cuesta quartzite often, but not always, reveal relatively strong archaeological traces of its use. Several of the productive sites lie close to one another and to one or more sources of quartzite cobbles. The debitage and other lithic artifacts reflect conscious decisions on the part of ancient knappers as to ways of working Cuesta quartzite as well as cryptocrystalline pebbles, argillite, and other lithic materials. Various materials were treated differently by aboriginal knappers depending upon the intrinsic characteristics of the stone and the desired products.

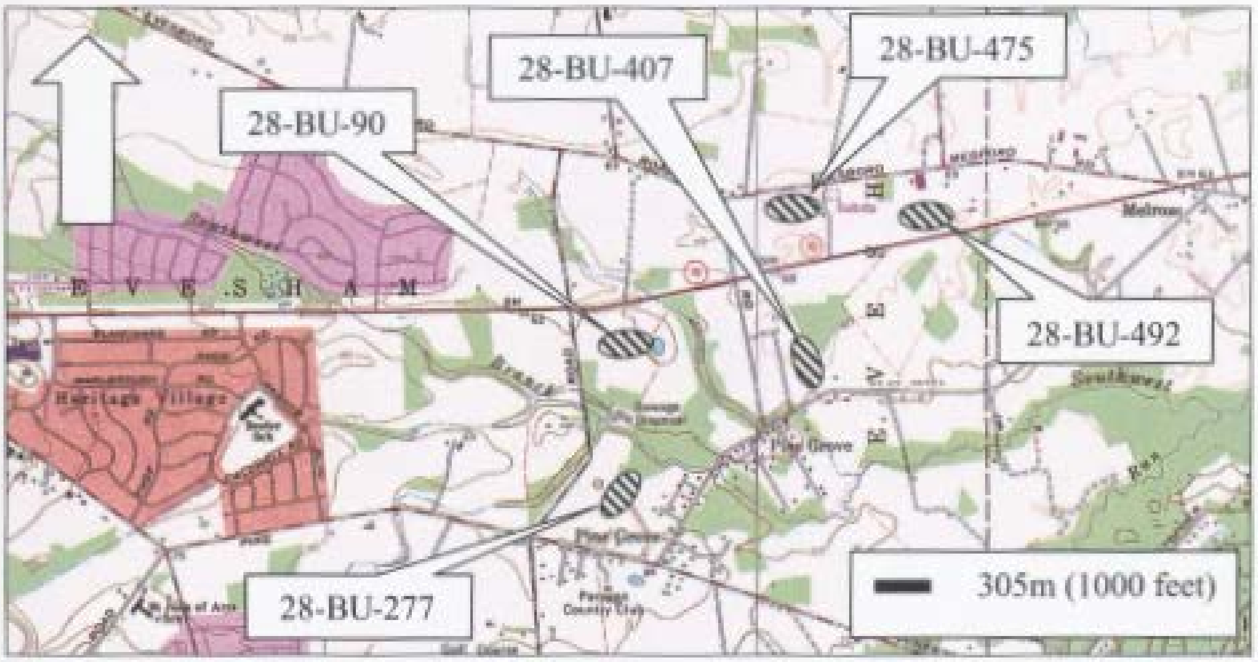


Figure 4.2: Map of Sites, Pine Grove Vicinity

4.1) The Baseman Site: 28-BU-475

The Baseman site is located in Evesham Township in the headwaters of the South Branch of Rancocas Creek (Figure 4.2). The site lies south of Route 70 and east of

Elmwood Road. Archaeological remains at 28-BU-475 consist mostly of flakes from the manufacture, repair, or maintenance of stone tools, as well as bifaces (projectile points or knives), aboriginal ceramics, cores, cobble tools, and thermally-altered rocks, among other things. Most of these artifacts pertain to Late Archaic and Early Woodland cultures. However, artifacts of Early Archaic and Paleoindian derivation were also found by others in prior inspections of this property (Mounier 1998b).

The site occupies part of the divide between the heads of Pennsauken and Rancocas Creeks. Internal drainage is also provided through several natural basins in the form of circular or oval depressions, which are thought to be relicts of a periglacial landscape.

The geological materials in most of the vicinity are composed of unconsolidated sands and gravels of Cretaceous and Tertiary age. Along the banks of Rancocas Creek are rich deposits of boulders and cobbles of Cuesta quartzite. Cobbles also occurred in the fields at this site.

In recent times, the site was part of the George Ivins farmstead. Mr. Ivins collected Indian relics on this property. His collection and others from the farm contained a relatively broad range of cultural material, including items from the Paleoindian to the Woodland periods. The uplands around the periglacial features produced most of the earlier cultural material. Artifacts that indicate the processing of Cuesta quartzite into refined chipped stone tools have been identified at several locations across the farm.

4.1.1) Cultural Remains

My 1998 excavations at 28-BU-475 covered a total of 104.5m^2 (1,125.50 square feet) and yielded 9,000 prehistoric artifacts as well as quantities of organic material, such as calcined bone, carbonized nuts, and wood charcoal. Much of the cultural debris occurred in activity areas (Mounier 1998b).

4.1.1.1) Artifacts: Table 4.1 provides a list of artifacts by general types.

Table 4.1: Artifacts from 28-BU-475

Artifacts	Qty	Percent
Bifaces	219	2.4
Cobble Tools	167	1.9
Cores	62	0.7
Flakes	7,524	83.6
Microtools	7	0.1
End-Tools	13	0.1
Unifaces	11	0.1
Polished Stone	1	0.0
Thermally Altered Rock	737	8.2
Unidentified	4	0.0
Potsherds	13	0.1
Ochre	8	0.1
Pebbles	34	0.4
Petrified Wood	198	2.2
Total	9,000	100.0

The array of bifaces by general category and material is presented in Table 4.2. In terms of named typology, the earliest formal bifaces (or fragments thereof) include fluted points, Palmer, Kirk, and MacCorkle bifaces, which reflect Paleoindian and Early Archaic presence on the site. Middle and Late Archaic period cultures are represented by the following types: Kanawha, LeCroy, Morrow Mountain, Eshback, Vosburg, Brewerton, Poplar Island, Bare Island, Lamoka, Lackawaxen, and Susquehanna. The only late prehistoric biface forms recovered in the work at this site are triangular in form.

Table 4.2: Bifaces from 28-BU-475 by General Category and Material

Material	Blk	E/S	Core	Stem	Not	Td/K	Tri	Tool	Misc.	Frag.	Total	Percent
Argillite	0	8	0	17	0	1	0	1	2	13	42	19.3
Argillaceous shale	1	0	0	4	1	1	0	1	0	14	22	10.1
Chalcedony	0	1	0	0	0	0	0	0	0	0	1	0.5
Chert	0	2	1	0	0	0	0	0	0	10	13	6.0
Cuesta quartzite	0	44	0	1	0	0	0	1	0	25	71	32.6
Jasper	0	5	0	1	1	2	3	0	0	8	20	9.2
Metasediment	0	0	0	1	0	0	0	0	0	2	3	1.4
Quartz	0	23	0	1	5	4	0	0	0	9	42	19.3
Quartz -schist	0	0	0	0	0	0	0	0	0	2	2	0.9
Schist	0	0	0	0	0	0	0	0	0	1	1	0.5
Slate	0	0	0	0	0	0	0	0	0	1	1	0.5
Total	1	83	1	25	7	8	3	3	2	86	219	100.0
Percent	0.5	38.1	0.5	11.5	3.2	3.7	1.4	1.4	0.9	39.0	100.0	

Abbreviations: Blk = Blank; E/S = Early-Stage; Stem = Stemmed; NOT = Notched; TD/K = Teardrop/Kite; FRAG = Fragments

Flakes are the most numerous artifacts, being represented by nearly 7,500 specimens in a wide range of materials (Table 4.3).

Table 4.3: Flakes by Type and Material at 28-BU-475

Material	DEC	PRI	THI	L/S	FF	RF	Total	Percent
Argillite	0	4	7	8	110	18	147	2.0
Argillaceous Shale	0	7	13	22	102	8	152	2.0
Chalcedony	0	0	0	2	3	0	5	0.1
Chert	25	11	11	51	87	25	210	2.8
Cohansey Quartzite	0	3	9	3	6	1	22	0.3
Cuesta quartzite	3	224	178	572	1,876	3,005	5,858	78.4

Table 4.3: Flakes by Type and Material at 28-BU-475								
Material	**DEC**	**PRI**	**THI**	**L/S**	**FF**	**RF**	**Total**	**Percent**
Jasper	11	16	19	81	124	47	298	4.0
Limonite	0	0	0	0	0	3	3	0.0
Metasediment	8	3	1	2	17	6	37	0.5
Quartz	19	26	15	116	335	169	680	9.1
Quartzite	3	0	2	9	5	0	19	0.3
Quartz-Schist	0	1	0	0	7	5	13	0.2
Rhyolite	0	0	1	4	0	0	5	0.1
Sandstone	1	0	0	0	4	1	6	0.1
Schist	0	0	0	0	8	4	12	0.2
Slate	0	0	0	0	1	2	3	0.0
Total	70	295	256	870	2,685	3,294	7,470	100.0
Percent	0.9	3.9	3.4	11.6	35.9	44.1	100.0	
Abbreviations: DEC- decortication flakes; PRI- primary flakes; THI- thinning flakes; L/S - late-stage flakes; FF - flake fragments; RF - reduction fragments								

As shown in Table 4.4, cores occur in several materials. Cores generally denote bifacial reduction. Those appearing in argillaceous materials were certainly imported; the others are probably local products. Table 4.5 arrays cobble tools by type, material, and inferred function, Note that slab tools are abraders, which have been set off to accentuate their tabular form.

As is commonly the case, thermally altered rocks are fairly numerous (Table 4.6). These rocks, presumably derived from ancient hearths, have been broken, cracked, or shattered by exposure to fire.

Table 4.4: Cores by Material (28-BU-475)			
MATERIAL	QTY	% GROUP	% TOTAL
Argillaceous Shale	1	1.6	0.0
Argillite	1	1.6	0.0
Chert	13	21.0	0.1
Cuesta Quartzite	8	12.9	0.1
Jasper	11	17.7	0.1
Quartz-Schist	2	3.2	0.0
Quartz	26	41.9	0.3
Total	62	100.0	0.7

Table 4.5: Cobble Tools by Type or Function and Material (28-BU-475)										
MATERIAL	ABRADER	ANVIL	CHOPPER	HAMMER	COMBINED FUNCTIONS	SLAB	MISC.	FRAGMENTS	TOTAL	% TOTAL
Cuesta Quartzite	0	0	0	10	0	0	0	0	10	6.0
Limonite	4	0	3	5	0	4	2	3	21	12.6
Metasediment	1	1	0	0	0	0	1	2	5	3.0
Quartzite	0	3	0	5	5	1	2	4	20	12.0
Quartz-Schist	0	0	0	0	0	1	0	0	1	0.6
Sandstone	0	6	1	8	49	3	13	29	109	65.3
Schist	0	0	0	0	0	1	0	0	1	0.6
TOTAL	5	10	4	28	54	10	18	38	167	100.0
% TOTAL	3.0	6.0	2.4	16.8	32.3	6.0	10.8	22.8	100.0	

Table 4.6: Thermally Altered Rock (28-BU-475)			
MATERIAL	QTY	% GROUP	% TOTAL
Chert	1	0.1	0.0
Cuesta Quartzite	190	25.8	2.1
Limonite	93	12.6	1.0
Metasediment	1	0.1	0.0
Quartzite	17	2.3	0.2
Quartz	215	29.2	2.4
Sandstone	220	29.9	2.4
Total	737	100.0	8.2

Other lithic artifacts that appear in relatively minor numbers are identified in Table 4.1. Most of these require little elaboration, but interesting details of others are presented below. Microtools, end-tools, and unifaces are all cutting, scraping, or perforating tools, commonly made of cryptocrystalline materials. As the name implies, microtools, are very small instruments, frequently not more than 13mm (½-inch) in length. Their very small size suggests that some form of hafting was necessary to hold them for useful work. The small splinter-like flakes from which they are prepared are commonly produced by splitting cryptocrystalline pebbles by bipolar percussion. Microtools are generally associated with Late Archaic/Early Woodland cultures.

End-tools and unifaces can be made on flakes or flake blanks of various sizes. These tools, always larger than microtools, are useful for general tasks involving cutting, scraping, or planing. They appear exclusively in fine-grained stones, never in Cuesta quartzite.

One small fragment of polished stone represents part of a grooved axe. Eight small lumps of ochre may have been gathered or produced for use as a pigment. The appearance of a few pebbles in geological deposits that otherwise contain only sand or loam suggests the cultural importation of these items. Potential uses for these pebbles include the production of bifaces, flake tools, or microtools.

Two atlatl weights are represented by fragments. The first consists of three matching pieces of a steatite weight of bipinnate form, together comprising part of one wing and a section of the central hole. The second weight is represented by a remnant of a fine-grained sandstone cylinder removed by drilling with an abrasive-laden tube.

Nearly 200 pieces of fossilized wood were recovered. These specimens resemble silicified wood from the Kirkwood Formation of Miocene age. This formation, which underlies much of the coastal plain, outcrops in the area southwest of Bridgeton, Cumberland County, and in Pilesgrove and Alloway Townships in Salem County. No exposures occur near the site. The existence of petrified wood in cultural deposits beyond its geological sources suggests introduction by cultural agency, as has been suggested with respect to other sites (Mounier 1974b). More than 25% of the pieces (51/198) show discoloration or other evidence of thermal alteration, further attesting to the use of this material by humans. The uses may have been magical or religious, or, possibly, just whimsical, because there is no evidence of any attempts to work functional edges onto the fossils or to utilize their natural abrasiveness in shaping other substances.

The last remaining category of aboriginal artifacts is pottery, of which only 13 examples have been observed. The surviving potsherds are predominately small in size and difficult to classify by named types. The aboriginal ceramics appear to reflect a mix of early and late wares, but precise cultural and chronological associations cannot be advanced. The co-occurrence of fabric-impressed sherds and small triangular bifaces is a fairly good indicator of late prehistoric occupation.

4.1.1.2) <u>*Activity Areas:*</u> A number of activity areas were identified in the excavations. For the most part they represent Archaic or Late Archaic/Early Woodland stations, related to seasonal plant collection and processing or to lithic tool production.

Intensive prehistoric activities were signaled by concentrated patches of artifacts in slightly discolored subsoils, whose salient characteristic was a reddish brown hue (Munsell colors in the range: 7.5YR 5/6, 10YR 4/6-5/6, and 2.5Y 4/6) which contrasts with the more yellow tone of the natural subsoil. The reddening of the soil was apparently a cultural effect because the patches of color were commonly coterminous with the horizontal and vertical spread of artifacts and organic remains.

Carbonized plant remains occurred in the form of wood charcoal or charred nut shell fragments. However, very few refuse bones were found. The sample for the entire site is limited to three calcined bones. No bones were found beyond the limits of the reddened earth.

The activity areas assumed irregular oval configurations in plan, measuring approximately 4.6 x 6.1m (15 to 20 feet) in greatest dimension. The artifact concentrations and discolored soils occurred immediately beneath the plowzone, evidently having been truncated by farming and erosion. They often extended to a depth of 38 to 46cm (15 to 18 inches) below the surface.

A concentration of carbonized nut shells and wood charcoal occurred in a restricted area, roughly oval in plan and lenticular in section. The greatest horizontal dimension was approximately 76cm (30 inches). The vertical spread was about 15cm (6 inches). Besides the carbonized plant remains this feature also contained a large quantity of flaking debris in Cuesta quartzite.

Another probable Archaic activity area contained expended cobble tools of sandstone and quartzite in association with carbonized nut shells and thermally altered rock, along with flake and biface remains of argillite. Some activity areas were devoted to the reduction of Cuesta quartzite into early-stage bifaces, biface cores, and flake blanks.

4.1.2) Artifact Analysis

The following paragraphs discuss the results of proportional flake analysis and flake-to-biface ratio analysis.

4.1.2.1) Proportional Flake Analysis: For the entire assemblage, the sum of decortication and primary flakes is 365, while the total of thinning and late-stage flakes is 1,126. Accordingly, the ratio of later to earlier flakes for the assemblage as a whole is 3.08:1. Because the flake sample is relatively large, this ratio reasonably indicates the predominance of late-stage flaking for the entire site.

For Cuesta quartzite, the ratio is somewhat greater. There are 227 earlier stage flakes vs. 750 later stage flake in this material. The later to earlier stage flake ratio, therefore, computes to 3.30:1.

Considering the 977 identifiable flakes of Cuesta quartzite from all excavated areas, the frequencies and proportions of flake types are: primary flakes, 224 (23%);

thinning flakes, 178 (18%); and, late-stage flakes, 572 (59%). These proportions again show an emphasis on late-stage processing.

More bifaces occur in Cuesta quartzite than in any other on this site. While there is only one finished (but broken) biface in this material, there are 44 early-stage bifaces, plus fragments. This situation is consistent with early-stage production and the incipient formalization of Cuesta quartzite bifaces from cobbles available at the site. If the sample can be considered to be unbiased, it would seem that formalized bifaces were removed from the site for use elsewhere.

4.1.2.2) <u>*Flake-to-Biface Ratio Analysis*</u>*:* In order to offset the biases introduced by the removal of artifacts over a long history of surface collecting, the following analysis deals only with bifaces and flakes recovered from subsoil contexts at site 28-BU-475. This evaluation includes all bifaces, whether or not formalized, and all discrete flake types. The pertinent data appear in Table 4.7. The table makes reference only to materials that are represented both by bifaces and flakes.

The flake to biface ratio for Cuesta quartzite is 14.8:1. In a part of the site that revealed very intensive reduction of Cuesta quartzite, the flake to biface ratio in that material is 17.3:1 (745 flakes / 43 bifaces). Ratios of this magnitude provide only a weak indication of biface production. Sampling errors may account for this situation. However, when considered in light of the flake analysis and biface count, bifacial reduction was practiced with considerable vigor at this site.

Table 4.7: Flakes, Bifaces and F/B Ratios at 28-BU-475			
Material	**Flakes**	**Bifaces**	**F/B Ratio**
Argillite	9	15	0.6
Chalcedony	2	1	2.0
Argillaceous Shale	34	12	2.8
Metasediment	9	2	4.5
Quartz	146	26	5.6
Quartzite	8	1	8.0
Jasper	78	7	11.1
Chert	74	6	12.3
Cuesta quartzite	816	55	14.8
Total	1,176	125	9.4

4.1.3) Radiocarbon Age

Two charcoal samples were submitted for radiocarbon age determination. The first sample returned an age estimate of 3,990±60 radiocarbon years (Beta-125251). The second sample yielded an age estimate of 1,670±80 radiocarbon years (Beta-125252). The details concerning these samples have been presented in Chapter 2, Section 2.6.2.

4.2) The Evesham Corporate Center Site: 28-BU-90

Site 28-BU-90 lies between two headwaters of the Southwest Branch of Rancocas Creek on land formerly maintained as agricultural fields and woodlots (Mounier 2001; Figure 4.2). Situated in Evesham Township, the site lies about midway between the crossroads of Pine Grove and Melrose. The site contains a natural deposit of Cuesta quartzite cobbles.

Most of the tract had been disturbed during earthmoving associated with the neighboring development, Elmwood Village, about 25 years ago. This disturbance is evidenced by extensive cut and fill, and by the installation of subterranean utilities (e.g., sewers and storm drains). In some spots, the surface has been cut a meter or more below the original grade. Only a little over 0.8 hectares (two acres) survives with any original topography. Where it is preserved, the landscape reflects a history of farming.

Fieldwork was conducted in the late fall and winter of 2000. The excavations covered about 86m^2 (925 square feet). As a prelude to archaeological excavation, extraneous fill and topsoil was removed by mechanical stripping. This operation was conducted to remove sterile overburden, to expose cultural features, and to facilitate efficient manual excavation.

The data recovery excavations yielded artifacts and natural items, such as cobbles and nut fragments, that show evidence of use by humans or that occur in contexts that strongly suggest such usage.

4.2.1) Cultural Remains

The cultural remains from this site consist of discrete artifacts, as well as activity areas and cultural features. Each is considered below.

4.2.1.1) Artifacts: In all, 7,951 artifacts were retrieved. Of these, 2,157 (or 27%) occurred in the plowzone and 5,794 (73%) occurred in undisturbed subsoil. Table 4.8 enumerates the finds by general type.

Bifaces occur in a variety of forms and stages of completion. The array of bifaces by general category and material is presented in Table 4.9.

Table 4.8: List of Artifacts (28-BU-90)		
Type	**Qty**	**Percent**
Atlatl Weight	1	0.0
Bifaces	130	1.7
Cobble Tools	90	1.2
Concretion	1	0.0
Cores	36	0.5
Flakes	6,896	86.7
End-Tools	2	0.0
Ornaments (?)	2	0.0
Pebbles	26	0.3
Petrified Wood	3	0.0
Potsherds	136	1.7
Slabs	3	0.0
Misc. Tools	2	0.0
Ulus (?)	2	0.0
Hearth Rock	615	7.7
Unidentified	6	0.1
Total	7,951	100.0

In terms of named typology, the earliest formal biface is the bifurcated LeCroy point. Several narrow-bladed, narrow-stemmed bifaces fall within the Morrow Mountain-Poplar Island-Rossville continuum. These points indicate Middle to Late Archaic cultures. Some of the narrow stemmed points probably reflect Early Woodland occupations as well. The convex-base bifaces (often called "Teardrop points") are Late Archaic/Early Woodland specimens.

Table 4.9: Bifaces by Type and Material (28-BU-90)									
Material	Early-Stage	Mid-Stage	Stemmed	Bifurcated	Teardrop	Tool	Fragment	Total	Percent
Argillaceous shale	1	2	3	0	0	0	7	13	10.0
Argillite	5	2	11	0	1	2	14	35	26.9
Chert	1	0	1	0	3	0	1	6	4.6
Cuesta quartzite	53	2	0	0	0	0	6	61	46.9
Diabase	1	0	0	0	0	0	0	1	0.8
Hardyston quartzite	0	0	1	0	0	0	0	1	0.8
Jasper	1	0	0	0	1	0	0	2	1.5
Quartz-schist	1	0	0	0	0	1	0	2	1.5
Quartzite	0	0	1	1	0	0	0	2	1.5
Quartz	2	0	2	0	0	1	2	7	5.4
Total	65	6	19	1	5	4	30	130	100.0
Percent	50.0	4.6	14.6	0.8	3.8	3.1	23.1	100.0	

As shown in Table 4.10, most of the cores occur in Cuesta quartzite, accounting for nearly half of the total.

Table 4.10: Cores by Material (28-BU-90)		
Material	Qty	Percent
Argillite	2	5.6
Chalcedony	1	2.8
Chert	5	13.9
Cuesta Quartzite	17	47.2
Jasper	5	13.9
Quartz	6	16.7
Total	36	100.0

Flakes outnumber all other artifact categories, being represented by 6,896 specimens in a wide range of materials, and comprising in the aggregate, about 87% of all aboriginal artifacts. Most of the flakes occur in Cuesta quartzite (Table 4.11).

Table 4.11: Flakes by Type and Material (28-BU-90)

Material	ES	DEC	PRI	THI	LS	FF	RF	BIP	BLK	TOOL	MISC.	Total	%
A/S	0	0	6	24	3	24	1	0	1	1	1	61	0.9
ARG	1	0	14	24	21	89	10	0	3	1	7	170	2.5
CHA	0	0	0	0	2	0	0	0	0	0	0	2	0.0
CHT	0	5	3	1	3	5	4	2	0	1	1	25	0.4
CUE	113	21	85	76	65	387	5,709	0	10	0	15	6,481	94.0
FEL	0	0	1	0	0	0	0	0	0	0	0	1	0.0
FEO	0	0	0	0	0	0	2	0	0	0	0	2	0.0
JAS	0	2	1	6	10	12	4	2	0	1	1	39	0.6
MET	0	4	2	8	3	13	4	0	0	1	4	39	0.6
QSC	0	0	0	0	0	1	0	0	0	0	0	1	0.0
QTT	0	1	1	0	0	0	0	0	0	0	0	2	0.0
QZZ	0	4	3	13	7	21	15	0	1	0	0	64	0.9
SAS	0	2	0	0	0	0	2	0	0	0	0	4	0.1
SCH	0	0	0	0	0	0	4	0	0	0	0	4	0.1
MISC	0	0	0	0	0	0	0	0	0	0	1	1	0.0
Total	114	39	116	152	114	552	5,755	4	15	5	30	6,896	100.0
%	1.7	0.6	1.7	2.2	1.7	8.0	83.5	0.1	0.2	0.1	0.4	100.0	

ABBREVIATIONS: ES = early-stage flakes; DEC = decortication flakes; PRI = primary flakes; THI = thinning flakes; LS = late-stage flakes; FF = flake fragments; RF = reduction fragments; BIP = bipolar flakes; BLK = flake blanks; MISC = miscellaneous flakes. A/S = argillaceous shale; ARG = argillite; CHA = chalcedony; CHT = chert; COH = Cohansey quartzite; CUE = Cuesta quartzite; DIA = diabase; FEL = felsite; FEO = limonite; JAS = jasper; MET = metasediment; QSC = quartz-schist; QTT = quartzite; QZZ = quartz or quartzose; SAS = sandstone; SCH = schist; MISC = unknown.

The excavations yielded a total of 90 cobble tools in several materials. These cobble tools are usually rough-service implements, such as hammers, anvils, abraders, and choppers. Some cobble tools are formed on tabular pieces of rough stone, either as milling gear or rough edged tools. Tools of this kind are known as slab tools. Commonly, cobble tools exhibit traits that indicate multiple functions in various combinations.

Hammerstones are the most common, single-purpose cobble tools, being represented by 31 specimens (34% of the total). The other categories—axes, abraders, anvils, and combination tools—are each represented by a minority of specimens. There are 39 fragmentary cobble tools and three specimens that could not be assigned to specific functions.

Other lithic artifacts appear in relatively minor numbers. End-tools can be made on flakes or flake blanks, usually of cryptocrystalline materials. These tools are useful for general tasks involving cutting, scraping, or planing. The two examples from the present work include one each of chert and jasper.

Three small pieces of worked slate are believed to be parts of one or more ulus, or semilunar knives, which were formed by grinding. The semilunar knife is a trait of the Archaic Laurentian tradition (Ritchie 1965:80, 84) and, like related elements, is far more common in New England and New York State than in New Jersey.

Three pieces of fossilized wood were recovered. These specimens resemble silicified wood from the Kirkwood Formation of Miocene age, which outcrops far to the southwest in portions of Cumberland and Salem Counties.

The last remaining category of aboriginal artifacts is pottery, of which 136 examples have been observed. The surviving potsherds are predominately small in size and difficult to classify by named types. The majority of the ceramics from the excavations can be divided into two sorts, both of which are examples of Early Woodland production. For this reason, these are types are sometimes called Early-Series wares. Wares of both types have been found commingled on coastal plain sites dating to the first millennium B.C.

The first variety is a moderately thick-walled, coarse mineral- tempered ware that is roughly marked with textile or cord impressions on the exterior surfaces. The interior surfaces are smooth. The paste is hard fired. The mineral temper consists of crushed granite, porphyry, diorite, syenite, or quartz. Paste colors range from reddish yellow to brown. Thirty seven sherds are of this type.

The second type is a moderately thin-walled, sand- or grit- tempered ware that is poorly fired. It is marked on the exterior with crisscrossed, open-corded impressions. The interiors are plain. The paste is reddish brown or yellowish red. This type is represented by 98 sherds. One grit-tempered, fabric-impressed sherd, reminiscent of the Late Woodland Riggins Fabric-Impressed type was recovered.

4.2.1.2.) Activity Areas and Features: A Late Archaic/Early Woodland activity area was exposed. The artifacts within it included abundant refuse from Cuesta quartzite biface production, faceted hammerstone fragments, argillaceous biface fragments and debitage, and expedient cobble tools (hammerstones, anvils abraders). A feature in this area contained approximately 124 pieces of quartzite, which weighed about 9kg (19.8 lbs.). Along with a small piece of worked slate, a small amount of calcined bone was present. In addition the feature contained carbonized nut shell fragments sufficient to support radiocarbon dating.

Four contiguous trenches (Nos. 12, 13, 62, and 63) revealed an oval cluster of densely packed Cuesta quartzite. This deposit measured approximately 46 x 91cm (18 x 36 inches) in plan. It appears to be related to heat processing, warming, or cooking. This feature contained approximately 170 pieces of rock, which weighed about 11.6kg (25.5 lbs). The feature was associated with small amounts of debitage in Cuesta quartzite and argillaceous materials, along with argillite biface tools and fragments, which are of typical Lackawaxen typology (Kinsey 1972:408-411). Also found were early-series, quartz-tempered, corded ceramics and expedient cobble tool fragments, some of which were hammers. One carbonized nut shell was recovered.

A large, lens-shaped Cuesta quartzite processing feature measured 2.1 x 2.4m (7 x 8 feet) and contained more than 1,900 pieces of stone. The total weight of the stone was about 139kg (306 lbs). Abundant Cuesta quartzite tool production and processing debris was found in association with argillaceous tools, debitage and expedient cobble tools of the Lackawaxen culture.

The excavation here revealed the co-occurrence of small bifacial and unifacial tools in cryptocrystalline materials, along with Lackawaxen implements in argillaceous materials. The associated debitage revealed production by the bipolar technique, in which the object to be knapped is broken into workable forms by direct percussion while resting upon a solid anvil.

The cryptocrystalline artifacts comprise Teardrop-variant bifaces along with pebble flake- and uniface-tools, including end-tools, a wedge, and core fragments, all of which were frequently found commingled with the Lackawaxen argillaceous materials around the Cuesta quartzite feature.

Also, heavily-tempered ceramic wares, were found flanking this feature and within the activity area. These types have recently been recognized as consistent elements in other Late Archaic/Early Woodland expressions on the coastal plain (Mounier 2000c). Two types are in evidence. The first is a thick, well-fired, heavy mineral-tempered, coarse textile- or cord-marked ware; the other is a thinner, poorly fired, fine grit-tempered ware with criss-cross cord malleations.

Two fragments of petrified wood were recovered from this feature, but there was scant evidence of any carbonized plant remains.

In the eastern portion of this excavation block, an older Archaic activity area was encountered. Significant vestiges include two Middle Archaic quartzite bifaces. The first of these implements is a narrow-bladed, narrow-stemmed biface in the Morrow Mountain/Stark/Poplar Island continuum. The second is a bifurcate-base LeCroy form, which was found with a full-grooved axe, cryptocrystalline pebbles, and cobble tool fragments, as well as tools and flakes of argillaceous shale. All of these items were recovered from the lowest levels of the excavations, between 61 and 84cm (24 and 33 inches) below the surface.

Another excavation block revealed a Late Archaic/Early Woodland activity area. Cuesta quartzite reduction fragments and limited biface production debris were found here but with less intensity than in the excavations described above. This feature contained abundant argillaceous tools and debris along with expedient and formal cobble tools, which relate to the Lackawaxen culture. Traces of formalized cobble tools were found as fragments and detached flake spalls. As in the other locations, specialized tool processing activities were identified by the occurrence of both complete and fragmented faceted hammerstones of Cuesta quartzite.

Also, evidence of small tool production from cryptocrystalline pebbles and bipolar processing was observed here in the form of Teardrop variant bifaces in chert and jasper as well as bipolar cores and core-derived tools in quartz, chert, and jasper. Flake tools in these materials were also noted.

The layer of discolored earth was found just under the plowzone. This feature covers an area that measures approximately 3.05 x 3.7m (10 x 12 feet) in a roughly rectangular configuration. It appeared as a discrete patch of soil containing brown to strong brown (2.5Y5/6-10YR 5/4) mottles within a surrounding matrix of olive brown (2.5Y4/4-5/6) soil. Occasional patches of interspersed reddish brown soils were also detected throughout this horizon. From all indications this was well-trod terrain and possibly served as a shelter. The coloration suggests the possibility of prolonged, concentrated use sometimes seen in other sites (Mounier 1991; 2003a:130-134). Larger, more profuse artifacts were found on the edges of this feature, especially on the eastern margin, where cobble tools and a small tool cluster were uncovered in situ.

An associated feature was a circular discoloration of brown earth (10YR 4/3), measuring 46cm in diameter and 23cm deep (18 x 9 inches). While this discoloration contained quite a lot of wood charcoal and small flaking debris, no other artifacts were recovered from the fill.

Other artifacts relating to the Late Archaic/Early Woodland episode include an edged slab tool of quartz-schist and a hornblende-schist atlatl weight fragment. A unique specimen—clearly not pertaining to this cultural phase—is a fragment of a slate ulu or semilunar knife, which occurred in the plowzone. This find attests to the presence of other Archaic encampments in the vicinity or the importation of an artifact from a previous era.

Lackawaxen biface fragments and debitage in argillaceous materials along with cores and flakes derived from quartz and jasper pebbles were found; also, Cuesta quartzite was found in limited quantities in an assortment of flakes and reduction fragments. Other finds include an elongated, faceted hammerstone of this Cuesta quartzite, as well as petrified wood. Work in this area was abandoned when the similarity of the finds to those at other loci was confirmed.

4.2.2) Artifact Analysis

The following paragraphs discuss the results of proportional flake analysis and flake-to-biface ratio analysis.

4.2.2.1) Proportional Flake Analysis: As shown in Table 4.11, early-stage, primary, thinning, and late-stage flakes are the most numerous of the identifiable types. These types account for 496 specimens (or 84% of all flakes other than fragments). The early-stage and primary flakes total 230 specimens, whereas the thinning and late-stage flakes total 266 flakes. Therefore, ratio of later to earlier stage flakes for the assemblage as a whole is 1.16:1.

This ratio becomes inverted when flakes of Cuesta quartzite are considered by themselves (Table 4.12). In Cuesta quartzite the ratio of earlier to later flakes is 1.55:1. While this ratio is not particularly strong, it is consistent with the presence of many (53) early-stage bifaces at this site.

The percentage representation of primary, thinning, and late-stage flakes is 37.6%, 33.6%, and 28.7%, respectively. Considered in relation to the proportional flake ratio, this pattern indicates a balanced range of Cuesta quartzite reduction, with a slight emphasis on early-stage knapping.

The overall pattern reflects a broad spectrum of bifacial reduction, including the thinning and shaping of biface cores and the preparation of flake blanks. The relatively low proportion of late-stage flakes suggests that the repair and resharpening of implements and weapons occurred on this site, but with limited frequency. Earlier stages of biface reduction are clearly in evidence, more so from the surviving bifaces themselves than from the flake evidence.

Table 4.12: Flake Ratios (28-BU-90)

Material	Early	Late	E/L	L/E
Argillaceous Shale	6	27	0.22	4.50
Argillite	15	43	0.35	2.87
Chert	8	4	2.00	0.50
Cuesta Quartzite	219	141	1.55	0.64
Jasper	3	16	0.19	5.33
Quartz	7	20	0.35	2.86
Total	258	176	1.47	0.68
Percent	59	41		

Early Flakes: Early-stage; decortication, primary.
Late Flakes: Thinning; Late-Stage.

4.2.2.2) <u>Flake-to-Biface Ratios</u>: Table 4.13 depicts the flake to biface ratios for various materials at this site. Note that materials that are not represented both by flakes and bifaces are not represented in the tabulation.

Considering only Cuesta quartzite, the flake-to-biface ratio is 106.2:1. A ratio of this magnitude is consistent with bifacial production from flake blanks; indeed, ten flake blanks appear in the excavated assemblage. On the other hand, the ratio seems small considering the multitude of early-stage bifaces and the complete absence of formalized specimens in this material. Evidently the production of formal artifacts in Cuesta quartzite was not major task at 28-BU-90.

Table 4.13: Flake-to-Biface Ratios (28-BU-90)				
Material	**Bifaces**	**Flakes**	**F/B**	**B/F**
Argillaceous Shale	13	61	4.7	0.2
Argillite	35	170	4.9	0.2
Chert	6	25	4.2	0.2
Cuesta Quartzite	61	6,481	106.2	0.0
Jasper	2	39	19.5	0.1
Quartz-Schist	2	1	0.5	2.0
Quartzite	2	2	1.0	1.0
Quartz	7	64	9.1	0.1
Total w/o Cuesta Quartzite	67	362	5.4	0.2
Total	128	6843	53.5	0.0

4.2.3) Radiocarbon Age

A composite sample of charred nut shells returned an age of 3840±60 radiocarbon years ago. The details concerning this sample can be found in Chapter 2, Section 2.6.6.

4.3) The Elmwood Estates Site: 28-BU-277

Site 28-BU-277 is located approximately 1000 feet northeast of the intersection of Elmwood and Tuckerton Roads in the development known as Elmwood Estates. (Mounier 1996b; Figure 4.2). The site is adjacent to site 28-BU-90, being separated from it by a stream and swampy ground in the head of the Southwest Branch of Rancocas Creek. In common with that site, the present location also has cobbles of Cuesta quartzite in a surficial bed. The soil is loamy sand.

The archaeological investigation of the Elmwood Estates development was required under Evesham Township Ordinance (38-9-87). The investigation resulted in the identification of four locations that yielded prehistoric cultural remains, mostly in the form of flaking debris.

4.3.1) Cultural Remains

Archaeological materials were obtained both by excavation and by surface collection. Since most of the artifacts at 28-BU-277 occur within the plowzone (or upon the surface), a regime of controlled surface collection was conducted as a simple means to augment the sample obtained by excavation. The procedure consisted of simply gathering artifacts from the weathered surface of the site, noting the location of discovery by gross provenience.

The search areas, defined by inspection and test excavations, consisted of four loci (A-D), which were separated by stretches of unproductive ground. Plowing in May of 1996 freshened the ground surface, and collection began after precipitation had washed the ground. Two episodes of collection sufficed to supplement the previous sample. Table 4.14 lists the finds.

Forty-two early-stage bifaces and 20 late-stage bifaces were found. Forty-one finished or formal bifaces occurred in four types or styles; viz., stemmed (23), Teardrop (9), corner-notched (3), and side-notched (4). Eighteen of the bifaces are made of Cuesta quartzite. These bifaces include 16 early-stage specimens, one refined (but not formalized) biface, and one formalized biface.

Table 4.14: Enumeration of Artifacts by Area (28-BU-277)						
Type	**Area A**	**Area B**	**Area C**	**Area D**	**Total**	**Percent**
Atlatl Weight	0	1	0	0	1	0.01
Axes	2	1	0	1	4	0.06
Bifaces	74	12	7	10	103	1.45
Flake Blanks	1	0	4	1	6	0.08
Choppers/Adzes	2	0	0	0	2	0.03
Cores	74	6	2	10	92	1.30
Drill	1	0	0	0	1	0.01
Flakes	4,325	879	270	1,108	6,582	92.72
Hammers	5	0	1	0	6	0.08
Microtools	10	1	0	0	11	0.16
Scrapers	7	1	0	0	8	0.11
Other Tools	63	8	5	12	88	1.24
Thermally Altered Rock	108	8	2	35	153	2.16
Potsherds	3	0	0	0	3	0.04
Pebbles	4	0	0	0	4	0.06
Misc. Finds	7	2	1	0	9	0.13
Petrified Wood	20	1	1	0	22	0.31
Shark Teeth	2	0	1	0	3	0.04
Total	4,708	920	294	1,177	7,099	100±

Table 4.15 details the frequency of all flakes. Nearly 80% of all flakes occur in Cuesta quartzite, a material that occurs in a cobble bed on the northern end of the site.

The artifacts have an uneven distribution across the site. The distribution is not only uneven in a numerical sense. It is also disproportionate in the variety of recognized artifacts, as shown in Table 4.14. Apparently, Locus A was most frequently visited or most heavily used (or both), possibly because it occupies the highest ground. Such habitations as might have existed on this site probably occurred here.

Table 4.15: Flakes by Type and Material (28-BU-277)								
Material	**DEC**	**PRI**	**THI**	**L/S**	**RF**	**FF**	**Total**	**Percent**
Argillaceous Shale	0	2	4	7	2	0	15	0.2
Argillite	0	14	9	12	13	177	225	3.4
Chert	10	7	10	17	15	94	153	2.3
Cuesta Quartzite	0	69	61	107	4,127	826	5,190	78.4
Jasper	19	17	37	159	20	388	640	9.7
Metasediment	1	0	0	2	2	15	20	0.3
Quartz	4	13	8	57	94	181	357	5.4
Quartzite	1	0	1	3	1	1	7	0.1
Sandstone	6	0	0	0	0	5	11	0.2
Schist	0	0	0	0	1	1	2	0.0
Total	41	122	130	364	4,275	1,688	6,620	100.0
Percent	0.6	1.8	2.0	5.5	64.6	25.5	100.0	

Flake Types: DEC = Decortication; PRI = Primary; THI = Thinning; L/S = Late-Stage; RF = Reduction Fragments; FF = Flake Fragments

Locus C was the principal source location for Cuesta quartzite. This conclusion is demonstrated by the high proportion of early-stage bifaces and primary flakes in this material. However, the working of Cuesta quartzite was a prime activity at other locations, where additional bifacial reduction took place.

4.3.2) Artifact Analysis

The following paragraphs discuss the results of proportional flake analysis and flake-to-biface ratio analysis.

4.3.2.1) Proportional Flake Analysis: The proportional flake analysis for Cuesta quartzite yielded a ratio of later to earlier stage flakes of 2.43:1 This ratio is based on a sample of 237flakes. These proportions show that mixed stages of biface reduction in this material occurred on this site. The slight majority of late-stage flakes indicates a degree of biface refinement.

The proportions of Cuesta quartzite flake types are: primary flakes, 29.1%; thinning flakes, 25.7%; and, late-stage flakes, 45.2%. These percentages show a range of knapping behaviors that focused on later-stage production, while early biface reduction and thinning occurred with approximately the same intensity, relative to one another.

4.3.2.2) Flake-to-Biface Ratio: The flake to biface ratio in Cuesta quartzite is 288.3:1. This ratio is among the highest for any site in this study. The large number of unfinished bifaces in the assemblage clearly suggests an emphasis on early-stage production. This situation would seem to be at odds with the proportional flake analysis. As always, the possible removal of formalized specimens by native knappers in antiquity or by collectors in modern times clouds the nature of biface refinement here.

4.4) Troth Farm: 28-BU-407

The Troth Farm site (a.k.a. the Troth Road site) is located to the east of Troth Road, between Route 70 on the north and Old Marlton Pike on the south in the Township of Evesham, Burlington County, New Jersey (Mounier 1998d; Figure 4.2). It is one of several closely spaced prehistoric sites that contain both geological and archaeological examples of Cuesta quartzite.

The subdivision of the farm for residential development was preceded by two archaeological investigations that identified the presence of prehistoric and historic cultural remains. The prehistoric remains consisted of a variety of lithic artifacts relating to the Late Archaic/Early Woodland period (2,000 - 4,000 B.C.). The historic remains comprise a house, originally constructed about 1770, and several more modern outbuildings. Inasmuch as the development plan envisions the preservation and rehabilitation of the house, the archaeological work concentrated entirely upon the prehistoric remains.

Most of the cultural material from this site comprises flaking debris associated with aboriginal stoneworking. An abundance of Cuesta quartzite flakes reflects the presence on the site of boulders and cobbles of this material. The remainder of the artifacts consists of thermally-altered hearth rocks, bifaces, cores, flake tools, and other familiar types.

A total of twenty-five excavation units were opened. Twenty-one were full 5 x 5 foot squares (roughly 1.5 x 1.5m), and four were 2.5 x 5 foot (0.76 x 1.5m) trenches. Except for a thin layer of turf, the topsoil from the plowzone was excavated and screened in all sample units. The excavation covered approximately 53.5m^2 (575 square feet) to a depth of not more than 91cm (36 inches) beneath the surface.

Sampling concentrated on three locations, where preliminary work revealed intact prehistoric deposits. These sub-areas (Loci A, B, and C) revealed relatively high artifact frequencies, carbonized plant remains, and culturally induced soil discolorations. This effort demonstrated a fundamental similarity between the loci in terms of artifact types, features, and inferred cultural activities. Locus A differed from the others by reason of especially dense deposits of Cuesta quartzite debitage, occasioned by the presence of a cobble bed as well as boulders of this material. All three loci produced evidence of concentrated prehistoric activities, including primary lithic production and maintenance activities; also, generalized seasonal procurement and processing of floral and faunal raw materials.

4.4.1) Cultural Remains

The majority of artifacts were found in the plowzone and the upper 15cm (six inches) of the subsoil; however, locations with higher artifact frequency also consistently produced artifacts—especially Cuesta quartzite debitage and cobble fragments—at the deepest levels in the site.

4.4.1.1) Artifacts: The collection includes 6,193 specimens, which are enumerated by type in Table 4.16. The vast majority of the specimens consist of debitage. The next most numerous artifacts are thermally-altered or fire-cracked rocks of may have served as heat reservoirs for heat-treating knappable stones.

Of the bifaces, 39 are formal bifaces, including: four broad-stemmed points of the Koens-Crispin type (Kinsey 1972:423-426); nine contracting-stemmed examples of or resembling the Lackawaxen Stemmed types (Kinsey 1972:408-411); seven stemmed or corner-removed specimens similar to the Morrow Mountain type (Coe 1964:37-43); seven broadspears of or similar to the Susquehanna Broad type (Witthoft 1953:7-9; Kinsey 1972:427-429); two Teardrop bifaces and two lozenge-shaped "Kite" points

(Cross 1956; Kraft and Blenk 1974; Mounier 2003a:158-159, Mounier and Cresson 1988, Mounier and Martin 1994); two triangular pieces; one basally-notched form resembling the Eshback type (Kinsey 1972:417-419); and, five miscellaneous specimens.

Table 4.16: Artifacts from 28-BU-407

Type	Qty	Percent
Bifaces	153	2.5
Cores	54	0.9
Unifaces	5	0.1
Debitage	5,550	89.6
Hearth Rock	245	4.0
Cobble Tools	129	2.1
Potsherds	29	0.5
Steatite Sherds	4	0.1
Petrified Wood	23	0.4
Celt	1	0.0
Total	6,193	100.0

The remaining 114 bifaces are non-formalized, early-stage forms and fragments. Of these pieces 40 are early-stage bifaces rendered in Cuesta quartzite. There are also two biface cores and three fragments in this material.

Most of the potsherds were pieces of coarse, steatite-tempered ware of or resembling the Marcey Creek Plain type (Manson 1948). Among these sherds were several that comprised the flat, basal portion or "heel" of a single vessel. Also found were two sherds of unidentified wares, coarsely tempered with granite, quartz, and grit.

Carbonized wood and nut shells were also recovered. The nut shell fragments appear to derive from one or another species of hickory. The analysis indicates a radiocarbon age of approximately 4,400 years.

Although some small flaking debris was present, most of the lithic remains comprised large flakes as shown in Table 4.17. Cuesta quartzite dominates the assemblage.

Table 4.17: Debitage from 28-BU-407

Material	DEC	PRI	THI	L/S	FF	RF	Total	Percent
Jasper	10	7	18	12	42	16	105	1.9
Chert	18	14	6	22	35	13	108	1.9
Quartz	15	31	34	36	108	77	301	5.4
Cohansey Quartzite	0	3	1	3	10	5	22	0.4
Cuesta Quartzite	5	250	46	61	416	3,858	4,636	83.5
Quartzite	5	1	2	0	1	1	10	0.2
Argillite	0	42	41	7	123	39	252	4.5
Argillaceous Shale	0	9	13	5	31	9	67	1.2
Rhyolite	0	2	0	0	0	0	2	0.0
Felsite	0	1	0	0	1	0	2	0.0
Metasediment	13	9	0	3	3	5	33	0.6
Granite	1	0	0	0	0	0	1	0.0
Sandstone	3	0	0	0	1	0	4	0.1
Schist	0	0	0	0	0	1	1	0.0
Siltstone	0	0	0	0	1	0	1	0.0
Quartz Schist	0	0	0	0	2	3	5	0.1
Total	70	369	161	149	774	4,027	5,550	100.0
Percent	1.3	6.6	2.9	2.7	13.9	72.6	100.0	

Flake Types: DEC = Decortication; PRI = Primary; THI = Thinning L/S = Late-Stage; FF = Flake Fragments; RF = Reduction Fragments

Also present were expedient and general-purpose cobble- and core tools including abraders, hammerstones, and anvils of limonitic sandstone in addition to faceted flaking hammers of Cuesta quartzite. Some of the hammers and anvils bear telltale scars from use in bipolar knapping.

Most of the artifacts occurred as elements of large clusters, some with associated anomalous soil discolorations. These locations define activity areas, which are discussed in detail below.

4.4.1.2) Activity Areas: Three activity areas were identified. Activity areas were defined by relatively dense arrays of artifacts and debitage along with scatters of charred wood or nuts. Anomalous soil discolorations were encountered in activity areas at Loci A and B.

Much of the cultural material exhibits a strong affinity to Late Archaic/Early Woodland forms, including: Lackawaxen stemmed (straight and contracting stemmed varieties), Poplar Island, Rossville, Teardrop, Koens-Crispin, Susquehanna, and Fishtail variants (see Ritchie 1961; Kinsey 1972; Kraft and Blenk 1974 for type descriptions). An Archaic triangle of quartz and a Late Woodland triangle of jasper were recovered from Locus A, while Locus C produced both a basally notched Archaic biface (of or resembling the Eshback type [Kinsey 1972:417-419]) and three contracting, diamond-based, Morrow Mountain-like bifaces (Coe 1964:37-37) of quartz and jasper. These last are also referable to Archaic occupations.

A soil anomaly at Locus A measured approximately 2.4 x 6.1m (8 x 20 feet). The maximum thickness was approximately 7cm (9 inches). First exposed at the base of the plowzone, this anomaly extended to a total depth of 15cm (19 inches) below the surface. Past research suggests that the discolored strata mark work stations that contain discrete groups of functionally-related artifacts, associated residues, and deposits of charred organic remains. The indications are that some of the work performed at these locations involved cooking or other forms of thermal processing.

The activity area at Locus C also produced ceramic artifacts diagnostic of Late Archaic/Early Woodland cultural episodes: 27 sherds of steatite-tempered, Marcey Creek Plain ware (Manson 1948; Cross 1956:175; Kier and Calverley 1957:86-88; Kinsey 1972:451-453). Two other ceramic artifacts were recovered in the activity areas. Both were single, small unidentified sherds tempered with granite, quartz, or grit. One sherd was found at Locus A and the other at Locus B.

The use of non-local materials also indicates Late Archaic/Early Woodland occupations. The related materials include: argillite and argillaceous shale, schist, quartz/schist and jasper. Well conserved primary- and thinning flakes of jasper, rhyolite, and Hardyston quartzite were also present. Discounting decortication flakes from the early fraction, the proportion of late-stage flakes rises to nearly 39%, or more than twice the frequency of late-stage flakes in Cuesta quartzite.

4.4.2) Artifact Analysis

The following paragraphs discuss the results of proportional flake analysis and flake-to-biface ratio analysis.

4.4.2.1) *Proportional Flake Analysis*: The earlier flakes in Cuesta quartzite total 255 specimens, while the later-stage flakes number 107 specimens. Thus, the ratio of earlier- to later-stage flakes in Cuesta quartzite computes to 2.38:1. This ratio would seem to indicate an emphasis on early-stage knapping. Although the sample of unbroken flakes is small (362), this interpretation is consistent with the predominance of primary flakes (70.0%), and much smaller representations of either late-stage flakes (17.1%) or thinning flakes (12.9%). It also accords well with the high number of early-stage bifaces, cores and fragments when compared to the apparent absence of formalized specimens. The focus on early-stage reduction seems reasonably clear.

4.4.2.2) *Flake-to-Biface Ratio*: The ratio of flakes to bifaces in Cuesta quartzite is 4,636 to 45, respectively, or approximately 103:1. Although this ratio does not approach that realized experimentally, it does seem to confirm bifacial reduction at this site, particularly in light of the biface and flake frequencies and the coincidence of the site with a geological deposit of Cuesta quartzite.

4.4.3) Radiocarbon Age

A carbon sample returned an age assessment of 4380±70 B.P. Pertinent details appear in Chapter 2, Section 2.6.9.

4.5) The Ivins Farm Site: 28-BU-492

The Ivins Farm lies along the eastern edge of Evesham Township, between Evesboro-Medford Road and State Highway Route 70 (Mounier 2000d; Figure 4.2).

Excavations here in 1991 covered an area of $85m^2$ (911.5 square feet). The topography is slightly undulating, with uplands comprised of sandy ridges and terraces that overlook lowland basins having internal drainage. These basins are remnants of conditions during glacial times (Bonfiglio and Cresson 1982; French and Demitroff 2001). Active runoff is channeled to two headwater tributaries of the Rancocas Creek, viz., Sharps Run to the north and the Southwest Branch to the south.

The geological deposits at the site comprise unconsolidated sands and gravels of Cretaceous and Tertiary age. Nearby, along the southern and southwestern corridors of the Rancocas Creek, are rich deposits of Cuesta quartzite boulders and cobbles. Cobbles also occur on the site itself.

4.5.1) Cultural Remains

In all, 3,058 artifacts were retrieved. Of these, 42% occurred in the plowzone and 58% occurred in undisturbed subsoil. Table 4.18 enumerates the finds by general type.

Table 4.19 lists the bifaces by general types and materials. In terms of named typology, the earliest formal bifaces (or fragments thereof) include Kirk corner-notched bifaces, which reflect Early Archaic presence on the site. Middle and Late Archaic period cultures are represented by stemmed forms that fall within the Morrow Mountain-Poplar Island-Rossville continuum. The sole Teardrop biface from this work is a Late Archaic/Early Woodland specimen.

Table 4.18: Enumeration of Finds (28-BU-492)		
Type	**Qty**	**Percent**
Bifaces	62	1.77
Cores	16	0.46
End Tools	13	0.37
Micro-Tools	2	0.06
Unifaces	5	0.14
Cobble Tools	29	0.83
Flakes	3,100	88.37
Pottery	8	0.23
Soapstone Bowl Fragment (?)	1	0.03
Ornament (?)	1	0.03
Thermally Altered Rock	253	7.21
Ochre	1	0.03
Petrified Wood	5	0.14
Pebbles/Cobbles	9	0.26
Miscellaneous/Unidentified	3	0.09
Total	3,508	100.00

Cuesta quartzite is the most commonly utilized material for flaked stone implements. This material is represented by 1,893 specimens. The next most common materials are jasper (605), quartz (206), and chert (138). Argillaceous shale and argillite number 128 and 70 pieces respectively. All of the other materials have minor representations.

Not counting fragments, nearly 1,000 flakes occur in Cuesta quartzite, a material that occurs at the site (Table 4.20). Jasper, chert, and quartz, gathered from pebbles, were also exploited. Cryptocrystalline pebbles are not known to occur on the site, but may have been available from the banks and beds of nearby streams. Argillite and argillaceous shale, both non-local stones, must have been imported.

Table 4.19: Bifaces by Type and Material (28-BU-492)								
Material	Early-Stage	Corner-Notched	Stemmed	Tool	Fragment	Miscellaneous	Total	Percent
Argillaceous Shale	0	0	4	0	6	0	10	16.1
Argillite	3	0	2	1	10	1	17	27.4
Chert	0	0	0	0	7	0	7	11.3
Cuesta quartzite	7	0	0	0	2	0	9	14.5
Jasper	1	2	0	0	4	0	7	11.3
Metasediment	1	0	0	0	1	0	2	3.2
Quartz	2	0	0	1	5	1	9	14.5
Rhyolite	0	0	1	0	0	0	1	1.6
Total	14	2	7	2	35	2	62	100.0
Percent	22.6	3.2	11.3	3.2	56.5	1.6	100.0	

Sixteen cores occur in six materials. Cores of quartz number nine specimens and account for 56.3% of all cores. Jasper is the next most common material, being represented by 3 items (19% of the group). The remaining materials are each represented by one specimen (6.3% of the total respectively). As a group cores represent less than 1% of all prehistoric artifacts.

The excavations yielded 29 cobble tools and fragments in several materials. Cobble tools are usually rough-service implements, such as hammers, anvils, abraders, and choppers. Slabs of rough stone served either as milling gear or rough edged tools. Commonly, cobble tools exhibit traits that indicate multiple functions in various combinations. Because of the character of the functions performed, cobble tools often appear in metamorphosed sediments or igneous rocks, which are capable of withstanding battering and abrasion.

Table 4.20: Flakes by Type and Material (28-BU-492)

Mat'l	ES	DEC	PRI	THI	LS	FF	RF	BIP	BLK	TOOL	MISC	Total	Percent
A/S	0	0	6	8	11	101	0	0	1	1	0	128	4.1
ARG	0	0	2	3	4	39	21	0	1	0	0	70	2.3
CHA	0	0	0	1	6	4	0	0	0	1	0	12	0.4
CHT	0	5	0	18	70	37	4	0	0	3	1	138	4.5
CUE	2	3	18	12	65	208	1,582	0	3	0	0	1,893	61.1
FEO	0	0	0	0	0	1	0	0	0	0	0	1	0.0
JAS	0	6	7	69	291	177	20	1	2	29	3	605	19.5
MET	0	2	0	0	2	10	2	0	0	1	0	17	0.5
QSC	0	0	0	0	1	0	5	0	0	0	1	7	0.2
QTT	0	0	0	0	14	1	2	0	0	0	0	17	0.5
QZZ	0	6	8	18	44	74	50	2	1	1	2	206	6.6
RHY	0	0	0	0	5	0	0	0	0	0	0	5	0.2
SCH	0	0	0	0	0	1	0	0	0	0	0	1	0.0
Total	2	22	41	129	513	653	1,686	3	8	36	7	3,100	100.0
Percent	0.1	0.7	1.3	4.2	16.5	21.1	54.4	0.1	0.3	1.2	0.2	100.0	

Abbreviations: *For Types*: DEC = decortication flakes; PRI = primary flakes; THI = thinning flakes; L/S = late-stage flakes; FF = flake fragments; RF = reduction fragments. *For Materials:* A/S = argillaceous shale; ARG = argillite; CHA = chalcedony; CHT = chert; CUE = Cuesta quartzite; JAS = jasper; MET = metasediment; QZZ = quartz; RHY = rhyolite.

Microtools, end-tools, and unifaces, are all cutting, scraping, or perforating tools, commonly made of cryptocrystalline materials. Microtools, generally associated with Late Archaic/Early Woodland cultures, were made from very small flakes. Most appear to have been perforators or gravers. End-tools and unifaces can be made on flakes or flake blanks of various sizes. These tools, always larger than microtools, are useful for general tasks involving cutting, scraping, or planing.

One small lump of ochre may have been gathered or produced for use as a pigment. The appearance of a few pebbles in geological deposits that otherwise contain only sand or loam suggests the cultural importation of these items. Potential uses for these pebbles include the production of bifaces, flake tools, or microtools.

Five pieces of fossilized wood were recovered. As at other sites in this vicinity, these specimens resemble silicified wood from the Kirkwood Formation of Miocene age. Some of the pieces show discoloration or other evidence of thermal alteration, further attesting to the use of this material by humans.

The last category of aboriginal artifacts is pottery, of which only eight sherds were observed. The surviving potsherds are predominately small in size and difficult to classify by named types. Combinations of tempering agents and surface treatments can be recognized on fewer than half of the potsherds. One sherd bears a corded exterior surface, four have plain surfaces, and three lack a finish that can be identified with any confidence. Six sherds have grit as the major aplastic element. The tempering agent in one sherd is indeterminate. The aboriginal ceramics appear to reflect a mix of early and late wares, but precise cultural and chronological associations cannot be advanced.

4.5.2) Artifact Analysis

The following paragraphs discuss the results of proportional flake analysis and flake-to-biface ratio analysis.

4.5.2.1) Proportional Flake Analysis: When the flake types are cast into earlier and later categories, the predominance of later stage flakes is immediately apparent (Table 4.21). The relatively high proportion of later stage flakes demonstrates that the repair and resharpening of implements and weapons occurred with some frequency on this site. Most of the late flakes occur in jasper. This situation reflects the fairly concentrated maintenance of tools and weapons of Early Archaic origin, which were fashioned predominately in quarried jasper, probably from eastern Pennsylvania.

With reference to Cuesta quartzite, the ratio of later to earlier flakes is 3.35:1, which appears to follow the pattern for the rest of the lithics. However, as there are only 100 unbroken flakes in this material, any conclusions as to its use must remain tentative.

As shown in Table 4.20, primary, thinning, and late-stage flakes are the most numerous of the identifiable types. In Cuesta quartzite, these flake types have the following respective percentages: 19%, 13%, and 68%. This would again suggest an emphasis on refinement or formalization. However, this conclusion is at odds with the frequency of recovered biface types (see Flake-to-biface ratio, below). The small sample may weaken any conclusions that can be drawn as to the nature of knapping at this site.

Table 4.21: Flake Ratios at 28-BU-492				
Material	**Early Flakes**	**Late Flakes**	**E/L**	**L/E**
Argillaceous Shale	6	19	0.32	3.17
Argillite	2	7	0.29	3.50
Chert	5	88	0.06	17.60
Cuesta Quartzite	23	77	0.30	3.35
Jasper	13	360	0.04	27.69
Metasediment	2	2	1.00	1.00
Quartz	14	62	0.23	4.43
Total/Average	65	642	0.10	9.88
Percent	9.2	90.8		
Early Flakes: Early-Stage, Decortication, and Primary Flakes.				
Late Flakes: Thinning and Late-Stage Flakes.				

4.5.2.2) Flake-to-Biface Ratios: The overall flake-to-biface ratio is 49.39:1. The ratio for Cuesta quartzite is 210.33:1, the strongest for any material at this site (Table 4.22).

Table 4.22: Flake-to-Biface Ratios (28-BU-492)				
Material	**Flakes**	**Bifaces**	**F/B**	**B/F**
Argillaceous Shale	128	10	12.80	0.08
Argillite	70	17	4.12	0.24
Chert	138	7	19.71	0.05
Cuesta Quartzite	1,893	9	210.33	0.00
Jasper	605	7	86.43	0.01
Metasediment	17	2	8.50	0.12
Quartz	206	9	22.89	0.04
Rhyolite	5	1	5.00	0.20
Total	3,062	62	49.39	0.02

Except for Cuesta quartzite, and possibly jasper, the flake-to-biface ratios are very weak indicators of knapping behavior. If the small sample can be trusted, the ratios for most materials appear to represent the maintenance of existing equipment or the manufacture of flakes for expedient uses, such as general cutting and scraping.

Cuesta quartzite appears in only seven complete bifaces—all early-stage forms—and two fragments. The ratio of earlier- to later-stage flakes clearly indicates that some bifacial finishing occurred in this material. It is possible that some the finished specimens, which are no longer in evidence, were exported for use at other sites. The removal of finished bifaces by collectors introduces an uncontrollable sampling bias.

4.6) The Medford Park Site: 28-BU-466

Medford Park is located to the southwest of Medford Village, Burlington County, N.J. (Mounier 1998c; Figure 4.3). The park occupies a tract of undeveloped land, consisting of lowlands along the Southwest Branch of Rancocas Creek and the adjoining sandy uplands. Distributed along the stream are cobbles of Cuesta quartzite.

The prehistoric remains have a focused distribution at a single location within site 28-BU-466. The clustered nature of the finds indicates that the artifacts are contemporaneous and that they relate to a specific process of stone tool manufacture by knapping. The greatest proportion of the assemblage was composed of Cuesta quartzite.

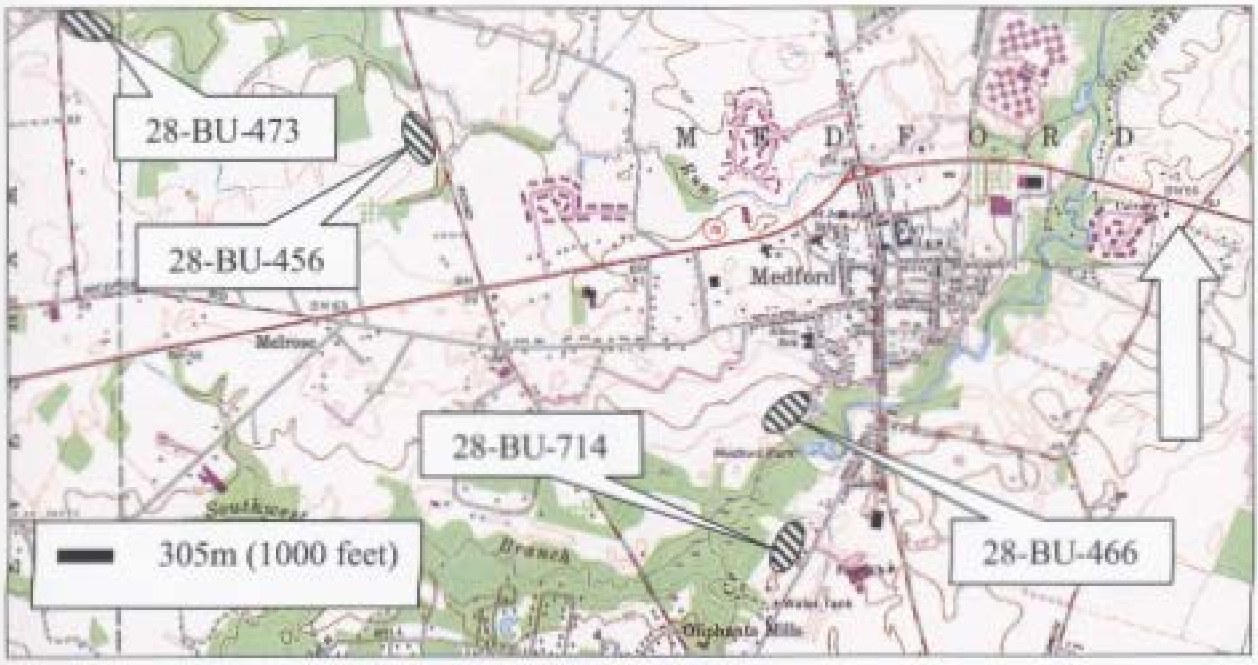


Figure 4.3: Map of Sites, Medford Vicinity

4.6.1) Cultural Remains

Over three thousand artifacts (comprising tools, broken or discarded bifaces, and flaking debris) were recovered from this activity area. These remains comprise over 98% of all the artifacts gathered from within the park during earlier archaeological surveys (Mounier 1996a). Table 4.23 enumerates the principal artifact types in Cuesta quartzite.

About two-thirds of all of the artifacts were excavated from a single large cluster, which represents an activity area, where Cuesta quartzite was knapped with considerable intensity. Since Cuesta quartzite dominated the assemblage, the discussion of other materials in any detail is not germane to the broader investigation.

The lithic remains recovered from Site 28-BU-466 comprise a very limited range of types, among which are bifaces, flakes, and cores. All of the Cuesta quartzite artifacts are the products of cobble reduction. Not counting flakes, the assemblage from the activity area is limited to a single faceted hammerstone, five cores (including complete biface cores), and an estimated total of 46 bifaces in various stages of completion. (The number of bifaces must be estimated, because an exact count cannot be derived from the fragments at hand for want of conjoining pieces.) The complete bifaces represent mostly intermediate levels of biface production, equivalent to Stages 2 and 3 in Callahan's (1979:10, 30-31, 1989:6) reduction scheme.

Table 4.23: Cuesta Quartzite Artifacts from 28-BU-466

Types		Qty	Percent of Type	Percent of Total
Bifaces	Early-Stage	68	84.0	2.2
	Middle-Stage	1	1.2	0.0
	Late-Stage	3	3.7	0.1
	Fragments	8	9.9	0.3
	Biface Cores	1	1.2	0.0
	Total	81	100.0	2.6
Flakes		3,047	100.0	97.3
Cores		4	100.0	0.1
Hammers		1	100.0	0.0
Total		3,133		100.0

Because of the concentration of finds at 28-BU-466 the remains are believed to reflect the work of only one knapper. The volume of artifacts is too slight to admit the possibility of many more knappers at this spot. The quantity of flakes is consistent with the results of our knapping experiments in which the production of a single biface yielded upwards of 3,000 flakes.

4.6.2) Artifact Analysis

The following paragraphs discuss the results of proportional flake analysis and flake-to-biface ratio analysis.

4.6.2.1) Proportional Flake Analysis: The ratio of later to earlier stages of flaking is 1.80:1. Given a flake population of 714 pieces, this index is as strong as one might hope, but it is consistent with other lines of evidence. While the biface assemblage contains 68 early-stage bifaces and one mid-stage biface, there are also three formalized specimens. Other specimens were doubtless removed for use elsewhere. Therefore, reduction to formalization did occur at this site.

Late-stage flakes comprise about 40% of the total when compared only to primary (33%) and thinning flakes (26.5%). This distribution shows a good balance between primary reduction and thinning, with a stronger emphasis on biface finishing.

4.6.2.2) Flake-to-Biface Ratios: The flake to biface ratio in Cuesta quartzite is 37.6:1. This ratio is low in comparison with experimental findings, but it lies at the median of the range for this index on all sites employed in this study.

Only three bifaces exhibit relatively refined flaking. The flakes themselves reveal a greater incidence of fine flaking than is expressed in bifaces alone. Two spherical bifacial cores suggest the intentional production of flakes, which would have been useful as small cutting tools.

The evidence further suggests that some of the bifaces were treated as cores, used to produce flakes blanks for small tools. These flake blanks were also heat-treated to facilitate reduction. A number of the primary flakes in the assemblage show post detachment heat-treating and initial flaking, evidently for small tool production.

4.7) The Riding Run Site: 28-BU-473

Site 28-BU-473 is located on the eastern side of Cox's Corner Road, about 915m (3,000 feet) south of the crossroads at Cox's Corner (Mounier 1992, 1995; Figure 4.3). Preliminary archaeological surveys in advance of residential construction identified this small site above the head of Sharps Run, a tributary of the Southwest Branch of Rancocas Creek. The soil is loamy sand, which is studded with cobbles and boulders of Cuesta quartzite. Despite its position at or above the head of the stream, much of the ground is perennially boggy. Only the highest elevations, which are expressed as minor topographic eminences, are reasonably well drained. The property had been used for many years as a livery and equestrian riding academy.

An initial survey revealed clusters flaking debris, resulting from the manufacture of stone tools, mostly from locally available cobbles of Cuesta quartzite (Mounier 1992). The artifacts occurred in three clusters, which occupied high spots on well drained ground. Archaeological testing (one-foot diameter shovel tests) indicated that the artifacts extended into the earth to a maximum depth of 20cm (8 inches). Except for trampling by horses these artifacts appeared to occupy undisturbed ground.

The excavation of 13 additional cuts, each either 0.76 x 1.5m or 1.5 meters square (2.5 x 5-foot trenches or five-foot squares), at various points around the property expanded upon the 1992 testing (Mounier 1995). Supplemental shovel tests were utilized as a means of refining excavation unit placement.

Prehistoric cultural material—almost entirely flaking debris—was observed on the surface of the ground and in exploratory excavations at the extreme eastern or southeastern end of the property. The observed distribution mirrored that noted during the 1992 investigation.

Archaeological remains here indicate early-stage lithic reduction, leading to the production of flake blanks and rudimentary bifacial tools. The refinement of blanks and tools, necessary to create formal implements, was apparently carried out at other sites. Excavations did not reveal complex prehistoric features, merely concentrations of flakes.

4.7.1) Cultural Remains

The 1995 survey yielded a total of 2,893 stone artifacts. Flakes, totaling 2,837 specimens, represent 98% of the assemblage. Nearly all of the flakes (97%) were made of Cuesta quartzite. The balance of the flakes occurs in quartz and in a variety of other materials (Table 4.24).

Fifty-six other artifacts were found. Of the nine bifaces recovered, six are early-stage specimens in Cuesta quartzite. There are 12 pieces of thermally-altered rock other than Cuesta quartzite, two cobble tools, seven cores, and two scrapers. The remainder of the assemblage consists of cobbles, pebbles, concretions, flake blanks, and so forth.

Table 4.24: Flakes by Type and Material (28-BU-473)

Material	DEC	PRI	THI	L/S	RF	FF	Total	%
Argillaceous Shale	0	0	1	0	1	0	2	0.1
Argillite	0	0	0	0	2	5	7	0.2
Chert	1	0	3	1	1	4	10	0.4
Cuesta Quartzite	0	46	10	7	2,407	281	2,751	97.3
Jasper	2	1	0	0	0	8	11	0.4
Metasediment	0	0	0	1	0	0	1	0.0
Quartz	1	2	4	3	8	19	37	1.3
Quartzite	0	0	0	0	0	2	2	0.1
Sandstone	2	0	0	0	0	0	2	0.1
Schist	0	0	0	0	2	3	5	0.2
Total	6	49	18	12	2,421	322	2,828	100.0

Flake Types: DEC = Decortication; PRI = Primary; THI = Thinning; L/S = Late-Stage; RF = Reduction Fragments; FF = Flake Fragments

4.7.2) Artifact Analysis

The following paragraphs discuss the results of proportional flake analysis and flake-to-biface ratio analysis.

4.7.2.1) Proportional Flake Analysis: The ratio of earlier to later flakes is 2.71:1, which suggests an emphasis on early-stage reduction. The relatively high proportions of primary flakes (73%), in relation to thinning flakes (16%), and late-stage flakes (11%) appears to be confirmatory. However, the flake sample is quite small (63 specimens).

4.7.2.2) Flake-to-Biface Ratios: The flake to biface ratio computes to 458.0:1, which is the highest index recorded for any archaeological site in this study. This ratio is well above the value experimentally associated with biface production from flake blanks, but less than that established by the same means for cobble reduction. All things considered, an early stage of biface knapping seems to characterize the work performed at this site.

4.8) The Northside School Site: 28-BU-456

Site 28-BU-456 was explored in connection with the construction of the Northside School (Mounier 2005;Figure 4.3). The property in question lies on the west side of Hartford Road approximately 2.4km (1.5 miles) northwest of Medford Village in Medford Township, Burlington County. Secondary woodlands occupy the field edges and nearby wetlands, but the site itself has been cleared of arboreal vegetation for centuries. The soils consist of loamy sand.

4.8.1) <u>Cultural Remains</u>

This site yielded a broad array of lithic materials, including Cuesta quartzite, which occurs in the vicinity. A total of 423 flakes occur in this material. Jasper, chert, and quartz, gathered from pebbles, were utilized strongly, as shown by an aggregate of 593 flakes, about evenly divided between these materials. Cryptocrystalline pebbles are not known to occur in great numbers on the site, but may have occurred locally. Argillite and argillaceous shale, both non-local stones, account for 98 and 87 flakes, respectively. The remainder of the flake assemblage consists of minor representations in other materials.

Considering the 45 identifiable, unbroken flakes of Cuesta quartzite from all excavated areas, the frequencies and proportions of flake types are: decortication flakes, 2 (4.4%), primary flakes (including flake blanks), 10 (22.2%), thinning flakes, 6 (13.3%), and late-stage flakes, 27 (60.0%). The ratio of earlier to later flakes computes to 0.36:1, and the inverse is 2.75:1 By this index alone, knapping would seem to have favored later stage reduction; however, the flake sample is too small to admit of convincing interpretation.

More bifaces (15) occur in Cuesta quartzite than in any other material on this site. Twelve are early-stage specimens and the remainder consists of fragments in various stages of formalization. While the early-stage forms might suggest an early stage of bifacial reduction, more formalized specimens may have been made but removed for use elsewhere.

The site also yielded four faceted hammers in Cuesta quartzite. These hammers occurred in association with bifaces and flaking debris in Cuesta quartzite, argillite, and argillaceous shale, as well as charred organic material.

4.8.2) Artifact Analysis

The following paragraphs discuss the results of proportional flake analysis and flake-to-biface ratio analysis.

4.8.2.1) Proportional Flake Analysis: The proportion of later to earlier stage flakes is 2.75:1, which would indicate a focus on biface refinement or rejuvenation. This ratio would seem to be inconsistent with the lack of formalized bifaces. However, finished bifaces may have been removed for use at other sites. In any case, the small size of the flake sample makes any conclusions tentative.

4.8.2.2) Flake-to-Biface Ratios: The flake to biface ratio is 28.2:1. This ratio is far smaller than would be expected on a site where relatively numerous early-stage bifaces suggest actual production from cobble cores. The presence of hammerstones gives added strength to the evidence of biface manufacture and maintenance at this site. However, this index cannot be regarded as definitive because of the small sample size.

4.8.2) <u>Radiocarbon Age</u>

A carbon sample yielded a measured radiocarbon age of 4470±50 B.P. See Chapter 2, Section 2.6.10 for additional details.

4.9) The Mill Street Site: 28-BU-714

The Mill Street site is located on the west side of Mill Street in the southern outskirts of Medford Village (Mounier 2003b; Figure 4.3). It occupies a terrace of deep sand along the Southwest Branch of Rancocas Creek adjacent to a small feeder stream. There is strong archaeological evidence of prehistoric occupation going back to Middle Archaic times. Excavations in 2003 were intended to recover artifacts and data from this site prior to its destruction for new residential construction. This account will focus on the prehistoric utilization of Cuesta quartzite.

4.9.1) Cultural Remains

Site 28-BU-714 contained a large number of artifacts and cultural features, which span the prehistoric and historic periods. Those pertaining to aboriginal occupations are discussed below. Table 4.26 enumerates the artifacts and organic remains.

Table 4.25: Archaeological Finds (28-BU-714)

Type	**Qty**
Bifaces	116
Cores	23
Axe	1
Celt	1
Cobble Tools	30
End-Tools	2
Unifacial Core Tools	5
Flakes	2,672
Ochre	30
Cobbles/Pebbles	7
Potsherds	3
Thermally Altered Rock	117
Fossils	3
Misc./Unidentified	12
Nut Shells	3
Animal Bones	2,891
Charcoal	1,198
Total	7,114

4.9.1.1) Artifacts: A typical range of aboriginal artifacts—including bifaces, cores, flakes, and cobble tools—was found. Out of a total of 116 bifaces, 52 were recovered in broken condition. Another 29 were early-stage specimens, and yet four more were in the mid-stage of production when lost or discarded. All of the 19 specimens in Cuesta quartzite were early-stage specimens, which account for 65.5% of all early-stage bifaces at this site (and 10.4% of all bifaces).

Sixty-eight bifaces exhibited production failures. The majority were early-stage forms in Cuesta quartzite, of which 12 exhibited the effects of heat-treating. A variety of cryptocrystalline materials, mostly derived from pebbles, was employed for tool-making. Twenty-seven specimens were recovered in various stages of production. These items included 14 in quartz, 7 in chert, and 6 in jasper. Four of the jasper specimens were heat-treated.

Of a total of 2,672 flakes, 243 (9.1%) occur in Cuesta quartzite. Argillaceous shale and argillite are the most common materials, being represented by 806 and 532 flakes, respectively. The rest of the flakes consists of various cryptocrystalline and metasedimentary materials.

Thirty cobble tools were found. Of these, two faceted flaking hammerstones were made of Cuesta quartzite, while the remaining specimens in this class were simple general purpose hammers of metaquartzite and sandstone.

Evidence of uniface tool production is reflected predominately in flake blanks and other flake types, and in cores. Fourteen flake blanks were recovered. The majority are primary flakes made at or carried to the site to serve as rough stock or as ready-made tools. Most specimens occurred in argillaceous materials (6) and Cuesta quartzite (6), with minor representation in jasper, quartz, and chert. Some of the flake tools derived from argillaceous materials may have been the byproducts of on-site biface processing. The use of pebble chert and quartz represents clear examples of expedient production from locally available materials. Most of these unifacial products were made on primary flakes. Over 50% of the Cuesta quartzite specimens exhibited worked edges.

4.9.1.2) Cultural Features: The excavations revealed several cultural features. Those that contained Cuesta quartzite are noted below. Feature 6, an oval patch of discolored, mottled sand, was first discovered at a depth of 43cm (17 inches) below the surface. The base of this feature formed a conical pit that extended 76cm (30 inches) into the subsoil. The soil colors ranged from 10YR 3/6 to 10YR 4/6 (on the Munsell charts) and occurred with gray and yellowish mottles. The feature contained abundant wood charcoal along with a few flakes of quartz, argillaceous shale, and Cuesta quartzite. Associated artifacts suggest a Lackawaxen component of Late Archaic/Early Woodland origin. The defining artifacts included an early-stage biface of Cuesta quartzite, a flake blank of siltstone (or argillite), and core rendered on a chert pebble.

Feature 17 was found at 63.5cm (25 inches) below the surface. It appeared as a small ovoid lens or bowl-shaped anomaly that measured 30 x 38cm (12 x 15 inches) and extended 89cm (35 inches) into the subsoil. The fill comprised a grayish brown (10YR 4/2-5/2) and yellowish brown to pale yellow-brown (10YR 5/6-7/8) mottled sand. In addition to charcoal, the feature contained a piece of calcined bone and a primary flake blank of Cuesta quartzite. The depth of this feature and association with surrounding deposits reflects another Late Archaic/Early Woodland episode.

Feature 18 had an oval configuration that measured approximately 76 x 107cm (30 x 42 inches) in plan and 30cm (12 inches) in depth (41-71cm or 16-28 inches below the surface). The fill was a mottled light grayish brown (10YR 5/2-6/2) and light yellowish brown (10YR 5/6-6/4) matrix with abundant charcoal and calcined bone. Two diagnostic bifaces—a Lackawaxen biface or Fishtail variant in argillite and a Susquehanna broadspear in argillaceous shale—were in the fill along with minor amounts of debitage in quartz, jasper, chert, argillite, and argillaceous shale. Other fragmented bifaces were also found in association. The distal and proximal portions of additional Lackawaxen contracting-stemmed types and early-stage biface fragments in Cuesta quartzite (broken in manufacture), along with several flake tools of argillaceous shale and jasper were also scattered around the feature. This feature is related to Terminal Archaic or Late Archaic/Early Woodland activities.

Feature 19 was initially found at a depth of 41cm (16 inches) below the surface. It appeared as an ovoid soil anomaly of mottled light gray to grayish brown (10YR 5/2-6/2) and light yellowish brown (10YR 5/6-6/4) sand rich with charcoal. It measured approximately 46 x 63.5cm (18 x 25 inches) and extended 23cm (nine inches) into the subsoil.

The fill contained charcoal, calcined bone, and a piece of ocher. Associated artifacts are similar to those in Feature 18 and include biface fragments and flake tools in argillaceous shale, flake tools in quartz and jasper, biface fragments in Cuesta quartzite, and mixed debitage in Cuesta quartzite, quartz, argillite, argillaceous shale, jasper, and chert. The similarity to Feature 18 suggests the same episode of use. These features were close to one another, being separated by just 76cm (2.5 feet).

A deposit of calcined bone was commingled with a variety of diagnostic bifaces and biface fragments. Early and Middle Archaic forms include Kirk, Stanly, Stark or Poplar Island types. Later Archaic types include Susquehanna broadspear variants, Lackawaxen, and other narrow-bladed, narrow-stemmed types. In addition, pebble-derived bifaces of cryptocrystalline materials, heat treated pebble cores, and uniface tools were also found in this feature and in surrounding parts of the site. Also, associated were simple cobble tool fragments, a faceted hammerstone in Cuesta quartzite, abraders in sandstone and limonite, processed ocher, and a mix of flaking debris in chert, jasper, quartz, argillite, argillaceous shale, Cuesta quartzite and Cohansey quartzite.

The margins of this feature revealed a similar range of cultural debris. Formal bifaces include Susquehanna and variant forms along with distal and proximal biface fragments, several showing evidence of impact fracture. Heat-treated Cuesta quartzite appeared in early- and mid-stage bifaces, abraders, and flake blanks. Processed ochre, cobble tools, and mixed debitage in chert, jasper, quartz, argillite, argillaceous shale, schist and Cuesta quartzite were also noted with some frequency. Both calcined bone and charcoal were also present as was evidence of nut residues in the form of organic stains.

4.9.2) Artifact Analysis:

The following paragraphs discuss the results of proportional flake analysis and flake-to-biface ratio analysis.

4.9.2.1) Proportional Flake Analysis: The ratio of later- to earlier-stage flakes in Cuesta quartzite calculates to 1.86:1. This ratio indicates a some early-stage reduction, with a slight emphasis on mid-stage production and formalization or tool repair.

Thinning flakes account for 48.3% of the flakes if considered only in relation to primary flakes (29.3%) and late-stage flakes (22.4%). However, all of the Cuesta quartzite bifaces from the site were early-stage specimens. This situation suggests that reduction of early-stage bifaces to more formalized forms may have occurred here, with the semi-finished and formalized pieces being removed for use elsewhere. It is also possible that the bifaces had been imported as cores for the production of flake tools. This interpretation is consistent with a relatively high percentage of thinning flakes, which would make sharp cutting tools.

4.9.2.2) Flake-to-Biface Ratios: The flake to biface ratio for Cuesta quartzite is 12.8:1. A ratio of this magnitude must be considered to be a weak indicator of knapping activity, particularly as it is based on a very small sample of flakes (243) and bifaces (19).

4.10) The Kings Grant Site: 28-BU-403

Site 28-BU-403 occupies the north-facing slope of a sandy peninsular terrace that overlooks extensive freshwater wetlands in the head of the Blacks Run, a tributary of

Rancocas Creek. The site lies in Evesham Township, about 8.9km (5.5 miles) south-southeast of the village of Medford (Mounier 1990b; Figure 4.4).

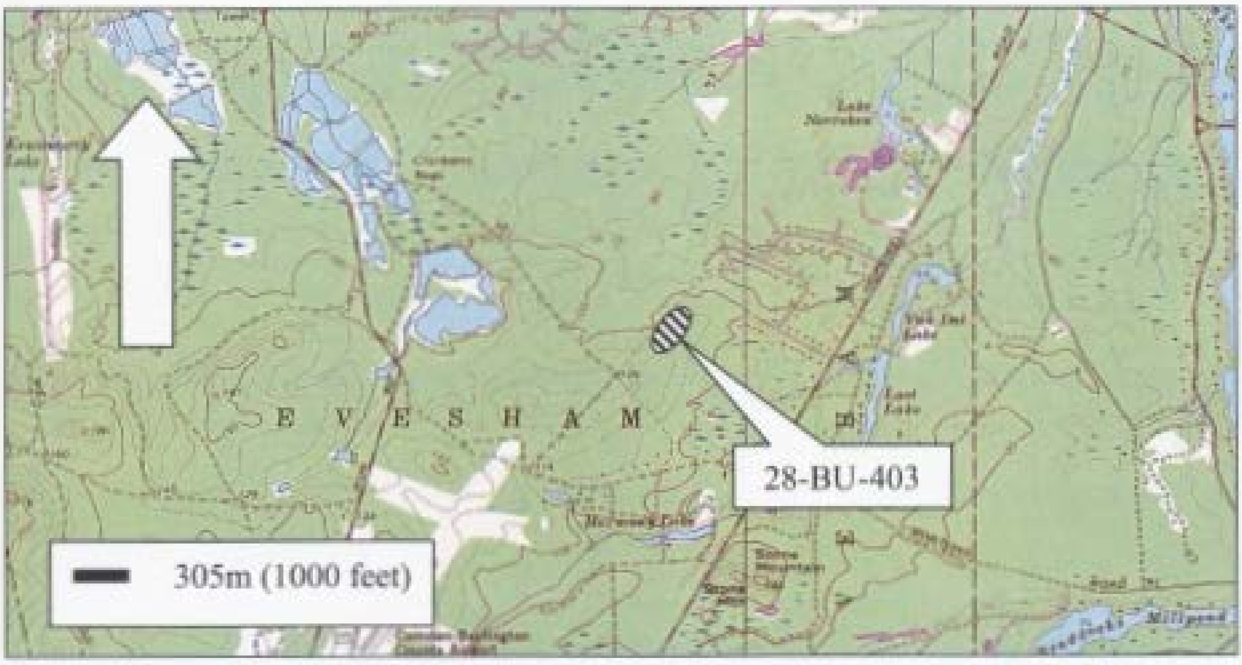


Figure 4.4: Map of Site 28-BU-403

Archaeological surveys—conducted at site 28-BU-403 in connection with the proposed Kings Grant, Phase II development—resulted in the discovery of prehistoric cultural remains, which consist of flaked stone implements, flaking debris, and thermally-altered rock, all in undisturbed contexts (Archaeological Interpretive Management 1989; Mounier 1990b). Mounier (1990b) explored the site in an excavation that covered about79m^2 (850 square feet, deployed over 34 complete or partial five-foot squares), beginning at the locations of previous finds. The units were arranged in three blocks, resulting from lateral expansion into previously unexcavated terrain according to the results of work in progress.

4.10.1) Cultural Remains

The excavations at 28-BU-403 revealed a limited variety of artifacts and features, which show specialized activities relating to the production of bifaces from Cuesta quartzite. Parts of the site exhibited a very tight clustering of flaking debris and early-stage bifaces. The form and concentration of artifacts indicate the reduction of Cuesta quartzite from cobbles to early-stage bifaces, with some formalization. Most of the reduction is equivalent to Stages 2 through 4 as defined by Callahan (1979:10, 30-31, 1989:6).

Since the archaeological record evinces at least some early sequences of cobble reduction on-site, the raw material appears to have been gathered locally, perhaps from outwash along the stream margins. However, the actual source of the material remains unknown.

Much of the cultural material shows evidence of purposeful thermal alteration or heat-treating as a prelude to reduction. Evidently, heating was employed repetitively at different stages in the process of cobble reduction. The frequent occurrence of reddened dorsal surfaces on the full range of flake types could only occur from repeated episodes of heating at various stages in the reduction sequence, as experiments show that discoloration is a surficial manifestation (see Chapter 6).

4.10.1.1) Artifacts: The finds at 28-BU-403 include bifaces, flakes, and a miscellany of other objects. The following pages enumerate the finds. The excavation yielded a total of 43 bifaces in a variety of materials (Table 4.26) as well as many flakes (Table 4.27) and a miscellany of other finds (Table 4.28).

The vast majority of bifaces occur in Cuesta quartzite, evidently from local production. Of interest is one specimen of argillaceous shale, which is a contracting-stemmed biface, resharpened virtually to exhaustion. Its shape is very similar to that of the formalized Cuesta quartzite biface from the same part of the site. These items most closely resemble the narrow, Morrow Mountain II type described by Joffre Coe (1964:34-37).

Table 4.26: Bifaces from 28-BU-403

Material	Early-Stage	Mid-Stage	Formalized	Fragment	Total	Percent
Cuesta Quartzite	15	1	1	24	41	95.3
Jasper	1	0	0	0	1	2.3
Argillaceous Shale	0	0	1	0	1	2.3
Total	16	1	2	24	43	100.0
Percent	37.2	2.3	4.7	55.8	100.0	

Flakes were the most numerous artifacts as shown in Table 4.27. Most flakes occur in Cuesta quartzite. The importation of exotic material was manifested in argillaceous shale. This material occurred on the site as primary flake blanks and as thinning flakes, which may have been retained for use as expedient tools. Only one diagnostic biface of argillaceous shale was recovered. Had such items been made on-site, more specimens might have been expected, along with debitage reflecting early stages of manufacture as well as rejuvenation.

Artifacts other than bifaces and debitage constitute a small fraction of the total assemblage. These items are listed by type and material in Table 4.28.

Table 4.27: Flakes by Type and Material (28-BU-403)

Material	Decortication	Primary	Thinning	Late-Stage	Miscellaneous	Fragments	Total	Percent
Cuesta Quartzite	63	664	544	648	3,081	280	5,280	97.47
Quartz	2	5	1	0	16	27	51	0.94
Chert	4	0	0	6	4	7	21	0.39
Jasper	1	0	0	0	1	5	7	0.13
Argillaceous Shale	0	6	5	0	15	0	26	0.48
Argillite	0	0	0	0	1	0	1	0.02
Ironstone	0	0	0	0	0	23	23	0.42
Sandstone	0	0	0	0	2	3	5	0.09
Quartzite	0	0	0	1	0	0	1	0.02
Hardyston Quartzite	0	0	0	1	1	0	2	0.04
Total	70	675	550	656	3,121	345	5,417	100.00
Percent	1.29	12.46	10.15	12.11	57.61	6.37	100.00	

Table 4.28: Miscellaneous Tools from 28-BU-403

Material	Abraders	Cores	Flake Tools	Hammerstones	Multi-Purpose Tools	Miscellaneous	Total	Percent
Cuesta Quartzite	0	2	0	0	0	0	2	9.5
Quartz	0	1	0	2	0	0	3	14.3
Chert	0	0	0	1	0	0	1	4.8
Jasper	0	1	1	0	0	0	2	9.5
Ironstone	3	0	0	0	1	7	11	52.4
Sandstone	0	0	0	0	1	0	1	4.8
Quartzite	0	0	0	1	0	0	1	4.8
Total	3	4	1	4	2	7	21	100.0
Percent	14.3	19.0	4.8	19.0	9.5	33.3	100.0	

4.10.1.2) Activity Areas: The finds at 28-BU-403 signify loci of prehistoric activity clearly delineated by the presence of lithic debris and artifacts. Two discrete clusters of Cuesta quartzite mark areas of intensive knapping, probably by individual knappers. The sizes of the work stations and the number of flakes produced preclude other interpretations.

The first concentration—which ranged from 15 to 69cm (6 to 27 inches) in depth—was oval in plan and bowl-shaped in profile. The horizontal dimensions were approximately 2.7 x 3.7m (9 x 12 feet). Primary and early-stage reduction debris was concentrated in the nucleus of this feature, surrounded by a scatter of thinning flakes and late-stage flake debris. Tools, flake blanks, and primary flakes occurred on the perimeter or lay within a few meters of the center of the pattern. This distribution suggests a drop- or toss-zone, commonly associated with aboriginal activity areas (see Binford 1980).

Another location showed a similar range of clustered flaking debris, which defined an elliptical station, measuring 2.7 x 5.5m (9 x 18 feet). The primary lithic constituent was Cuesta quartzite, which had a vertical dispersal that ranged between 15 and 61cm (6 and 24 inches) in depth. The lithic remains conformed to a bowl- or basin-shaped cross-section.

In the core of the first activity area was a concentration of charcoal intermixed with small fragments of silicified wood. No petrified wood was associated with the second flaking station. However, the occurrence of petrified wood was corroborated by previous investigators at this site (Anthony J. Bonfiglio, pers. comm.).

A few pieces of limonitic sandstone (so-called "ironstone") were observed at the first, but not at the second activity area. Although most of these specimens have highly weathered surfaces, which make functional interpretations difficult, some are suspected to have served as general purpose tools. Implied functions, partially based on earlier research (Mounier 1990a), include abrading, chopping, and grinding.

In addition, a few thermally-altered quartz pebbles were observed in very small clusters or as isolates. These artifacts frequently occur on archaeological sites, probably in testimony of some behavior involving thermal processing (possibly as an expedient to the manipulation of materials such as hides, wood, or bark). The preparation of foods or beverages is also possible. However, the target resources of such processing have eluded identification to date. The behavior is independent of the thermal processing of lithic raw material described above.

The archaeological data indicate a pattern of behavior focused upon processing of Cuesta quartzite, quite likely with a view to replenishing toolkits for use at other sites. The presence of associated tools, not directly connected with lithic reduction, indicates a small-scale exploitation of locally available animal and plant resources. The latter exploitation (utilizing stemmed bifaces, expedient flake tools, and abraders) may have been no greater than necessary to sustain the lithic processors during the performance of their duties.

Other than wood charcoal—the presumed by-product of the thermal-treatment of Cuesta quartzite—the only floral residues observed were carbonized nut shells. Faunal remains were not recovered. As already noted, the size and configuration of the associated lithic features suggest short-term occupation by very small groups, or even individuals. The rather tight spatial clustering of lithic debris, with substantial amounts of empty space intervening, supports the inference of intermittent visitation.

The research conducted at 28-BU-403 provides insights regarding the techniques of reduction as applied to Cuesta quartzite. Reduction on the scale evidenced at this site requires initial preparation of the quartzite with hammerstones, followed by extensive "soft-hammer" work to thin bifaces for subsequent utilization. Materials for soft hammers commonly used in modern replicative flintwork include soft stone, antler, wood, and horn. No evidence of flaking hammers was found at any investigated locus. The total absence of faceted stone hammers, commonly associated with the reduction of Cuesta quartzite and argillaceous materials, is problematical.

4.10.2) Artifact Analysis

The following paragraphs discuss the results of proportional flake analysis and flake-to-biface ratio analysis.

4.10.2.1) Proportional Flake Analysis: The earlier stages of Cuesta quartzite flaking—denoted by decortication and primary flakes—are represented by 727 specimens, while a combined total of 1,192 thinning and late-stage flakes reflect more refined, later stage knapping. Hence, the ratio of later- to earlier-stage flakes is 1.64:1. Considering the ample flake assemblage, this index gives a rather good measure of knapping practices at 28-BU-403.

Primary and late-stage flakes are about evenly divided, with percentages of 35.8% and 34.9% respectively, when tallied with regard to thinning flakes (29.3%). These percentages would suggest a well balanced spectrum of early-, mid-, and late-stage reduction in Cuesta quartzite at this site. This interpretation is consistent with the presence of bifaces that reflect the full range of reduction and refinement.

4.10.2.2) Flake-to-Biface Ratios: The ratio of flakes to bifaces in Cuesta quartzite is 128.8:1. To judge from experimental data, a ratio of this magnitude would suggest at least the production of bifaces from flake blanks, but the number of early-stage bifaces in relation to more highly finished items indicates an earlier stage of production from cobble cores as well.

4.10.3) Radiocarbon Age

Laboratory analysis yielded an age of 4240±70 B.P. for one charcoal sample and an age of 5980±70 B.P. for another. Pertinent details appear in Chapter 2, Section 2.6.8.

4.11) The Highbridge Site: 28-BU-226

Site 28-BU-226 occupies a series of sandy ridges on the divide between the Rancocas and Mullica Rivers in Medford Township, Burlington County, N.J. (Mounier 2000e; Figure 4.6). The site lies to the west of the existing Highbridge Lakes development on a series of low knolls and ridges. Data recovery excavations in advance of renewed residential construction were undertaken in the spring of 2000. The excavation covered $87m^2$ (937.5 $feet^2$).

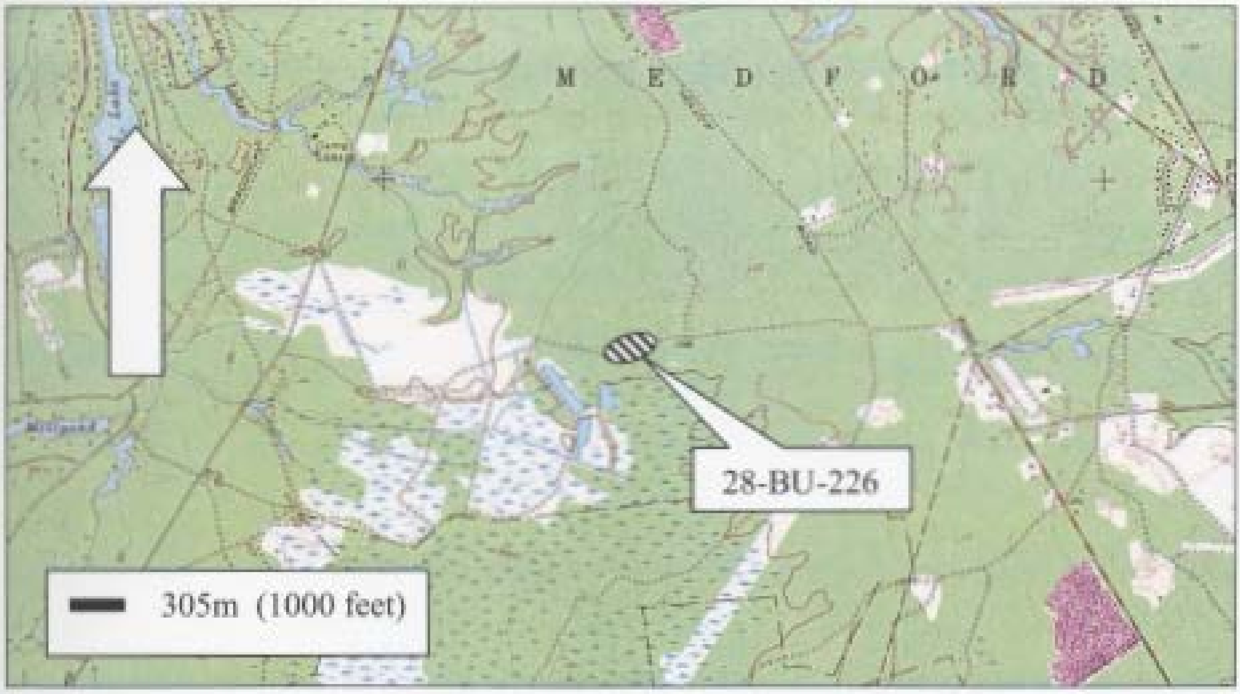


Figure 4.5: Map of Site 28-BU-226

4.11.1) Cultural Remains

The excavations revealed a total of 2,718 artifacts, mostly lithics in two primary components. The earliest is an expression of Early or Middle Archaic culture that is represented by bifurcate based bifaces in cryptocrystalline materials and argillite. For the most part, the later component contains contracting stemmed bifaces in argillaceous shale, characteristic of the Late Archaic/Early Woodland period. Table 4.29 summarizes the finds by general type.

Artifacts were distributed throughout the soil column to a maximum depth of 86cm (34 inches) below the surface. The excavated artifacts occurred at minimum depths of six inches (15cm), and had a mean depth of slightly less than 19 inches (48cm). For

Cuesta quartzite artifacts, the shallowest discoveries occurred at 12 inches (30cm) beneath the surface, the deepest at 24 inches (61cm), and the mean at 19 inches (48cm). Although holotypical "layer-cake" stratigraphy is lacking, the vertical distribution of artifacts reveals a general cultural stratigraphy in that the oldest artifacts appear most deeply in the soil column.

Table 4.29: Enumeration of Finds (28-BU-226)

Types	Qty	Per Cent
Bifaces	87	3.2%
Cobble Tools	52	1.9%
Cores	14	0.5%
Flakes	2023	74.4%
Microtools	2	0.1%
Ochre	4	0.1%
Pebbles	132	4.9%
Potsherds	155	5.7%
Scrapers	2	0.1%
Slabs	20	0.7%
Hearth Rock	214	7.9%
Unifaces	11	0.4%
Unidentified	2	0.1%
Total	2718	100.0%

Because relatively few Cuesta quartzite artifacts were recovered, a detailed account of the artifacts will not be presented. The site is principally important because it contains a Cuesta quartzite flaking hammer amidst bifaces and debitage in argillaceous materials.

Argillaceous shale appears in 23 bifaces and fragments. Argillite bifaces and fragments number 34 pieces. Argillite and argillaceous shale flakes, numbering 558 and

498 specimens respectively, comprise more than half of the 2,021 flakes recovered during the excavation.

This activity is also illustrated in the flake to tool ratios. The flake to tool ratio in argillaceous shale is 21.65:1 (498/23); the same ratio in argillite is 16.41:1 (558/34).

4.11.2) Artifact Analysis

The following paragraphs discuss the results of proportional flake analysis and flake-to-biface ratio analysis.

4.11.2.1) Proportional Flake Analysis: Because the site contained no debitage in Cuesta quartzite, analysis is only possible for other materials. The earlier stages of argillaceous shale reduction resulted in 14 primary flakes; the later stages yielded 95 thinning flakes and 134 late-stage flakes. Hence, the ratio of later to earlier flaking debris in argillaceous shale debris in argillaceous shale is 16.36:1.

The earlier stages of argillite knapping resulted in five decortication flakes and 12 primary flakes; the later stages yielded 75 thinning flakes and 73 late-stage flakes. Hence, the ratio of later to earlier flaking debris in argillite is 8.71:1. These ratios clearly indicate that repair and maintenance of bifaces was the principal knapping behavior in these materials at this site. This outcome is not surprising considering that both argillite and argillaceous shale must have been imported from distant sources.

4.11.2.2) Flake-to-Biface Ratios: The excavations recovered no bifaces. It could be argued that any bifaces that had been present were removed when the occupants left the site. Of course, sampling error cannot be ruled out. In any case, the absence of bifaces precludes the calculation of the ratio.

4.11.2) Radiocarbon Age

A carbon sample returned an age assessment of 4010±60 B.P. Pertinent details appear in Chapter 2, Section 2.6.7.

4.12) Summary

This chapter has reviewed the archaeological occurrences of Cuesta quartzite at 11 sites in Burlington County. Many of these sites reside at or near geological deposits of Cuesta quartzite. For others, the geological sources remain unknown. The production of early-stage bifaces and the refinement or rejuvenation of formalized specimens are common attributes, as is the association of Cuesta quartzite hammerstones with bifaces in argillaceous materials. In all cases, the character of the debitage gives important clues to the nature of knapping that transpired at these locations. These sites complement those found elsewhere as reported in the following chapter.

Chapter 5: Sites in Gloucester and Other Counties

This chapter deals mostly with excavations at quartzite-yielding sites in Gloucester County, but brief reference will also be made to stations in Camden and Monmouth Counties. Sites that contain less than 30% Cuesta quartzite (in relation to the overall lithic assemblage) will be discussed in summary fashion; those with greater representations will be treated in more detail. Sites that lie near geological sources of Cuesta quartzite often, but not always, reveal relatively strong archaeological traces of its use. Several of the productive sites lie close to one another and to one or more sources of quartzite cobbles.

Among the Gloucester County sites are five clustered stations, which lie within the tidal reaches of Raccoon Creek in Logan Township, Gloucester County. This suite includes the following sites: 28-GL-30, 28-GL-31, 28-GL-32, 28-GL-33, and 28-GL-45. Two other sites in Gloucester County—28-GL-383 and -344—occupy headwater settings in the Raccoon Creek basin, several kilometers upstream of the tidewater sites. These sites provide interesting points of comparison and contrast. The investigation of these sites follows from decades of intermittent research undertaken in the noted localities in connection with bureaucratically mandated surveys. We will begin with the tidewater suite and move on to the headwater sites in succession. Finally, the sites in Camden and Monmouth Counties will be briefly considered. Figure 5.1 shows the general locations.

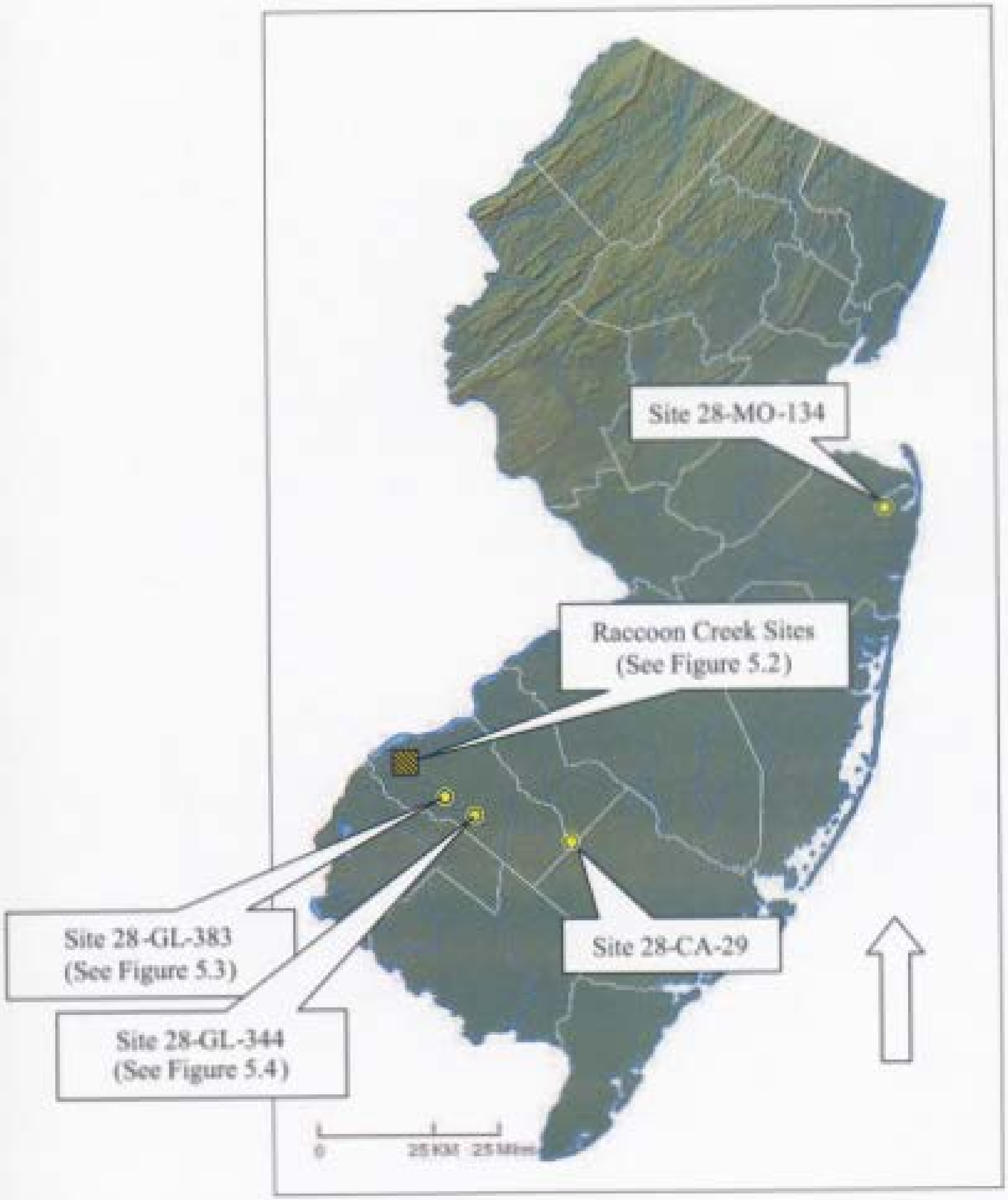


Figure 5.1: Archaeological Sites in Gloucester and Other Counties

5.1) Site 28-GL-30

Site 28-GL-30 is located in Logan Township, Gloucester County, N.J. on the east side of Raccoon Creek, about 5.2km (3.2 miles) in a straight line upstream from its confluence with the Delaware River (Mounier 1975a, 1998a; Figure 5.2). Prehistoric artifacts are scattered over an area of approximately 3.2 hectares (eight acres), but mostly they occur in concentrations along the waterfront.

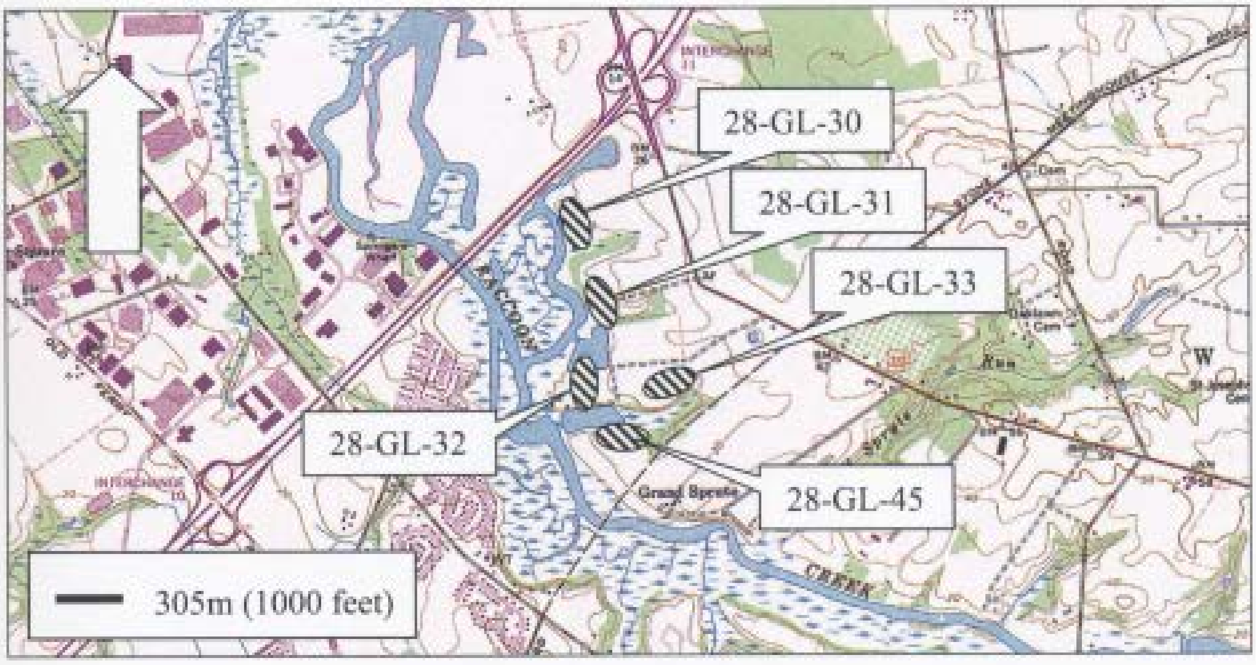


Figure 5.2: Map of Raccoon Creek Sites

Altogether, the excavations covered 74.3 m^2 (800 square feet). These excavations have shown that the prehistoric materials from Site 28-GL-30 comprise a general zone of occupation, into which elements of Anglo-American settlement were later implanted. Evidence of prehistoric occupation is manifested by artifacts and features that are widely distributed along the edges of wetlands and in the field and woods. Over the years, numerous prehistoric artifacts have been found on the surface, when part of the site was under active tillage. Typical artifacts include bifaces, flakes, flaked and rough stone tools, pottery, and thermally-altered rocks. Aboriginal features consisted of artifact clusters and pits, which are associated with zones of relatively intensive settlement or activity areas.

Testing has demonstrated that the majority of remains survive below ground in undisturbed subsoil or in features. About 53% of all prehistoric finds were retrieved from the subsoil or from features, the balance occurring in the plowzone.

5.1.1) Cultural Remains

The prehistoric materials indicate occupation over a long period of time. The latest artifacts relate to the Middle Woodland and Late Woodland periods (ca. A.D. 350 - 1600). Representative artifacts include one Jack's Reef biface and cross-cord marked ceramics; a Fox Creek biface, related flakes, and ceramics; triangular bifaces and fabric-impressed pottery; also, a range of lithic debris and a miscellany of aboriginal ceramics. The contents of the site at and beneath the level of plowing also include artifacts of Early Woodland and Late Archaic origin (3000-1000 B.C.). These artifacts include a variety of stemmed and notched bifaces, and rough, heavily-tempered pottery. As usual, there is a certain amount of undiagnostic cultural material, such as fire-broken rock and general-purpose tools, whose cultural-temporal associations remain problematical.

Cuesta quartzite is not especially well represented in the lithic assemblage from Site 28-GL-30, comprising only about 3% of the flakes, and less than 5% of the bifaces.

Three early-stage bifaces, one biface core, one stemmed point, and two biface fragments occur in Cuesta quartzite, which is also represented by a total of 55 flakes. Two faceted hammers of Cuesta quartzite are among the cobble tools from this site. The sparse representation of Cuesta quartzite is informative, given the presence of an aboriginally exploited source for this material about 900m (3,000 feet) distant, at nearby site 28-GL-33. The presence is important as a point of comparison with the exploitation of Cuesta quartzite at 28-GL-33 and other nearby sites.

5.1.2) Artifact Analysis

The following paragraphs discuss the results of proportional flake analysis and flake-to-biface ratio analysis.

5.1.2.1) Proportional Flake Analysis: The ratio of earlier to later flakes for Cuesta quartzite calculates to 2.08:1. The percentages of primary (65.8%), thinning (23.7%), and late-stage flakes (10.5%) also show a preponderance of early-stage flaking. Ordinarily, these measures would suggest an emphasis on early-stage reduction. However, the production of early-stage bifaces would not be expected at sites that occur at appreciable distances from a cobble source as in the present case. It seems more likely that early-stage bifaces were employed as cores for the generation of flakes. Note, however, that the total count for unbroken flakes Cuesta quartzite amounts to only 40 specimens, and the results must be viewed with caution.

5.1.2.2) Flake-to-Biface Ratio Analysis: The average flake-to-biface ratio in all materials at 28-GL-30 is about 11:1. The flake-to-biface ratio for argillaceous shale is 35:1. This proportion is higher than ordinarily expected and may reflect some bifacial knapping of this material or the importation of large flakes as tool blanks. Metasediments have a ratio of approximately 23:1, possibly reflecting the production of ground stone tools whose incipient forms are fashioned by rough preliminary flaking. The ratio for argillite is about 9:1; for cryptocrystalline materials (chert, jasper, and quartz) it is about 9:1; and for ordinary quartzite it is 20.2:1. The same ratio in Cuesta quartzite is 7.9:1.

Based on knapping experiments, ratios of this magnitude are indicative of tool maintenance or the manufacture of flakes for expedient uses, such as general cutting and scraping (Jack Cresson, pers. comm.). The full range of biface manufacturing is not indicated. If the production of formal artifacts here were a major task, the flake-to-tool ratios would have been substantially higher. Taking into account the innumerable bifaces previously removed by farmers and collectors, the actual flake-to-biface ratio in ancient times would have been much less than presently calculated, because bifaces were removed differentially. The repair or refinement of imported bifaces remains a plausible explanation.

5.2) Site 28-GL-31

Site 28-GL-31 is located along the east bank of Raccoon Creek, about 305m (1,000 feet) upstream from Site 28-GL-30 (Mounier 1975a, 1997a; Figure 5.2). This site is located between two tidal sloughs that drain to Raccoon Creek.

5.2.1) Cultural Remains

Evidence of prehistoric occupation is manifested by artifacts and features that are widely distributed across the site. As determined by testing, about 56% of all finds were retrieved from the subsoil or features, the balance occurring in the plowzone.

Over the years, numerous prehistoric artifacts have been found on the surface, when part of the site was under active tillage. Typical artifacts include flakes, flaked and rough stone tools, pottery, and thermally-altered rocks. Seven aboriginal features consisted of artifact clusters and soil anomalies. Noteworthy are two large pits and a buried occupational floor of considerable size. However, none of the features contained artifacts of or relating to the manipulation of Cuesta quartzite; consequently, no detailed accounting of features will be presented.

Material expressions of varied cultures are present. The latest artifacts relate to the Middle Woodland and Late Woodland periods (ca. A.D. 350 - 1600). Representative artifacts include Jack's Reef bifaces and cross-cord marked ceramics; a Fox Creek biface and related flakes; two triangular bifaces and fabric-impressed pottery; also, a range of lithic debris. The contents of the site at and beneath the level of plowing also include artifacts of Early Woodland and Late Archaic origin (3000-1000 B.C.). These artifacts include a variety of stemmed and notched bifaces, and rough, heavily-tempered pottery. As usual, there is a certain amount of undiagnostic cultural material, such as fire-broken rock and general-purpose tools, whose cultural-temporal associations remain problematical. Altogether, the excavations covered 80.1 m^2 (862.5 square feet).

Cuesta quartzite is not well represented in the lithic assemblage from Site 28-GL-31, comprising only slightly more than 5% of the flakes, and less than 4% of the bifaces. Two early-stage bifaces and one specimen each of contracting-stemmed and side-notched bifaces occur in Cuesta quartzite, which is also represented by a total of only 51 flakes. Only one core fragment of Cuesta quartzite appears at this site. This sparse representation—consistent with that at 28-GL-30—is of particular interest considering the existence of a cobble field not more than 600m (2000 feet) away at site 28-GL-33.

5.2.2) Artifact Analysis

The following paragraphs discuss the results of proportional flake analysis and flake-to-biface ratio analysis.

5.2.2.1) Proportional Flake Analysis: The calculated ratios of flake types indicate that the manufacture of bifaces or other formal tools was not a major activity here. The ratio of earlier- to later-stage flakes in Cuesta quartzite is 2.10:1. In the presence of early-stage bifaces, this index would suggest that early-stage bifaces were employed as cores for the generation of flakes for subsequent tool use, an interpretation that would accord with the relatively high number of primary flakes at a distance from a known geological source. However, the total count for unbroken flakes in Cuesta quartzite only amounts to 31 specimens, and the results must be considered to be tentative because of the small sample size.

5.2.2.2) <u>Flake-to-Biface Ratio Analysis</u>: The average flake-to-biface ratio in all materials is about 9:1. The ratio for argillaceous materials (argillite and argillaceous shale) is 6:1; for cryptocrystalline materials (chalcedony, chert, jasper, and quartz) it is 10:1; and for metamorphosed sediments (quartzite and metasediment) it is approximately 13:1. The ratio of flakes to bifaces in Cuesta quartzite is 12.75:1.

Ratios of this magnitude appear to represent the maintenance of existing equipment or the final refinement of bifaces. Given the nature of bifaces in Cuesta quartzite at this site—both early-stage and formalized specimens are in evidence—either interpretation would be plausible; however, the ratios of flake types would seem to accentuate the earlier rather than later stages of knapping.

5.3) Site 28-GL-32

Site 28-GL-32 is located along the east bank of Raccoon Creek, about 560m (1000 feet) upstream of site 28-GL-31 (Mounier 1975a, 2000a; Figure 5.2). Extensive excavations, covering 95.2 m^2 (1,025 square feet), have shown that the prehistoric materials from this site are all part of one general zone of occupation, into which elements of Anglo-American settlement were later implanted.

5.3.1) Cultural Remains

Evidence of prehistoric occupation is manifested by artifacts and features that are widely distributed in the farmyard. Over the years, numerous prehistoric artifacts have been found by the previous owner, on the surface of nearby fields and in the farmyard when the ground was opened for various construction projects. Typical artifacts include flakes, flaked and rough stone tools, pottery, and thermally-altered rocks. Aboriginal features revealed in the present research consisted of artifact clusters and soil anomalies.

Testing has demonstrated that the majority of remains survive below ground in undisturbed subsoil or in features. About 66% of all finds were retrieved from the subsoil or features, the balance mostly occurring in the plowzone. Only 26 specimens occurred as surface finds.

The prehistoric materials indicate occupation over a long period of time. The latest artifacts relate to the Middle Woodland and Late Woodland periods (ca. A.D. 350 - 1600). Representative late prehistoric artifacts include cross-cord marked and fabric-impressed ceramics. The site also contains artifacts of Early Woodland and Late Archaic origin (3000-1000 B.C.). These artifacts include a variety of stemmed and notched bifaces, and rough, heavily-tempered pottery. Of particular interest is the discovery of several triangular bifaces of Archaic age. Two notched bifaces indicate occupations during Early Archaic times. As usual, there is a certain amount of undiagnostic cultural material, such as fire-broken rock and general-purpose tools, whose cultural-temporal associations remain problematical.

Cuesta quartzite accounts for a relatively small percentage of the total lithic artifacts. Fifty-seven flakes of this material represent less than one percent of all debitage; two early-stage bifaces represent only one percent of the bifacial artifacts. Likewise, one cobble tool (a rough bifacial chopper) and two pieces of thermally altered rock account for minor fractions of their respective totals.

Several prehistoric features and activity areas were found. The features include pits and artifact clusters, which are associated with zones of relatively intensive settlement or activity areas. Since none of the features contained Cuesta quartzite they will not be detailed in the following presentation.

5.3.2) Artifact Analysis

The following paragraphs discuss the results of proportional flake analysis and flake-to-biface ratio analysis.

5.3.2.1) Proportional Flake Analysis: In Cuesta quartzite the ratio of later to earlier flakes is 1.19:1, indicating a non-decisive majority of later-stage flakes. The distribution of flake types at 28-GL-32—not located near a known cobble bed—probably reflects the maintenance of tools and weapons. The proportion of late-stage flakes may denote the trimming or resharpening of unfinished bifaces during their use. As there are only 35 Cuesta quartzite flakes other than fragments, the sample can support only tentative interpretations. However, intensive knapping in Cuesta quartzite is not indicated.

5.3.2.2) Flake-to-Biface Ratio Analysis: The average flake-to-biface ratio in all materials is 33.4:1. For argillaceous and cryptocrystalline materials this index ranges from 19.9:1 to 51.4:1. The ratio for Cuesta quartzite at this site is 28.5:1. As with other sites, these rather weak ratios do not suggest the production of formalized bifaces; rather the manufacture of flakes for expedient tooling or the maintenance of equipment can be inferred. With very small samples of bifaces (2) and flakes (57, including fragments), no further interpretations are warranted.

5.4) Site 28-GL-33

Site 28-GL-33 occupies the northern bank of a small tributary stream, about 490m (1,600 feet) east of its confluence with Raccoon Creek at site 28-GL-32 (Mounier 1975a, 1997b; Figure 5.2).

Evidence of prehistoric occupation is manifested by artifacts and features. Over the years, numerous prehistoric artifacts have been found on the surface, when part of the site was under active tillage. Testing has demonstrated that remains survive below ground in undisturbed subsoil as well as on the surface.

The prehistoric materials include a range of artifacts and features that indicate intensive occupation over a long period of time. The latest artifacts relate to the Middle and Late Woodland periods (ca. A.D. 500 - 1600). Representative artifacts include triangular bifaces (projectile points) and along with cross-cord marked and fabric-impressed ceramics; also, a range of lithic debris. The contents of the site at and beneath the level of plowing also include artifacts of Early Woodland, and Late Archaic origin (3000-1000 B.C.). These artifacts include a variety of stemmed and notched bifaces, and rough, heavily-tempered pottery. As is often the case, undiagnostic cultural material, such as fire-broken rock and general-purpose tools are common.

The total area excavated covers 263 m^2 (862.5 square feet). Archaeological investigations demonstrate the survival of substantial archaeological remains in undisturbed subsoil as well as on the surface of the ground. The estimated size of the site is approximately 0.91 hectares (2¼-acres).

5.4.1) Cultural Remains

The collection contains 4,139 items (Table 5.1). In all, 1,726 artifacts (41%) were recovered from disturbed contexts, while 2,444 specimens (59% of the total) occurred in undisturbed subsoil. Features yielded 152 items (4%).

Table 5.1: Artifact Summary by Types (28-GL-33)

Types	Plowzone	Subsoil	Qty	Percent
Bifaces	38	82	120	2.9
Cores	20	65	85	2.1
Unifaces	7	11	18	0.4
Flakes	921	1,689	2,610	63.1
Cobble Tools	6	39	45	1.1
Hearth Rock	8	985	993	24.0
Pottery	148	62	210	5.1
Miscellaneous	21	37	58	1.4
Total	1169	2,970	4,139	100.0
Percent	28.2	71.8	100.0	

5.4.1.1) Artifacts: The prehistoric items include flakes and other knapping residues, fire-broken or thermally-altered rocks, potsherds, flaked stone tools and weapons, and miscellaneous pieces. Cuesta quartzite is represented by 17 bifaces, all in an early stage of reduction. Flakes of this material are much more common (Table 5.2).

Table 5.2: Flakes by Type and Material (28-GL-33)

Material	DEC	PRI	THI	L/S	FF	RF	MISC	Total	Percent
Argillaceous Shale	0	19	14	8	56	2	0	99	3.8
Argillite	0	46	21	25	134	12	0	238	9.1
Chalcedony	1	7	2	6	24	2	0	42	1.6
Chert	20	15	7	15	57	38	2	154	5.9
Jasper	18	29	22	34	68	12	2	185	7.1
Quartz	18	43	17	26	189	154	1	448	17.2
Quartzite	19	25	1	3	36	24	0	108	4.1
Cuesta Quartzite	0	100	106	264	678	51	2	1,201	46.0
Sandstone	1	0	0	0	5	5	0	11	0.4
Metasediment	5	5	1	1	60	27	2	101	3.9
Miscellaneous	0	5	0	0	9	9	0	23	0.9
Total	82	294	191	382	1,316	336	9	2,610	100.0
Percent	3.1	11.3	7.3	14.6	50.4	12.9	0.3	100.0	

PRI = Primary; THI = Thinning; L/S = Late-Stage; FF = Flake Fragments;
RF = Reduction Fragments; MISC = Miscellaneous.

The preponderance of Cuesta quartzite debitage at this site correlates with the existence of a cobble field in the wooded portion of this site.

One hundred-twenty bifaces account for 51% of the flaked stone items, exclusive of flakes. The distribution of bifaces from all levels is shown in **Table 5.3**.

Table 5.3: Biface Types by Material (28-GL-33)

Material	Early-Stage	Contracting Stemmed	Plain Stemmed	Side-Notched	Teardrop	Fishtail	Triangular	Misc.	Fragments	Total	Percent
Argillaceous Shale	5	1	0	1	0	0	0	0	6	13	10.8
Argillite	6	8	4	1	0	1	0	2	6	28	23.3
Chalcedony	0	0	0	1	0	0	0	0	1	2	1.7
Chert	1	0	0	0	0	0	6	1	0	8	6.7
Jasper	1	0	0	1	1	0	2	0	1	6	5.0
Quartz	9	1	0	0	1	0	1	2	4	18	15.0
Quartzite	5	0	0	0	3	0	0	0	1	9	7.5
Cohansey Quartzite	0	0	0	0	0	1	2	0	0	3	2.5
Cuesta quartzite	17	0	0	0	0	0	0	0	9	26	21.7
Metasediment	6	0	0	0	0	0	0	0	1	7	5.8
Total	50	10	4	4	5	2	11	5	29	120	100
Percent	41.7	8.3	3.3	3.3	4.2	1.7	9.2	4.2	24.2	100	

Twenty-six of the bifaces (22% of the biface total) are of Late Archaic or Early Woodland typology, including plain-stemmed, contracting-stemmed, side-notched, Teardrop, Fishtail, and triangular forms. There are five complete Teardrop bifaces and 11 fragments. Triangular bifaces relating to the Late Woodland period number ten specimens, representing 8% of the total. One triangular biface is of Archaic origin (0.83%). Twenty-nine (29) biface fragments comprise a variety of forms that cannot be identified as to age, culture, or chronology. These specimens account for 24% of all the bifaces in the present assemblage.

Table 5.4 depicts the distribution of cores by types and materials. Eighteen unifacially prepared tools were recovered, all but one in cryptocrystalline materials: chert, jasper, quartz-schist, and quartz. One specimen was rendered in quartzite. True to form, no unifaces appear in Cuesta quartzite.

Forty-five cobble tools and fragments were found. These items include a range of rough-service tools, such as choppers and hammerstones. Materials represented include quartzite (19 specimens, 42%), sandstone (17 specimens, 38%), metasediment (6 specimens, 13%), and quartz-schist (1 specimen, 2%).

Table 5.4: Cores by Material (28-GL-33)

Material	Non-Pebble Cores	Pebble Cores	Bipolar	Biface	Misc.	Fragments	Total	Percent
Chalcedony	0	1	0	0	0	2	3	3.5
Chert	10	2	5	0	3	4	24	28.2
Jasper	10	6	1	1	2	5	25	29.4
Quartz	6	2	5	0	1	9	23	27.1
Quartzite	5	0	1	1	0	2	9	10.6
Cuesta Quartzite	0	0	0	0	0	1	1	1.2
Total	31	11	12	2	6	23	85	100.0
Percent	36.5	12.9	14.1	2.4	7.1	27.1	100.0	

Fire-broken rocks, numbering 993 specimens, were the most frequently encountered class of artifacts. These rocks, believed to derive from hearths or other features in which open fires were employed, consist of cobbles of sandstone, quartzite, quartz, and other materials whose fragments show angular corners, fissures or discoloration (usually reddening) from exposure to fire. These rocks occurred singly, in scatters, and in discrete concentrations, which apparently mark the locations of their use. The frequency distribution of thermally-altered rocks is illustrated in Table 5.5.

Table 5.5: Thermally-Altered Rocks (28-GL-33)

Material	Total	Percent
Cuesta quartzite	5	0.5
Quartzite	218	22.0
Quartz	263	26.5
Ironstone (Limonite)	29	2.9
Sandstone	476	47.9
Miscellaneous	2	0.2
Total	993	100.0

Finally, the lithic inventory contains 58 miscellaneous items. This category contains one axe fragment of metasediment; one axe blank of argillaceous shale; one slate ornament fragment; 11 flake tools (one each in hornfels and metasediment, two in jasper, three in quartzite, and four in quartz); six fragments of one or more metasediment slabs; four tool fragments (one each in argillite, chert, metasediment, and schist); four unidentified pieces in hornfels; eight mica books; one piece of petrified wood; one spherical quartz pebble; and, twenty other unmodified pebbles or cobbles. The last four entries are natural items, probably brought to the site by humans. Fragmentary containers are represented by 210 ceramic sherds which display a variety of tempering materials and surface treatments.

5.4.1.2) Cultural Features: In addition to individual artifacts and other specimens, six cultural features were revealed by excavation. These features included soil anomalies and concentrations or clusters of diagnostic artifacts, tools, and debitage. Five features were revealed in the 1997 investigation, the sixth having been found in the 1974 survey (Mounier 1975a). Features 1through 4 were basin- or lens-shaped soil anomalies with associated artifact concentrations. Only those containing Cuesta quartzite are described below.

Feature 1 was a lens-shaped deposit, extending from 123 to 38cm (5-15 inches) below the surface. It appeared to be a roughly circular shallow basin or floor, between 0.91 and 1.2m (three and four feet) in diameter. The soil matrix was mottled sandy loam of dark gray or gray brown color (10YR 3/3-3/4). It contained a mix of pebble-derived cryptocrystalline and Cuesta quartzite debitage, an expedient cobble tool (hammerstone-anvil), one sherd of Riggins Fabric-Impressed ceramics, thermally altered rock, and charcoal. A sample of carbonized wood was collected. Based on the ring and cell structure the parent material is judged to have been some type of hardwood.

Feature 2 occurred as an oval soil anomaly, measuring 61 x 91cm (24 x 36 inches). It was lenticular in section. First observed at the base of the plowzone (25cm [10 inches]), this features extended to 41cm (16 inches) below the surface. The fill was a mottled, dark yellow brown sandy loam (10YR 4/6) with gravel. The artifacts include unusual gravel- and mica- tempered, coarse textile (net?) marked ceramics, Cuesta quartzite lithic processing debris, mica books, an expedient cobble hammer, slab tools, carbonized nut remains, a piece of calcined bone, as well as thermally-altered rocks.

Feature 4 appeared as a deep, basin shaped soil anomaly, extending from 23 to 58cm (9-23 inches) below the surface. The overall configuration was probably oval to circular, but because of incomplete excavation, the dimensions in plan remain unknown. The fill was a mottled, brownish red to yellow sandy loam (10YR 7.5 and 5YR 4/6). In the fill were found sherds of thick, coarse textile-impressed pottery, tempered with grit and grog; also, mid- to late-stage debitage in quartz, chert, jasper, Cuesta quartzite, and argillite, and thermally-altered rocks. No charcoal was present. This feature also occurred within a larger activity area (covering 6.1 x 9.1m, or 20 x 30 feet) that yielded Late Archaic or Transitional bifaces in argillite and Cuesta quartzite, flake tools and blanks in argillaceous stone, expedient flake tools, bipolar cores and processing debris, slab tools, general- and special-purpose cobble tools, and thermally-altered rocks.

Feature 5 was a small concentration of charcoal, from 30 to 38cm (12-15 inches) below the surface, and approximately 15cm (6 inches) in diameter. It occurred within a larger activity area, which covered about 91 m2 (750 square feet). Artifacts in association include bifaces in Cuesta quartzite and argillaceous shale, biface processing debris in Cuesta quartzite, bipolar pebble debitage, expedient cobble and pebble tools, and thermally-altered rocks. A sample of wood charcoal of large, platy fragments was obtained for radiocarbon age analysis by the Beta Analytic Laboratory in Miami, Florida.

The sample has an assessed age of 1890±60 B.P. See Chapter 2, Section 2.6.3 for more details.

Features 1 and 6 relate to the late prehistoric activities on the site. The incorporation of debitage of Cuesta quartzite may have been adventitious, but proximity to a source also suggests intentional exploitation. Late prehistoric knappers clearly had the capability to work orthoquartzites as is shown by the abundance of Cohansey quartzite in Late Woodland sites across the region. Cohansey quartzite may have been preferred because of its knappability (Jack Cresson, pers. comm.).

Features 2, 3, 4, and 5 reflect the earlier Late Archaic/Early Woodland occupations. The three activity areas revealed use related to Late Archaic/Early Woodland tool production, equipment maintenance, and plant processing. The use of Cuesta quartzite in this period of time is consistent with evidence from other parts of the coastal plains.

5.4.2) Artifact Analysis

The following paragraphs discuss the results of proportional flake analysis and flake-to-biface ratio analysis.

5.4.2.1) Proportional Flake Analysis: The calculated ratios from the present assemblage generally indicate that the manufacture of finished bifaces or other formal tools in most materials did not occur as a primary function at Site 28-GL-33. Table 5.6 shows the frequency distributions and ratios of later-stage to earlier-stage flakes.

Table 5.6: Frequency and Ratio of Flake Types (28-GL-33)				
Material	**Early Stage** 1	**Late Stage** 2	**Ratio E/L**	**Ratio L/E**
Argillaceous 3	65	68	0.96: 1	1.04:1
Cryptocrystalline 4	151	129	1.12: 1	0.85:1
Quartzite	44	4	11.0: 1	0.09:1
Cuesta quartzite	100	370	0.27:1	3.70:1

[1] Combines Decortication and Primary Flakes
[2] Combines Thinning and Shaping Flakes
[3] Argillite and Argillaceous Shale
[4] Chalcedony, Chert, Jasper, and Quartz

For Cuesta quartzite, the ratio of later- to earlier- flakes is 3.70:1, which would seem to be at variance with the presence of several early-stage bifaces at a natural deposit of this material. In other words, a greater proportion of earlier-stage flakes might have been expected as a consequence of preliminary processing.

Nevertheless, the calculated ratio indicates a slight emphasis on late-stage knapping, which is consistent with the observed percentages of primary flakes (21.3%), thinning flakes (22.6%), and late-stage flakes (56.1%). The apparent discrepancy can be reconciled if we posit the ancient removal of finished bifaces for use elsewhere, together with the effects of artifact collecting in modern times.

5.4.2.2) Flake-to-Biface Ratio Analysis: As shown in Table 5.7, the overall flake-to-biface ratio in all materials is about 23:1. Considering only Cuesta quartzite, the flake-to-biface ratio is 46:1. Although it does not approach the ratios witnessed in knapping experiments, the higher ratio for Cuesta quartzite in relation to other lithic types suggests an emphasis on tool manufacture. The original flake-to-biface ratio for Cuesta quartzite was undoubtedly greater than can be revealed archaeologically because its knapping results in a large number of small flakes and granular debris that is unrecoverable in conventional excavations.

Table 5.7: Ratio of Flakes to Bifaces (28-GL-33)

Material	Flakes	Bifaces	F/B Ratio
Argillaceous[1]	337	41	8.2:1
Cryptocrystalline[2]	829	34	24.4:1
Metasedimentary[3]	220	16	13.8:1
Cuesta quartzite	1201	26	46.2:1
Total	2587	117	23.2:1

[1] Argillite and Argillaceous Shale
[2] Chalcedony, Chert, Jasper, and Quartz
[3] Quartzite, Sandstone, Metasediment

On the other hand, the actual flake-to-biface ratio in ancient times would have been much less than presently calculated if the innumerable bifaces previously removed by collectors—and possibly by ancient artisans—could be taken into account. All things considered, it seem likely that a wide range of bifacial knapping transpired here.

5.5) Site 28-GL-45

Site 28-GL-45 is located on the southern bank of a tidal slough, opposite site 28-GL-33. Raccoon Creek lies approximately 305m (1,000 feet) to the southwest (Mounier

1975a, 2000b). The major concentration of cultural remains occurs in an area of about 1.1 hectares (2.8 acres) mostly on level ground atop the crest of the bluff.

Excavation units were distributed along the northern edge of the site in both the agricultural field and its wooded buffer. Four large excavation blocks were opened along with ten single exploratory trenches. Altogether, the excavations covered $242m^2$ (793.75 square feet).

The site also revealed portions of an ancient living floor, which appeared as an artifact-rich wedge or lens of strong brown or dark yellow-brown sandy loam (10YR 4/6-7.5YR 4/6). This deposit widened northward toward the wooded bluff edge, indicating that the portion in the field had been diminished by plowing and erosion. Similar living floors were also found at other locations along Raccoon Creek in this vicinity, including sites 28-GL-30 and -31 (Mounier 1975a, 1997a, 1998a).

Testing demonstrated that the majority of remains survive below ground in undisturbed subsoil or in features. About 76% of all finds were retrieved from the subsoil or features, the balance occurring in the plowzone.

The prehistoric materials indicate occupation over a long period of time. The latest artifacts relate to the Middle Woodland and Late Woodland periods (ca. A.D. 350 - 1600). Representative artifacts include cross-cord marked and fabric-impressed ceramics. The contents of the site at and beneath the level of plowing also include artifacts of Early Woodland and Late Archaic origin (3000-1000 B.C.). These artifacts include a variety of stemmed and notched bifaces, and rough, heavily-tempered pottery. As usual, there is a certain amount of undiagnostic cultural material, such as fire-broken rock and general-purpose tools, whose cultural-temporal associations remain problematical.

Fieldwork resulted in the collection of 7,307 items, which include artifacts or other objects used by the prehistoric occupants of the site (Table 5.8). The inventory includes bifaces, cores, unifaces, flakes, cobble tools, ceramic and stone vessel fragments, thermally-altered rock, culturally gathered pebbles, and miscellaneous items. Cuesta quartzite is quite well represented in the lithic assemblage from 28-GL-45, comprising 94% of the flakes and 89% of the bifaces.

5.5.1) Cultural Remains

In order of numerical frequency the prehistoric items include: flakes and other knapping residues, fire-broken or thermally-altered rocks, potsherds, flaked stone tools and weapons, and miscellaneous pieces. The miscellaneous pieces include two fragmentary mica books, two calcined bone fragments, and one piece of petrified wood. The frequency distribution of all finds by level appears in Table 5.8.

Thirty-three early-stage bifaces and 32 fragmentary specimens occur in Cuesta quartzite, which is also represented by a total of 4,445 flakes. Surprisingly, no cores of Cuesta quartzite appear at this site. This strong representation in this material is easily explained by the presence of a source at the site and across a tidal slough at 28-GL-33.

Table 5.8: All Artifacts by Level (28-GL-45)				
Artifact Type	**Plowzone**	**Subsoil**	**Total**	**Percent**
Bifaces	18	55	73	1.0
Cores	4	23	27	0.4
Unifaces	0	3	3	0.0
Flakes	1,368	3,339	4,707	64.4
Cobble Tools	2	33	35	0.5
Steatite Vessel (sherd)	0	1	1	0.0
Pottery	36	61	97	1.3
Thermally Altered Rock	319	2,026	2,345	32.1
Pebbles	0	14	14	0.2
Miscellaneous	0	5	5	0.1
Total	1,747	5,560	7,307	100.0
Percent	23.9	76.1	100.0	

The distribution of bifaces by type and material is shown in Table 5.9. Thirty-four bifaces are early-stage specimens, which have not been formalized or rendered into other tool types. These early-stage examples account for nearly half of all bifaces. As shown in the table, bifaces were made from a variety of materials, most of which were locally available as pebbles or cobbles. Nearly 90% of the bifaces occur in Cuesta quartzite. The abundance of this material doubtless reflects the exploitation of a cobble bed at the site.

In addition to bifaces, there are three unifacially flaked tools in Cuesta quartzite. These unifaces are expedient tools, not to be confused with specially prepared end-tools or scrapers.

Table 5.9: Bifaces by Type and Material (28-GL-45)						
Material/Type	**Early-Stage**	**Notched**	**Stemmed**	**Fragments**	**Total**	**Percent**
Argillaceous Shale	0	0	0	1	1	1.4
Argillite	0	0	2	0	2	2.7
Chert	1	0	0	0	1	1.4
Cuesta quartzite	33	0	0	32	65	89.0
Jasper	0	1	0	0	1	1.4
Metasediment	0	0	0	1	1	1.4
Quartz	0	0	0	1	1	1.4
Rhyolite	0	0	0	1	1	1.4
Total	34	1	2	36	73	100.0
Percent	46.6	1.4	2.7	49.3	100.0	

Table 5.10 depicts the cores, most of which were probably made from locally abundant pebbles.

Table 5.10:Cores from 28-GL-45		
Material	**Qty**	**Percent**
Cryptocrystalline	23	85.2
Quartzite	3	11.1
Quartz-schist	1	3.7
Total	27	100.0

Debitage includes a total of 4,707 specimens (Table 5.11). The frequency distribution among the various flake types indicates the production and maintenance of stone implements on the site. Cuesta quartzite is the most commonly represented material among the flakes, accounting for 4,445 flakes (94.4% of the total). Undoubtedly, this frequency results from knapping on cobbles from a deposit at the site.

Table 5.11: Flakes by Type and Material (28-GL-45)

Material	ES	DEC	PRI	THI	LS	FF	RF	BIP	BLK	TOOL	MISC	Total	%
A/S	0	0	4	9	3	13	0	0	0	0	2	31	0.7
ARG	0	0	15	7	2	11	0	0	0	1	1	37	0.8
CHA	0	0	0	1	1	1	2	0	0	0	0	5	0.1
CHT	0	6	1	4	5	13	17	0	0	0	0	46	1.0
CUE	45	114	388	663	668	2,178	336	0	2	1	50	4,445	94.4
JAS	0	6	5	7	2	9	2	1	0	0	0	32	0.7
MET	0	2	1	0	0	6	4	0	0	0	0	13	0.3
POR	0	0	0	0	0	0	1	0	0	0	0	1	0.0
QSC	0	0	0	0	0	0	2	0	0	0	0	2	0.0
QTT	0	1	0	1	0	3	1	0	0	0	0	6	0.1
QZZ	0	7	8	9	3	21	19	0	1	1	0	69	1.5
RHY	0	0	0	3	5	1	0	0	0	0	0	9	0.2
SAS	0	0	0	0	0	1	3	0	0	0	0	4	0.1
SCH	0	0	0	0	0	1	6	0	0	0	0	7	0.1
Total	45	136	422	704	689	2,258	393	1	3	3	53	4,707	100.0
Percent	1.0	2.9	9.0	15.0	14.6	48.0	8.3	0.0	0.1	0.1	1.1	100.0	

Types: ES = Early-Stage; DEC = Decortication; PRI = Primary; THI = Thinning; LS = Late-Stage; FF = Flake Fragment; RF = Reduction fragment; BIP = Bipolar; BLK = Blank; MISC = Miscellaneous.

Materials: A/S = Argillaceous Shale; ARG = Argillite; CHA = Chalcedony; CHT = Chert; CUE = Cuesta quartzite; JAS = Jasper; MET = Metasediment; QSC = Quartz Schist; QTT = Quartzite; QZZ = Quartz; RHY = Rhyolite; SAS = Sandstone; SCH = Schist.

Fire-broken rocks, numbering 2,346 specimens, were the most frequently encountered class of artifacts after flakes (Table 5.12). These rocks probably derived from hearths or other features in which open fires were employed.

Table 5.12: Thermally-Altered Rocks (28-GL-45)		
Material	**Total**	**Percent**
Cuesta quartzite	26	1.1
Chert	20	0.8
Limonite	28	1.2
Jasper	2	<1.0
Metasediment	2	<1.0
Quartzite	90	3.8
Quartz and Quartzose Pebbles	1784	76.0
Sandstone	394	16.8
Total	2346	100.00

Finally, the lithic inventory contains three miscellaneous items, which include two small masses of mica and one piece of petrified wood. In addition, there are 14 cobbles, pebbles, or fragments, slightly modified or not modified, but so situated in the site as to suggest importation by humans. Six of these items occurred in quartzite, three each in Cuesta quartzite, and one each in sandstone and metasediment.

Fragmentary containers are represented by 97 ceramic sherds which display a variety of tempering materials and surface treatments. Thirty sherds bear impressions of cordage, fabrics, or heavy textiles, while 61 one sherds have smoothed or plain surfaces. The temper agents include grit, heavy unidentified minerals, porphyry, quartz, gravel, schist, and steatite. These substances occur in various combinations in sherds with diverse surface treatments. There are several sherds in which neither the surface treatment nor the aplastic elements could be identified. Fabric-impressed ceramics reminiscent of the late prehistoric Riggins type (McCann 1950:315) were found in several clusters. These deposits probably represent distinct episodes of late prehistoric refuse disposal.

5.5.2) Artifact Analysis

The following paragraphs discuss the results of proportional flake analysis and flake-to-biface ratio analysis.

5.5.2.1) Proportional Flake Analysis: The frequency distributions and ratios of later- to earlier-stage flakes in all materials indicate multiple stages of bifacial knapping. These ratios do not strongly represent the production of early-stage bifaces, which is manifestly inconsistent with the presence of many early-stage specimens, especially in Cuesta quartzite.

For Cuesta quartzite, the ratio of later- to earlier- flakes is 2.43:1. Given the number of early-stage bifaces and the complete absence of formalized bifaces in Cuesta quartzite at this site, a greater number of earlier-stage flakes would have been expected. As at 28-GL-33, the calculated flake ratio would suggest a slight emphasis on the later stages of reduction, possibly for the refinement of bifaces that were subsequently removed for use at other locations. Again, the differential collection of finished bifaces in historic times has undoubtedly distorted the archaeological record.

5.5.2.2) Flake-to-Biface Ratio Analysis: The mean flake-to-biface ratio in all materials is about 65:1. The flake-to-biface ratio for argillaceous materials (argillite and argillaceous shale) is 22.7:1; for cryptocrystalline materials (chert, jasper, and quartz) it is 49.0:1; for metamorphosed sediments it is 13.0:1. The same ratio for Cuesta quartzite is 68.4:1.

Ratios of this magnitude indicate on-site production of bifaces, especially in cryptocrystalline and metamorphic materials. The lower ratio of flakes to bifaces in argillaceous materials indicates the very restricted manufacture of tools on site and the maintenance of implements brought onto the site in finished or nearly finished condition.

Although the flake-to-biface ratio for Cuesta quartzite is much lower than shown by experimental knapping, the higher representation relative to most other materials can be taken to mean that biface production in Cuesta quartzite occurred here with some intensity. This conclusion is consistent with the appearance of many early-stage bifaces and fragments in this material at this site. This situation is also consonant with the presence of a natural deposit of Cuesta quartzite cobbles at this site.

5.5.3) Ecofacts and Cultural Features

A limited amount of organic material was observed and collected: a few grams of wood charcoal and two pieces of calcined bone fragments. The charcoal, associated with Cuesta quartzite debitage, was delivered to the Beta Analytic Laboratory in Miami, Florida for analysis. The results are reported below.

Aside from a suspicious aggregation of mostly unmodified stones, no rock-lined hearths or cobble tool clusters were identified in the excavations. However, a buried, artifact-rich horizon appeared as a lens of distinctly colored soil underlying the earliest plowzone. This horizon occurred as a wedge of discolored soil from 5 to 18cm (2 to 7 inches) in thickness running parallel, or nearly so, to the wood line. The fill consistently appeared as a dark yellow brown color (10YR 4/6) in contrast to the surrounding yellow-brown (10YR 5/6) soil matrix. This horizon contained a high frequency of lithic and ceramic artifacts, most of which exhibited cultural affinities to the Late Archaic/Early Woodland episodes. This feature resembles those on other sites in the locality, viz., 28-GL-30, and -31 (Mounier 1975a, 1997a, 1998a).

Two basin shaped pits were noted. The smaller of the two (designated Feature 1) was truncated by plowing. It appeared as a bowl-like, irregular oval that measured 69 x 48cm (27 x 19 inches) in plan and about 41cm (16 inches) in depth. It contained Cuesta quartzite debitage and wood charcoal. The feature fill was yellow-brown (10YR 5/6) to strong brown (7.5YR 5/6) in color, while the subsoil matrix was brownish yellow (10YR 6/6). Charcoal from this feature was dated to 1600±60 B.P. by the Beta Analytic Laboratory in Miami, Florida (Beta-139737).

As with the date from 28-GL-33, this assay is more recent than others that are associated with the use of Cuesta quartzite, which often appears in clear Late Archaic/Early Woodland or even earlier contexts (Chapter 2, Section 2.6.1). In other words, a date more closely aligned with the previously known temporal limits of Cuesta quartzite usage was anticipated. However, diagnostic artifacts were not recovered in direct association with the feature or its carbonaceous contents. It is quite likely that the use of Cuesta quartzite persisted later in time than has been previously appreciated, especially on sites where the material occurs in some natural abundance.

A larger feature was uncovered within the wooded buffer. This deposit appeared as a sub-oval to rectangular patch of discolored, mottled soil that measured approximately 2 x 3 m (7 x 10 feet) with a maximum depth of 46cm (18 inches). The fill was brown (10YR 4/2), gray/brown (10YR 4/3) or strong brown (7.5YR 4/6) in color. This feature contained a dense accumulation of Cuesta quartzite debitage (over 900 flakes and fragments), 20 unfinished or broken bifaces in the same material as well as a Fishtail variant biface in argillite. Thermally altered quartzose pebbles and fragments were numerous, but the feature matrix contained no charcoal. Consistent with its contents, this feature appears to represent Late Archaic/Early Woodland activities related to on-site tool production and maintenance.

5.6) Site 28-GL-383

Site 28-GL-383 lies on the edge of the "Cuesta Belt," about 5.8 km (3.6 miles) to the southeast of Swedesboro and about 3.4 km (2.1 miles) north of Harrisonville (Mounier 1975a, 2006a; Figure 5.3). This site lies along Raccoon Creek about 11.6km (7.2 miles) upstream of the tidewater sites (28-GL-30, etc.), following the course of the creek. The size of the site remains unknown for want of complete survey. Scattered cobbles of Cuesta quartzite occur at the site.

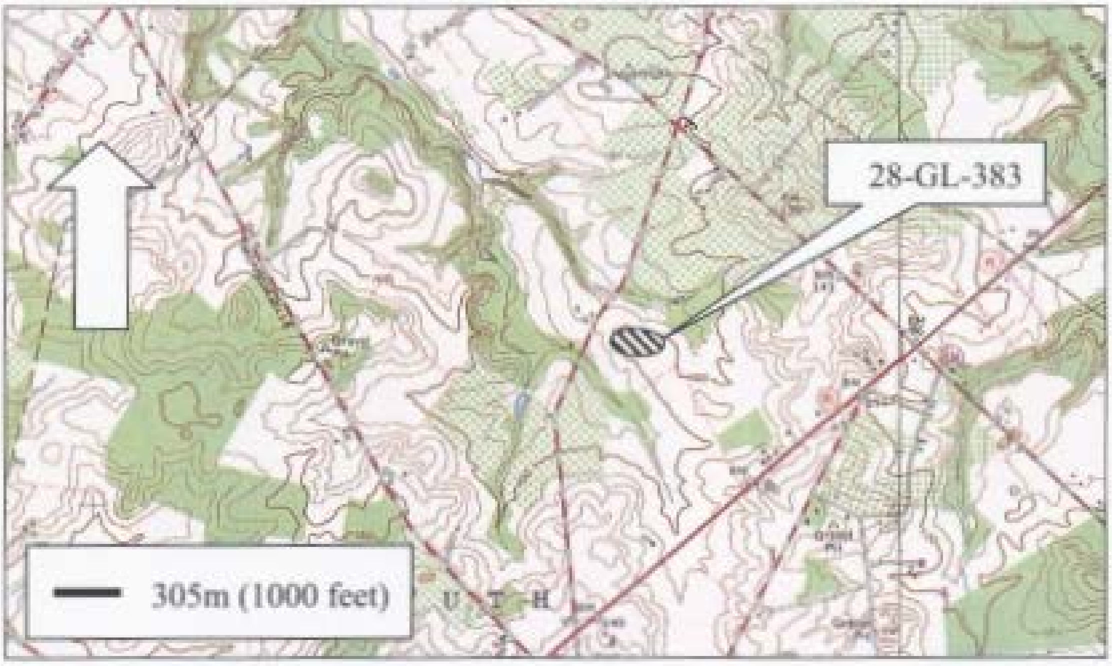


Figure 5.3: Map of Site 28-GL-383

5.6.1) Cultural Remains

Prehistoric artifacts were found in seven locations, four of which contained artifacts in undisturbed subsoil deposits. All of the productive locations coincide with deep, sandy soils. In contrast to most prehistoric site settings, none of the productive loci occur directly along the wetlands/uplands transitional area. Several occur more than 61m (200 feet) from any wetlands and clearly exhibit preferential occupation of terrain with sandy soil. This pattern is sensible when one considers that the upland stream edges have dense gravel or limonite deposits, which would make for uncomfortable camping.

5.6.1.1) Artifacts: The surface finds include a narrow range of lithic items, comprising early-stage bifaces (broken in manufacture and unfinished), flake blanks, cobble tools, cobble and pebble cores, debitage, and thermally altered rock. Four of the seven surface locations exhibited evidence of local Cuesta quartzite procurement and processing. The subterranean finds are consistent in distribution and general type with the surface-borne artifacts. Table 5.13 lists the prehistoric artifacts.

Table 5.13: Enumeration of Finds (28-GL-383)

Measures	— Artifact Types —					Total
	Bifaces	Cores	Flakes	Cobble Tools	Hearth Rock	
Qty	13	16	161	6	102	298
Percent	4.4	5.4	54.0	2.0	34.2	100.0

Ten of the bifaces (84.62%) are early-stage specimens. One is a formalized Teardrop style, which was fragmented by the accidental removal of a triangular notch near the base. The remaining two are fragments of indeterminate type.

Four of the bifaces are made of Cuesta quartzite (30.77%); six occur in quartz, and one each in chalcedony, jasper, and quartz-schist. The chalcedony biface and one of the Cuesta quartzite specimens are fragments; all others are early-stage specimens. The lack of formalized specimens may reflect the differential removal of finished bifaces by ancient artisans or by collectors in modern times. All of the Cuesta quartzite specimens are early-stage bifaces.

Most of the 16 cores appear to be types associated with biface reduction. One has a form that would have made it useful as a chopper, but this form alone does not rule out a biface trajectory. Eleven cores are made of quartz, two others occur in chalcedony and chert. One Cuesta quartzite core (6.25%) was found.

Flakes number 161 specimens. The frequency and materials represented by flakes are as follows: 64 quartz (39.75%), 45 Cuesta quartzite (27.95%); 22 chert (13.66%); 11 jasper (6.83%), 9 quartzite (5.59%), 5 argillite (3.11%), 4 metasediment (2.48%), and 1 schist (0.62%).

Of the six cobble tools, two were assessed as anvils and four as hammerstones. One cobble tool was made of quartzite, the others of sandstone.

Thermally altered rock consists of 102 specimens, represented in the following frequencies: quartzose, 60; sandstone, 28; quartzite, 9; limonitic sandstone, 4; and Cuesta quartzite, 1.

The Cuesta quartzite artifacts are enumerated in Table 5.14., while the flake types appear in Table 5.15.

Table 5.14: Cuesta Quartzite Artifacts (28-GL-383)

Measures	Bifaces	Core	Flakes	TAR [1]	Total
Qty	3	1	45	1	50
Percent	6.0	2.0	90.0	2.0	100.0

[1] TAR = Thermally Altered Rock

Table 5.15: Cuesta Quartzite Flakes (28-GL-383)									
Measures	**Early-Stage**	**Primary**	**Thinning**	**Late-Stage**	**Flake Fragments**	**Reduction Fragments**	**Misc.**	**Flake Blanks**	**Total**
Qty	**3**	**4**	**1**	**1**	**9**	**19**	**1**	**7**	**45**
Percent	**6.7**	**8.9**	**2.2**	**2.2**	**20.0**	**42.2**	**2.2**	**15.6**	**100.0**

One fossil brachiopod may have been gathered anciently or may have existed naturally in the soil. Sometimes fossils appear as a result of spreading marl as a soil amendment. The present data are insufficient to make a determination on this point.

5.6.2) Artifact Analysis

The following paragraphs discuss the results of proportional flake analysis and flake-to-biface ratio analysis.

5.6.2.1) Proportional Flake Analysis: For Cuesta quartzite, there are only three early-stage and four primary flakes. Thinning and late-stage flakes are represented by only one specimen each. The ratio of earlier- to later-stages of knapping in Cuesta quartzite computes to 3.50:1. While the data presently at hand are not definitive because of the very small sample size, knapping with the aim of early-stage biface production seems likely. This interpretation is consistent with the presence of early-stage bifaces at this site.

5.6.2.2) Flake-to-Biface Ratio Analysis: The flake-to-biface ratio for Cuesta quartzite is 11.25:1; for jasper, it is 11.00:1; and for quartz, it is 10.67:1. Although not subjected to statistical analysis (because of the small sample size), this distribution appears to indicate a fairly consistent flake-to-biface ratio for the site for all materials at the site. However, the ratios are small when compared to experimental results. The small sample size precludes conclusive statements about the character of bifacial work at this site.

5.7) Site 28-GL-344

Site 28-GL-344 is located in Elk Township, Gloucester County, in the drainage of Raccoon Creek, near the divide between the Inner and Outer Coastal Plains (Mounier 2006b; Figure 5.4). This site lies about 24km (14.9 miles) upstream of the tidewater sites (28-GL-30, etc.) following the course of the creek.

The site contains several distinct archaeological loci, which are widely scattered over a tract that covers about 60 hectares (140 acres). Of the various loci, the one of interest here is Locus B2, which contains a strong expression of Cuesta quartzite in the form of a knapping station. This locus covers an area of 1,742m^2 (18,750 square feet). The excavations in this vicinity covered approximately 31.4 m^2 (337.5 square feet). The excavations focused on an activity area relating to the reduction of Cuesta quartzite by knapping.

5.7.1) Cultural Remains

The archaeological remains at 28-GL-344 consist mostly of lithic artifacts, some of which are clustered in an apparent flaking station. These remains are detailed separately below.

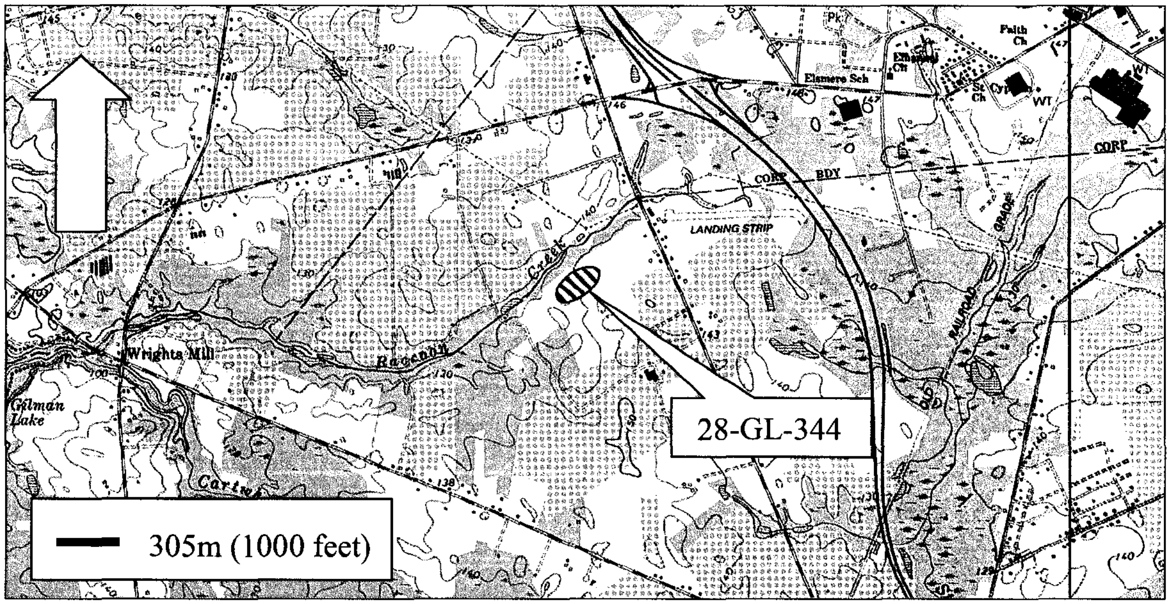


Figure 5.4: Map of Site 28-GL-344

5.7.1.1) Artifacts: Excavations at Locus B2 produced a limited assemblage, which includes bifaces, cores, debitage, and a miscellany of other artifacts (Table 5.16).

Table 5.16: Artifacts from 28-GL-344 (Locus 2B)		
Types	**Qty**	**Percent**
Bifaces	34	4.2
Cores	18	2.2
Flakes	566	70.4
Cobble Tools	8	1.0
Slab Tools	1	0.1
Thermal Rocks	172	21.4
Cobbles	2	0.2
Pebbles	2	0.2
Miscellaneous	1	0.1
Total	804	100.0

Table 5.17 enumerates the bifaces by general form and material. There are seven contracting-stemmed bifaces, diagnostic of Late Archaic/Early Woodland cultures. The

forms are characteristic of the typologically overlapping Lackawaxen, Stark, and Morrow Mountain styles.

Table 5.17: Bifaces by Type And Material (28-GL-344)

Material	Early-Stage	Stemmed	Fragment	Total	Percent
Argillaceous Shale	0	1	0	1	2.9
Argillite	1	1	4	6	17.6
Chalcedony	0	1	0	1	2.9
Chert	1	1	1	3	8.8
Cuesta Quartzite	10	2	4	16	47.1
Jasper	3	1	0	4	11.8
Quartzite	1	0	0	1	2.9
Quartz	2	0	0	2	5.9
Total	18	7	9	34	100.0
Percent	52.9	20.6	26.5	100.0	

Of a total of 566 flakes, 373 occur in Cuesta quartzite, representing 65.9% of all flakes. The remainder is divided between cryptocrystalline and argillaceous materials, as well as metasediments. The Cuesta quartzite flakes are highlighted in Table 5.18.

Eight cobble tools were found. Of the cobble tools that could be assigned to functional classes, one limonite specimen served as an abrader, two sandstone pieces were anvils, and two quartzite implements were used as hammerstones. In addition, a slab of ironstone is presumed to have been an abrading tool.

Table 5.18: Cuesta Quartzite Flakes (28-GL-344)		
Flake Type	**Qty**	**Percent**
Early-Stage	18	4.8
Decortication	4	1.1
Primary	30	8.0
Thinning	110	29.5
Late-Stage	75	20.1
Flake Fragments	118	31.6
Reduction Fragments	18	4.8
Total	373	100.0

Two unmodified quartz pebbles were apparently brought onto the site with the intention of eventual use. One of these pebbles had one or more "test flakes" removed. There are also two cobbles (one each in metasediment and sandstone) that are unworked.

Thermally altered rocks are represented by 172 specimens having the following distribution by material and frequency: quartzose (80), sandstone (64), ordinary quartzite (23), limonite (4), and Cuesta quartzite (1).

No features that could be recognized as pits were encountered in this portion of the site, but a dense lithic reduction area was completely explored. This cultural deposit exhibited a strong brown (7.5YR 5/6) discoloration at the plowzone-subsoil interface. Beneath this level, to a depth of 15cm (six inches) into the subsoil, the lithic deposit showed an increasing density across an oval area that covered about 15m^2 (160 feet). The activity area was dominated by heat-treated Cuesta quartzite, the residues of biface production. The biface production debris indicates the production of ovate, early-stage bifaces, leading to the manufacture of contracting-stemmed bifaces typical of a Late Archaic/Early Woodland style. Minor amounts of debitage in jasper and quartz were found intermingled with the Cuesta quartzite. No thermally altered rock was present, but remnants of carbonized nut shells and related mineralized residues (organic concretions) were found in association.

5.7.1.2) Ecofacts: Locus B2 yielded only 39 ecofacts, including 24 granules of wood charcoal and 15 pieces of probable nut charcoal. Hickory is assumed as the source of the carbonized nut shells, but this assumption cannot be validated because of the poor quality of the sample.

5.7.2) Artifact Analysis

The following paragraphs discuss the results of proportional flake analysis and flake-to-biface ratio analysis.

5.7.2.1) Proportional Flake Analysis: If the tally is restricted only to Cuesta quartzite, then the earlier stages of flaking are represented by 52 flakes and the later stages by 185 flakes. The ratio of later- to earlier-stage flakes is 3.56:1 (Table 5.19).

The respective percentages of primary flakes (14.0%), thinning flakes (51.2%), and late-stage flakes (34.9%) indicate an emphasis on bifacial thinning and finishing. Evidently, Cuesta quartzite knapping involved the formalization or reworking of bifaces, with some earlier stage processing. The proportions of early-stage and formalized bifaces in the midst of a knapping station makes this relationship very clear.

Table 5.19: Earlier and Later Flake Types at 28-GL-344				
Materials	**Early Flakes**	**Late Flakes**	**E/L Ratio**	**L/E Ratio**
All Materials	102	230	0.44:1	2.25:1
Cuesta Quartzite Only	52	185	0.28:1	3.56:1

5.7.2.2) Flake-to-Biface Ratio Analysis: The flake-to-biface ratios for all materials at 28-GL-344 vary from 0.4:1 to 53:1 . For Cuesta quartzite this index is 23.3:1 (Table 5.20). A ratio of this magnitude ordinarily does not indicate a high degree of bifacial reduction. However, the excavation and analysis of a Cuesta quartzite knapping station clearly shows that bifacial knapping occurred here. Since the Cuesta quartzite flakes are heavily weighted toward the middle and later stages of reduction, much of the bifacial work appears to have involved finishing or refurbishing implements that were initially produced elsewhere.

Table 5.20: Flake-to-Tool Ratios (28-GL-344)	
Material	**Ratios**
Argillite	0.4:1
Chalcedony	2.0:1
Chert	5.3:1
Cuesta Quartzite	23.3:1
Jasper	18.0:1
Quartzite	5.0:1
Quartz	33.0:1
Mean	12.4:1

Early stages of reduction are represented by 102 flakes, the later stages by 230 flakes (Table 5.19). The ratio of later- to earlier-stage flaking debris is 2.25:1. This, ratio, though not strong in relation to experimental results, is consistent with activities associated with the refinement of bifaces.

5.7.3) Analysis of Cuesta Quartzite Workshop

The excavation of 28-GL-344 offered an opportunity to examine the remains of a discrete lithic workshop in some detail. The workshop extended across an area of approximately 3.6 x 7.6 m (12 x 25 feet), covering an area approximately of 28 m^2 (300 square feet). Apparently, the cultural deposits was truncated by plowing, and some loss of specimens probably occurred as a result of colluvial erosion and soil grading. (Farmers frequently level their fields mechanically.) The artifacts extended to a depth of 23cm (nine inches) into the subsoil.

The Cuesta quartzite assemblage from the workshop consisted of debitage (including one flake blank) and bifacial remains. Of a total of 373 Cuesta quartzite flakes, 41 (about 11.0% of all flakes in this material) were retrieved from the plowzone, and 332 (89%) from the subsoil. The plowzone also yielded four bifaces (25.0%) while another 12 (75%) came from undisturbed subsoil.

The bifacial remains in Cuesta quartzite include 10 early-stage fragments, two formalized contracting stemmed specimens, and four fragments (Table 5.17). Both of the formalized bifaces exhibit distal use as perforating or piercing implements.

The measurements for the largest single formalized specimen—a broad-bladed, contracting stemmed biface—are as follows: Length: 65.8mm (2.59 inches); Width: 32.5mm (1.28 inches); and Thickness: 10.4mm (0.41 inches). The width-thickness ratio is 3.13:1. This biface snapped across the blade just above the tang, apparently during manufacture. Figure 3.4 (upper left) and Figure 3.5 (left) depict this item.

A very similar, broad-bladed, but squared stemmed, biface appears in argillaceous shale, whose dimensions are: Length: 55.2mm (2.2 inches); Width: 28.1mm (1.1 inches); and Thickness: 10.0mm (0.39 inches). The width-thickness ratio is 2.81:1.

Measurements for a refitted early-stage biface in Cuesta quartzite are: Length: 76mm (3.0 inches); Width: 67mm (2.625 inches); and Thickness: 26.5mm (1.04 inches). The single specimen of a primary flake blank is 1.02cm (4.0 inches) long, 70mm (2.75 inches) wide, and 28mm (1.125 inches) thick.

Locations that have relatively high proportions of later- to earlier-stage flakes probably saw an emphasis on biface refinement, sharpening, and repair, rather than on primary biface production. At Locus B2, where bifaces were clearly being made, a substantial amount of effort went into the refinement and rejuvenation of early-stage bifaces.

Bifacial reduction in Cuesta quartzite apparently concentrated on the manufacture of transportable, semi-finished or formalized pieces, of which ten remained on the site.

Others were presumably removed from the site for use at other locations. This is a common feature on sites that contain this material.

5.7.4) Radiocarbon Age

The Cuesta quartzite knapping feature yielded a small amount of charcoal, which yielded an assessed age of 6640±50 B.P. (Beta-222524). Chapter 2, Section 2.6.11 contains additional information.

5.8) Site 28-CA-29

The Blue Hole site lies upon the left bank of the Great Egg Harbor River in Winslow Township, Camden County, New Jersey (Mounier 1972b; Figure 5.1). The site—now heavily looted and disturbed by pipeline construction—formerly extended upon a sandy stream terrace for a distance of approximately 610m (2000 feet).

The site contained a broad variety of lithic and ceramic artifacts, ranging by typological assessment from Early Archaic to Late Woodland forms. My very cursory testing in 1967 yielded about 200 bifaces mostly in cryptocrystalline and argillaceous materials. Two fragmentary stemmed bifaces of Cuesta quartzite were recovered. These bifaces were formalized specimens that had been transported to the site as finished pieces. No local sources of Cuesta quartzite are known. The data do not permit further discussion of these pieces.

5.9) Site 28-MO-134

Now destroyed by highway construction, the Site 28-MO-134 (a.k.a. the Abature site) occupied a well drained, sandy ridge that forms the divide between Wampum and Cranberry Brooks in Eatontown Borough, Monmouth County, New Jersey (Mounier 1990a; Figure 5.1). An extensive freshwater wetland bordered the site to the west and south.

Archaeological materials were diffusely arrayed across an area of approximately 3.6 hectares (9 acres). The finds clustered around freshwater springs. The presence of fire-broken rocks, flake tools, bifaces, and a small amount of pottery, along with simple, hearth-like features suggests that the site served as a supply camp or processing station at various times in prehistory. The site lacks the density and variety of cultural remains that would be expected at a base camp. The setting in the extreme headwaters of small coastal streams is also consistent with this characterization.

Site 28-MO-134 contained cultural material that represented several thousand years of human settlement. The earliest artifacts that could be considered holotypical of specific archaeological cultures are bifaces relating to one or more Early-Middle Archaic components. Among these bifaces are bifurcate-stemmed specimens, resembling the LeCroy type (Broyles 1966, 1971) and the Stanly Stemmed type (Coe 1964; Dincauze 1971). Also present are early, corner-notched bifaces of uncertain typology, but resembling early forms found elsewhere on the coastal plains at the bottom of the cultural columns in unstratified sites (Mounier 1975b).

The most numerous artifacts at 28-MO-134 relate to Late Archaic/Early Woodland cultures which have an antiquity of approximately 3,000 years, as determined by typological considerations and the analysis of a charcoal sample. The relics appear in a variety of lithic materials including jasper, chert, cobble quartzite, Cuesta quartzite, sandstone, limonitic sandstone, argillite, argillaceous shale, and porphyry. The cryptocrystalline materials were largely available in pebble or cobble form from local geological deposits. Quartzites probably occurred as cobbles or boulders but the sources have not been identified. Argillite and argillaceous shale have no local sources and must have been imported, probably as partially or completely formalized artifacts.

The site contained a number of simple features, such as clustered rocks and pits. Feature 2 was a soil anomaly, probably a highly weathered pit. It measured 43 x 86cm (17 x 34 inches) in plan. First visible at a depth of 53cm (21 inches) beneath the surface, the stained soil disappeared at a depth of 89cm (35 inches). This feature contained datable quantities of wood charcoal and a small piece of limonite. Found in proximity were a Cuesta quartzite core fragment and a fragmentary end-tool of chert.

Charcoal from this feature yielded an assessed date of 1060 B.C. (3010$\pm$80 B.P. [Beta-24154]). This assay is consistent with the imputed Late Archaic/Early Woodland origin. The presence of stemmed bifaces in argillaceous materials and faceted hammers in Cuesta quartzite in neighboring units also supports this conclusion. See Chapter 2, Section 2.6.4 for more detailed information on the radiocarbon age determination.

5.10) Summary

This chapter has considered the archaeological expressions of Cuesta quartzite at seven sites in Gloucester County, as well as two others in Camden and Monmouth Counties. Two of the Gloucester County sites occur at geological deposits of Cuesta quartzite. The production of early-stage bifaces and the refinement or rejuvenation of formalized specimens are common attributes. As elsewhere, Cuesta quartzite is often associated with bifaces in argillaceous materials. At all sites, the debitage reveals bifacial reduction. These sites augment the data from the Burlington County stations, and with them provide both guidance and counterpoise to experimentally derived data, to which we now turn.

Chapter 6: Experimentation

This chapter concerns itself with experimentation into the manipulation of Cuesta quartzite by ancient people, both with respect to its alteration by fire and its reduction through the process of knapping. Experimentation into the thermal alteration of many lithic materials has a fairly long history, particular during the latter half of the twentieth century. Notable experimenters include Crabtree and Butler (1964), Mandeville (1973), Purdy (1974, 1975, 1981), Brooks (Purdy and Brooks 1971), as well as Behm and Faulkner (1974) and Ebright (1987). Experimental knapping, which witnessed an efflorescence in the 1960s—largely inspired by the work of Bordes in France and Crabtree in the United States—began much earlier, with classic studies by Holmes (1893, 1894, 1919) at the turn of the nineteenth century and by Pond (1930) two or three decades later (Johnson 1978).

The present study relies in large measure on experimentation, some of it conducted years ago on an impromptu basis and some more recently, with greater attention to recording certain critical details. These experiments can be divided into two groups, namely those dealing with thermally altering the properties of Cuesta quartzite on the one hand, and those dealing with the replication of archaeologically recovered specimens on the other. Except as noted, all of the materials used in these experiments came from a single geological source; namely, site 28-BU-90 in Evesham Township, Burlington County, N.J.

One of the characteristics of virtually all Cuesta quartzite artifacts is that their color and luster often differ noticeably from those of the raw material. These changes attend to thermal alteration, as has been long known. Almost always, especially when bifacial knapping is involved, these changes can be assumed to be the result of intentional heat-treatment; that is, conscious exposure to fire for purposes of altering the appearance or working qualities of the stone.

Before proceeding, a word about definitions is in order. While the term, "thermal alteration," may imply any heat-related changes, including inadvertent ones (Gregg and Grybush 1976; Callahan 1979:169), it is used here as a synonym for "heat-treatment," which specifically denotes intentional thermal processing for purposes of transforming—and thereby, improving—the nature of stone, including its visible characteristics and its knappability. From an archaeological perspective, unintentional thermal alteration in Cuesta quartzite appears to be almost entirely restricted to the material when used as hearth rock. Accidental thermal alteration appears to have been limited to very occasional expressions of "pot-lidded" bifaces, which were obviously exposed to destructively high temperatures under circumstances that we cannot now reconstruct (e.g., No. W- 78.6.).

For 20 years or so, Jack Cresson has conducted informal heat-alteration exercises on Cuesta quartzite, jasper, and other lithic materials. For nearly as long, he and I have collaborated in similar, loosely structured "tests" directed at understanding the behaviors that underlie the archaeological record as it appears in diverse surveys. These past exercises were generally undertaken on the spur of the moment, with little regimentation, and with little or no written record—certainly, nothing in the nature of detailed formal reporting—either of the procedures involved or of the results obtained. Furthermore, many of the impromptu studies made no particular attempt to replicate the conditions likely to be found in aboriginal settings. For example, a number of thermal-alteration "experiments" on various jaspers were conducted as an adjunct to the incineration of scrap paper from the daily operation of my office. Others transpired on a burner of an electric range, in toaster-ovens, microwaves, and so forth. Parenthetically, it turns out, that lithic materials can be just as successfully "heat-treated" in a steel drum half-full of burning waste paper as beneath a carefully constructed wood fire, and that the period required to obtain satisfactory results often can be measured conveniently in minutes rather than in hours or days. As far as the duration of firing is concerned, this finding is consistent with results obtained by Griffiths et al. (1987).

Of course, such home-grown experimentation only shows that the desired physical changes in the sample rocks can occur if enough heat is applied for a sufficient period of time (cf. Silsby 1994:323-326). It says nothing in particular about how much heat is enough, what length of time is sufficient, and how these parameters might have been viewed—and controlled—by ancient knappers. In many cases, aboriginal heat-treating procedures were highly ritualized and transpired over periods of time far in excess of what would have been required if the practical transformation of the stone were the only consideration (Steward 1938:337; Hester 1972).

In order to gain a better understanding of such things, simple, but controlled, experimentation was undertaken. With respect to thermal-alteration itself, the principal dimensions to be defined were temperature and time. With regard to knappability, the principal question was whether Cuesta quartzite could be successfully flaked without first exposing it to fire. The answer to this question bears on possible interpretations as to the symbolic significance of thermal alteration from the knapper's perspective.

With the foregoing in mind, several sets of related experiments were conducted. First, a large fragment of a Cuesta quartzite cobble was heated in an open fire to see whether thermal fracture would produce knappable pieces of manageable size; to determine the number and sizes of fragments produced, and to ascertain whether any of the fragments would exhibit good flaking properties. Fires were also employed to heat-treat some early-stage bifaces that would later become the subjects of experimental knapping.

I asked Jack Cresson to knap some small stemmed bifaces from cryptocrystalline pebbles, with the aim of determining the time required to make serviceable implements from these commonly available stones. The results were later employed in comparison with the staged reduction of the larger bifaces rendered in Cuesta quartzite.

Cresson also made several pairs of early-stage bifaces in Cuesta quartzite. Within each pair, the bifaces were matched as closely as possible with regard to size, proportions, and weight. One biface from each pair was heat-treated while its partner was left in an unheated state. In each case, each member of the biface pairs derived from a single cobble. Using one pair each, four experienced knappers attempted to replicate the formalized bifaces known from antiquity. This experiment was done to measure the time required and to gauge the relative difficulty of working Cuesta quartzite in its native state in comparison with heat-treated specimens. As to the latter point, the results are idiosyncratic, but as the knappers are all experienced, it was believed that their evaluations of relative knappability would serve as valid benchmarks. At any rate, the assessments in all cases are consistent. In its natural state, Cuesta quartzite is very tough and can only be flaked with great difficulty.

6.1) The Test Site

The test site employed in thermal-alteration experiments is located in Vineland, Cumberland County, N.J., where I keep my office. This site was used for all experiments involving open fires. The local soil consists of sandy loam, which was very moist at the start of the thermal experiments; soil moisture was about 70% of retention capacity. Beginning with the thermal trials, the experiments and their results appear on the following pages.

6.2) Thermal Alteration Experiments

I conducted eight thermal experiments to gauge the effect of fire on Cuesta quartzite. These experiments transpired over a period of approximately one month, between mid-September and mid-October, 2006. The following pages describe the experiments and the related findings. The order of presentation is chronological.

6.2.1) Thermal Experiment No. 1 (18 September 2007)

This experiment was an attempt to fire-crack a core of Cuesta quartzite for purposes of entry for knapping (Plate 6.1). This exercise is distinct from heat-treating specifically to improve flaking quality. This experiment also tested for changes in weight and color that might result from thermal exposure.

6.2.11) Procedures and Measurements: Adhering soil was brushed and scraped off of the specimen, which was then washed and thoroughly air-dried. Then the sample was weighed, and scaled for color using Munsell Color Charts. The sample weighed 5.5kg (12.1 lbs.). Cortical colors of the untreated stone were in the range of 10YR 6/1-6/3 (gray, light brownish gray, pale brown) to 10YR7/2-7/4 (light gray, very pale brown).

After the preliminary data were recorded, the specimen was exposed directly to flames and heat within an open-air wood fire. A hearth, about 60cm in diameter, was prepared on bare earth. A supply of well cured hardwood, principally hickory and maple, was laid by. The sample rock was placed on the earth and a tipi fire was built around it. This configuration ensured that the rock was mostly surrounded by fuel. The sample rock remained in place, during the fire and overnight, while temperatures were recorded at various times and at different places on the sample, in the hearth, and in the earth.

The fire was ignited at 13:20 and became well established within seven minutes. Then, more firewood was added, maintaining a tipi style of construction. When the fire burned vigorously in open flames, a thermocouple was inserted at its base, about 20cm (eight inches) from the nearest part of the sample rock. This is as close as I could position the device without its being damaged by the fire at the height of the blaze. The maximum temperature of the fire at this point was found to be 705°C (1301°F).

Clockwise from upper left: Cuesta quartzite core (keys give rough scale—see small arrow); laying the tipi fire over the core; core after firing (note cracks—see small arrow); fire in progress (bricks at left shelter thermocouple probe). The large arrow depicts a landmark corner on the core.

Plate 6.1: Heating a Cuesta Quartzite Core

After burning down nearly to coals, at 13:45, the fire was built up again using more billets of split and dried hickory and maple. The restored fire was then allowed to consume all of the wood to charcoal and ash. By 14:45 nearly all of the wood had completely burned to glowing coals. One piece of maple was charred but not consumed.

By15:00 the fire had subsided to the point that the temperature of the rock could be measured directly. With the instrument in contact with the coals and the nearest rock surface, the maximum temperature was observed to be 432°C (809.6° F). With the probe touching the rock only—it was inserted into a crack to ensure intimate contact—the temperature was 227°C (440.6° F). Within one half hour, the temperature at the same location had fallen to a maximum of 212°C (413.6° F). At this time the temperature of the earth directly under the rock measured between 84°C and 93°C (183.2° F and 199.4° F), depending upon location.

At 17:30 the temperature in the rock crevice—the same as previously used—was 111°C (231.8°F). The temperature of the earth directly beneath the rock was recorded at 156°C (312.8°F). At 18:40 the air temperature was 21.1°C (70°F), the rock crevice measured 54°C (129.2°F), and the earth beneath the rock had a temperature of 101°C (213.8°F).

At 7:00, on the morning of 19 September 2006, the air temperature stood at 16.7°C (62°F). The surface of the rock had a temperature of 22.8°C (73°F), and residual charcoal, though no longer incandescent, was still warm, measuring up to 115.6°C (240° F). The ground beyond the limits of the hearth measured between 10.6 and 11.7°C (51-53°F).

At 10:00, the upper surface of the rock and the earth had temperatures of 26.7°C (80°F). The slight increase in the temperature of the rock resulted from its exposure to direct sunlight. The rock was lifted, and the temperature of the soil directly beneath its center was found to be 37.8°C (100°F).

In the course of heating and cooling, the rock spalled (Plate 6.2). Large pieces of the broken rock were gathered and set aside. The detritus from the hearth bed, down to bare earth, was collected and doubly screened, first through ¼-inch mesh hardware cloth, and then through a U.S. Standard No. 6 sieve, having openings of 0.131 inches (3360 microns). The small sieve captured only one piece of Cuesta quartzite.

Plate 6.2: Cuesta Quartzite Core after Thermal Alteration

6.2.1.2) <u>*Results and Observations*</u>*:* The weight of the assembled pieces was equal to the starting value of the core, indicating no major loss from dehydration. Some water loss was expected, and undoubtedly occurred, but the magnitude of the loss could not be recorded, given the gross graduations (1kg, estimable to 0.5kg) of the scale employed.

Later experimentation with smaller pieces showed minor, but detectable, loss in weight as a result of thermal exposure (Table 6.6).

After exposure to fire, the color of the stone deepened and became somewhat redder than originally (cf. Plate 6.1, upper left and Plate 6.2). The starting colors were in the range of 10YR 6/1-6/3 (gray, light brownish gray, pale brown) to 10YR7/2-7/4 (light gray, very pale brown). Afterwards the colors were predominantly in the range of 7.5YR 5/2-6/2 (brown, pinkish gray) to 5YR 5/2 (reddish gray). Some ferruginous patches assumed a dark, rusty red color—or simply red in the Munsell nomenclature (10R 5/6-4/6). Portions of the surface displayed black smudging or fire-clouding, which was darker than any chip among the reference colors.

The rock cracked, and several fragments were detached. In addition to the core remnant, there were four spalls, ranging between 10 and 15cm in greatest dimension. Another 18 pieces measured between 5 and 10cm, and 13 more—measuring between 2.5 and 5cm—were recovered by screening through ¼-inch mesh hardware cloth. One very small piece, about 0.5cm in greatest dimension, was recovered from the No. 6 sieve.

The changes in color, the survival of fragments of sufficient size, and the knappability of the stone all indicate successful heat-treating. Thermal fracture, if it is not injurious to pieces of knappable size, can be taken as another sign of successful heat-treatment; otherwise, it denotes failure. Many of the larger pieces were suitable for reduction by knapping, as demonstrated by the successful removal of test flakes.

Demonstrably, thermal shock is sufficient to produce knappable spalls. Without doubt, further fragmentation could have been accomplished by dousing the hot rock with cold water, as experiments by others with sandstones and metasediments clearly show (Cavallo 1987:168-181).

6.2.2) Thermal Experiment No. 2 (19 September 2006)

This experiment provided a trial of thermal alteration. It involved heating 11 items (Series 1, Specimens A-K) under a covering of earth in an open wood fire. Six specimens were flake blanks, and four others were early-stage bifaces. All of these items had not been previously heated. A fifth biface had been exposed to heat in Experiment No. 1.

I also used the fire to cook a meal (Plate 7.1). This was not merely a frivolous exercise. It was done to determine whether simultaneous uses of the fire would have any effect on heat alteration. None was expected and none was observed.

6.2.2.1) Procedures and Measurements: The specimens were inscribed with indelible marker (on the face directed away from the fire) and arranged in a circle measuring about 30cm in diameter. The individual pieces were close closely spaced but not in physical contact. Then a layer of loose, burned earth, charcoal, and ash (gathered from the sifted remains of the earlier fire) was emplaced by gently sifting through a hand screen. The covering varied in thickness from 3.8 to 5cm (1½ - 2 inches). Then, as before, a tipi style fire of cured hardwoods was kindled over the buried stones.

Two blocks of Cuesta quartzite, about 20-25cm in greatest dimension, were set adjacent to the foot of the firewood so as to gauge the surficial heat gain from radiation through air at this location.

The fire, kindled at 11:45, soon reached a maximum temperature of 716°C (1320.8 °F). At 12:20, more wood was added, and within 40 minutes (by 13:00) this new charge had mostly burned to coals. At this time, the Cuesta quartzite masses set next to the fire had surface temperatures of 330°C (626°F) on the proximal sides, while the distal surfaces measured 97°C (206.6 °F), about the same as the earth under the specimens. By 14:00, the fuel had been reduced to ashes and fine residual charcoal. The specimens were left to cool in the ground. At 17:00 the ashes were cleared away and the specimens were photographed in place (Plate 6.3).

6.2.2.2) *Results and Observations:* The extent of thermal alteration seemed to be very limited. With regard to the buried specimens, the surfaces nearest the fire showed at best faint color shifting, while those facing the earth showed no change whatsoever. Based on this visual evidence, the thermal alteration was deemed to be unsuccessful. Jack Cresson reported that detaching test flakes from each of the five bifaces required the same effort as before any thermal exposure. Evidently, the buried pieces did not reach a critical temperature or the temperature was not sustained long enough to result in successful heat-treatment.

The large pieces stationed outboard of the fire showed reddening on the portions closest to the fire. The colors of those surfaces changed from gray (7.5YR 7/1) to red

(10R 4/8) and dark red (10R 3/6). Evidently, a critical temperature had been reached on these surfaces. To judge from the results of the first experiment, a minimum temperature in the range of 220-230°C is required to effect this change (also see Ebright 1987). The two rocks in the present experiment attained temperatures of at least 330°C.

Plate 6.3: Thermally Altered Bifaces (Experiment No. 2)

6.2.3) Thermal Experiment No. 3 (20 September 2006)

Because the fire on 19 September 2006 did not produce the desired thermal effects, the same items were fired for a second time the following day. The procedures were the same as before, except that the pieces were covered with a very thin layer of earth and ashes. The covering varied from a mere dusting to 13mm (0 - ½ inch). Two additional flake blanks were laid directly amidst the glowing coals after the fire had ceased to blaze.

6.2.3.1) Procedures and Measurements: This fire was typical of the others with respect to thermal activity. At 12:00 the fire was ignited, and within one half hour (by 12:30) most of the wood had been consumed, leaving a bed of heavy coals. At 13:10 additional wood was added. This fuel was reduced to coals by 14:00. At 14:15 two flake blanks of untreated Cuesta quartzite were placed in the coals.

6.2.3.2) Results and Observations: All of the buried specimens showed signs of successful heat treatment. The colors became darker or redder than before (Table 6.1), and many pieces showed blackening, one might suppose from being heated in a reducing environment, or from exposure to a high-carbon milieu (Behm and Faulkner 1974:273).

In all cases, the constituent quartz grains assumed a lustrous sparkle. The specimens most directly exposed to the heat exhibited minor thermal spalling. The treated bifaces yielded test flakes easily, and those flakes were longer and thinner than those detached from the same bifaces in unheated condition.

The two flake blanks directly exposed to glowing coals—with variable temperatures in the range of 450°C to 750°C (806°F and 1382°F)—showed dramatic discoloration, spalling, and micro-fractures ("crazing"). The upper limit of the indicated range approaches the temperature indicated by Blackwelder (1929) as destructive of quartzite (800°C). In essence, thermal exposure destroyed their physical integrity. They crumbled upon impact during test knapping.

Table 6.1: Color Change from Fire, Series 1 Specimens		
Item	Color Before Treatment	Color After Treatment
A	2.5Y 5/6 – 5-8 (red)	5YR 3/2 – 3 /3 (dark reddish brown) 5YR 4/1 – 6/1 (gray to dark gray)
B	10YR 6/2 – 6/4 (light brownish gray to light yellowish brown	2.5Y 4/2 (dusky red) 5YR 3/3 – 5/2 – 6/2 (dark reddish brown, reddish gray, pinkish gray)
C	10YR 5/1 – 7/2 – 6/4 (gray, light gray, light yellowish brown)	2.5YR 2/2 – 5/2 (very dusky red) 5YR 5/1 (gray) 7.5YR 4/1 (dark gray)
D	10YR 6/2 – 7/2 (light yellowish brown, light gray)	5YR 2.5/2 (dark reddish brown) 5YR 4/1 (dark gray)
E	2.5YR 4/6 (dark red)	7.5YR 3/2 (dark brown) 5YR 5/2 (reddish gray) 2.5YR 3/4(dusky red)
F	10YR 6/2 – 6/4 (light brownish gray – light yellowish brown	2.5YR 2.5/4 (very dark red) 7.5YR 6/2; 5YR 6/2 (pinkish gray)
G	10YR 6/2 – 6/6 (light brownish gray – brownish yellow)	5YR 5/4 (reddish brown) 7.5YR 6/2 (pinkish gray)
H	10YR 6/2 – 6/4 (light brownish gray – light yellowish brown)	7.5YR 5/6 – 6/2 (strong brown – pinkish gray) 5YR 3/4 (dark reddish brown)
I	10YR 6/2 ((light yellowish brown)	5YR 3/1 – 5/1 (very dark gray, dark gray, gray)
J	10YR 6/4 (light yellowish brown) 7.5YR 5/4 (brown)	5YR 4/4 – 5/3 (reddish brown) 7.5YR 5/2 (brown) 10YR 5/2 (grayish brown)
K	10YR 4/1 – 5/2 – 6/1 – 7 /4 (dark gray, grayish brown, gray, light gray)	5YR 2.5/1 (black) 5YR 4/1 – 5/1 (dark gray – gray)

6.2.4) Thermal Experiment No. 4 (22 September 2006)

As in the previous undertaking, this experiment, attempted to heat-treat Cuesta quartzite specimens. Seven specimens—consisting of Series 4, Items A-G—constituted the entire lot.

6.2.4.1) *Procedures and Measurements:* The procedures were the same as before, except that the fire was set to burn with only one charge of wood, which lasted for about one hour. The bifaces (Series 4, A-E) were covered with a very thin layer of earth and ashes, ranging from a dusting to a maximum of 13mm (½-inch). Flake blanks (Series 4, Specimens F and G) were placed directly on the coals as the fire reduced itself to embers. When the fire had cooled sufficiently, the specimens were removed for examination and test flaking.

6.2.4.2) *Results and Observations:* All of the specimens showed signs of successful heat treatment. The exterior colors became noticeably darker or redder than before. Black splotches appeared on many pieces. The interior colors, revealed by test flaking, tended not to shift much in chroma or value, but their hue tended to move toward yellow (Table 6.2).

In all cases, the entrained quartz grains assumed a lustrous sparkle. The treated bifaces flaked easily. The test flakes were both longer and thinner than those removed from the same bifaces in unheated condition.

Table 6.2: Color Change from Fire, Series 4 Specimens			
Item	**Color before Treatment**	**Color after Treatment (Exterior)**	**Color after Treatment (Interior)**
A	2.5YR 5/N5 (gray) 2.5YR 6/4 (weak red)	5YR 4/1 – 4/2 (dark gray – dark reddish gray)	10YR 6/1 (gray) 5YR 5/1 (gray)
B	7.5YR 5/N5 (gray) 2.5YR 5/N5 (gray) 2.5YR 6/4 (weak red)	2.5YR N2.5/ (black) 2.5YR 3/4 (dusky red)	5YR 6/3 (light reddish brown) 7.5YR 5/2 (brown) 7.5YR 6/2 (pinkish gray) 10YR 6/1
C	7.5YR 5/N5 (gray) 2.5YR 5/N5 (gray) 2.5YR 6/4 (weak red)	5YR 4/2 (dark reddish gray) 2.5YR 3/3 – 4/4 (dusky red)	10YR 6/1 (gray)
D	7.5YR 5/N5 (gray) 2.5YR 5/N5 (gray) 2.5YR 6/4 (weak red)	5YR 3/1 (very dark gray) 5YR 4/1 (dark reddish gray) 5YR 4/3 (reddish brown)	5YR 5/1 (gray) 7.5YR 5/2 – 6/2 (brown – pinkish gray)
E	7.5YR 5/N5 (gray) 2.5YR 5/N5 (gray) 2.5YR 6/4 (weak red)	5YR 3/1 – 3/3 (very dark gray – dark reddish brown)	7.5YR 6/2 (pinkish gray)
F	7.5YR 5/N5 (gray) 2.5YR 5/N5 (gray) 2.5YR 6/4 (weak red)	5YR 3/1 – 4/3 (very dark gray – reddish brown)	7.5YR 7/2 (pinkish gray)
G	7.5YR 5/N5 (gray) 2.5YR 5/N5 (gray) 2.5YR 6/4 (weak red)	2.5YR 3/4 – 3/6 (dusky red – dark red) 5YR 3/1 (very dark gray)	7.5YR 6/2 (pinkish gray)

6.2.5) Thermal Experiment No. 5 (26 September 2006)

This experiment attempted to heat-treat seven bifaces, including the following: Series 2 (Specimens O, P, R, S, and V), and Series 3 (Specimens A and B). A flake blank was heated directly on coals after the fire burned down.

6.2.5.1) Procedures and Measurements: The procedures were the same as before in that the pieces were covered with a thin layer of earth and ashes, ranging from 13mm to 19mm (½ to ¾-inches). A tipi fire was set at 14:18. Within 52 minutes (by 15:10), it burned to heavy coals. Then the fuel was replenished, and at 15:30 a flake blank was placed directly upon exposed coals.

6.2.5.2) *Results and Observations:* All of the buried specimens were successfully heat-treated. The colors became darker or redder than before firing (Table 6.3 and 6.4). Many specimens showed blackened surfaces. The material became lustrous, and knapping easily produced long, gracile flakes.

Specimen S broke transversely and longitudinally along natural seams, resulting in thin, platy fragments, two of which were later successfully reduced into formalized bifaces. The flake blank also heat-treated well and was subsequently knapped into a formalized biface.

Table 6.3: Color Change from Fire, Series 2 Specimens

Item	Color Before Treatment	Color After Treatment
O	5YR 5/1 (gray)	5YR 4/1 (dark gray)
P	7.5YR 5/N5 (gray)	7.5YR 6/2 (pinkish gray) 5YR 4/1 (dark gray)
R	10YR 5/2 – 6/2 (grayish brown – light brownish yellow)	5YR 6/2 (pinkish gray) 5YR 3/3 – 3/4 (dark reddish brown)
S	7.5YR 5/N5 (gray)	7.5YR 5/2 (brown) 5Y 3/1 (very dark gray)
V	2.5Y 4/N4 (dark gray) 2.5Y 5/N5 (gray) 7.5YR 4/N4 (dark gray)	2.5YR 4/4 (olive brown) 5YR 5/3 – 6/3 (reddish brown) 5YR 4/1 (dark gray)

Table 6.4: Color Change from Fire, Series 3 Specimens		
Item	**Color Before Treatment**	**Color After Treatment**
A	2.5Y 6/4 (pale olive) 2.5Y 5/N5 (gray) 7.5YR 5/N5 (gray)	2.5YR 4/4 (olive brown) 5YR 5/1 (gray)
B	2.5Y 6/4 (pale olive) 2.5YR 5/N5 (gray) 7.5YR 5/N5 (gray)	5YR 4/1 – 5/1 (dark gray – gray)

6.2.6) Thermal Experiment No. 6 (27 September 2006)

This round of firing was done to reheat three previously treated specimens along with two items not formerly subjected to heat-alteration. The items included: 1) Series 2, Specimen M; 2) Series 3, Specimen C; 3) Series 4, Specimen C; 4) Series 4, Specimen E; and 5) Series 4, Specimen G. Of these, Items 3 through 5 (Series 4, C, E, and G) were heated once previously (on 22 September 2006), while Items 1 and 2 (Series 2, M and Series 3, C) had not been previously subjected to firing.

6.2.6.1) Procedures and Measurements: The procedures were the same as before. The specimens were covered with a thin layer of earth and ashes, ranging from 13mm to 19mm (½ to ¾-inches). A tipi fire was set at 13:05. Within a few minutes, the temperature of the fire was recorded at 478°C (892°F). The fire burned to glowing embers by 13:43 and was replenished with fuel. Within 17 minutes, it burned to heavy coals. At 14:00 the temperature of the earth at the location of the specimens was recorded at 206°C (403°F).

6.2.6.2) <u>Results and Observations</u>: Thermal alteration was successful. All specimens showed darker or redder colors than before firing, and many showed blackening. Table 6.5 lists the color shifts for the items in Series 3 and 4. The other specimens showed similar color changes. Enhanced knappability was also observed.

<u>6.2.7) Thermal Experiment No. 7 (03 October 2006)</u>

This test was done to see whether heating Cuesta quartzite would affect the visible and tactile aspects of its texture; that is, whether changes in texture could be seen and sensed by touch. Eight unheated cores were flaked, and the detached flakes were saved for examination. Then the cores were heated in an open fire with the intention of removing one or more flakes upon cooling.

Table 6.5: Color Change from Fire , Series 3 and 4 Specimens

Series	Item	Color Before Treatment	Color After Treatment
3	M	7.5YR 5/N5 (gray)	5YR 5/1 (gray) 10YR 5/1 (gray) mottled with 10R 3/3 – 3/6 (very dark red – dark red, and reddish black)
3	C	7.5YR 5/N5 – 6/4 (gray – light brown)	10R 5/1 (reddish gray)
4	C	5YR 4/2 (reddish brown) 2.5YR 3/3 (very dark gray) 2.5YR 4/2 (dark reddish gray)	10R 5/1 (reddish gray)
4	E	5YR 3/1 (very dark gray) 5YR 3/3 (dark reddish gray)	2.5YR 6/2 (weak red)
4	G	2.5YR 3/4 (dusky red 2.5YR 3/6 (dark red) 5YR 3/1 (very dark gray)	2.5YR 6/2 (weak red) 10R 3/6 (dark red)

The idea was that the heating would weaken the cement bonds, in which case, the subsequent flaking would release more quartz grains per unit of area than among the unheated samples. I postulated that the flaked surfaces of the unheated specimens would display more broken quartz grains than those that separated cleanly from their cement bonds. The difference, if it existed at all, should be visible under magnification. In addition, the flakes with a majority of broken grains would feel smoother than those in which the grains tore free from the cement. In other words, the surfaces with more grains intact would have a micro-pebbly texture.

6.2.7.1) *Procedures and Measurements:* Eight cores were arranged in a single course in an oval cluster near the center of the hearth. A light covering of ashy soil—from a dusting to 13mm (½-inch) in thickness—was placed over the artifacts. The fire was constructed as before.

Initial ignition occurred at 15:20. The air temperature was 23°C (74°F). Within 20 minutes, the temperature of the air at the base of the fire—then still actively flaming—was 453°C (847°F). The temperature in the coals measured 747°C (1377°F). By 16:00 the fire had subsided. More fuel was added and blazed almost immediately. By 16:30 the fire comprised only heavy coals, which were left to burn out.

The thermocouple, placed in the coals at 16:00, returned a minimum temperature of 568°C (1054°F) and a maximum of 595°C 1103°F). By 17:00 the temperature in the coals measured 610°C (1130°F), but declined consistently, losing about 1°C (1.8°F) every minute or two. The final reading for the day showed a temperature of 606°C (1123°F). The air temperature at that time was 22.8 (73°F).

After cooling over night, the samples were dusted off and examined. Test flakes were driven off and their surfaces were examined comparatively under a 20x microscope, along with those of the untreated specimens.

6.2.7.2) Results and Observations: A close visual and tactile examination of the heated and unheated specimens showed no obvious differences in texture or in the number of fractured quartz grains as opposed to grains pulled from the cement matrix.

On a macroscopic level, the thermal alteration appeared to have been successful. Test flaking by Jack Cresson demonstrated that the treated objects would sustain large, long flakes, which detached easily.

6.2.8) Thermal Experiment No. 8 (12 October 2006)

This experiment tested whether soil moisture in the hearth would affect thermal alteration. It will be remembered that at the beginning of the experiments the soil moisture was recorded to be 70%. With repeated fires in the same hearth, moisture retention had declined to 40%. On the night of 11 October 2006 rain soaked the ground, saturating the hearth. Heat lost to evaporation during the fire might retard the thermal effects witnessed on Cuesta quartzite.

6.2.8.1) Procedures and Measurements: Most of the test items were buried at a very shallow depth in the hearth, using the wet soil as the covering medium. A tipi fire was erected of thoroughly dry firewood and fired at 14:15. By 15:00 the original fuel charge had burned to coals, and three flake blanks were placed among the embers. Then fresh firewood added. The fire burned in diminishing flames until 16:15 when it was again reduced to embers. The fire appeared in all respects to be typical of the previous ones; however, because of unexpected exigencies, temperatures were not recorded.

6.2.8.2) Results and Observations: Heat treatment of the flake blanks exposed directly to the coals was typical of previous attempts. The buried specimens showed only minor discoloration on the side closest to the fire, but no visible change was noticed on the opposite face. The pieces showed moderate surface luster.

Not surprisingly, it would appear that soil moisture adversely affects thermal alteration. Moisture draws heat away from the fire by generating steam (ordinarily at 100°C, unless under pressure). A wet hearth will slow the rise of heat necessary to bring the rocks to critical temperature. Repeating the experiment with rigorous controls would be necessary to state this conclusion definitively.

6.2.9) General Observations

The following observations concern the general thermal properties of open-air fires, as well as changes in the weight and color of specimens as a result of exposure to fire.

6.2.9.1) General Thermal Properties: It seems that open fires of the sort employed here rather rapidly reach a peak temperature of not less than 700°C, as observed in several experiments. Absent precipitation or dramatic changes in ambient temperature, one may suppose that the peak temperature will persist as long as sufficient fuel and air are present. As fuel diminishes the heat drops rapidly, but at a declining rate, reaching ambient temperature asymptotically after many hours, as suggested by the accompanying graph (Figure 6.1).

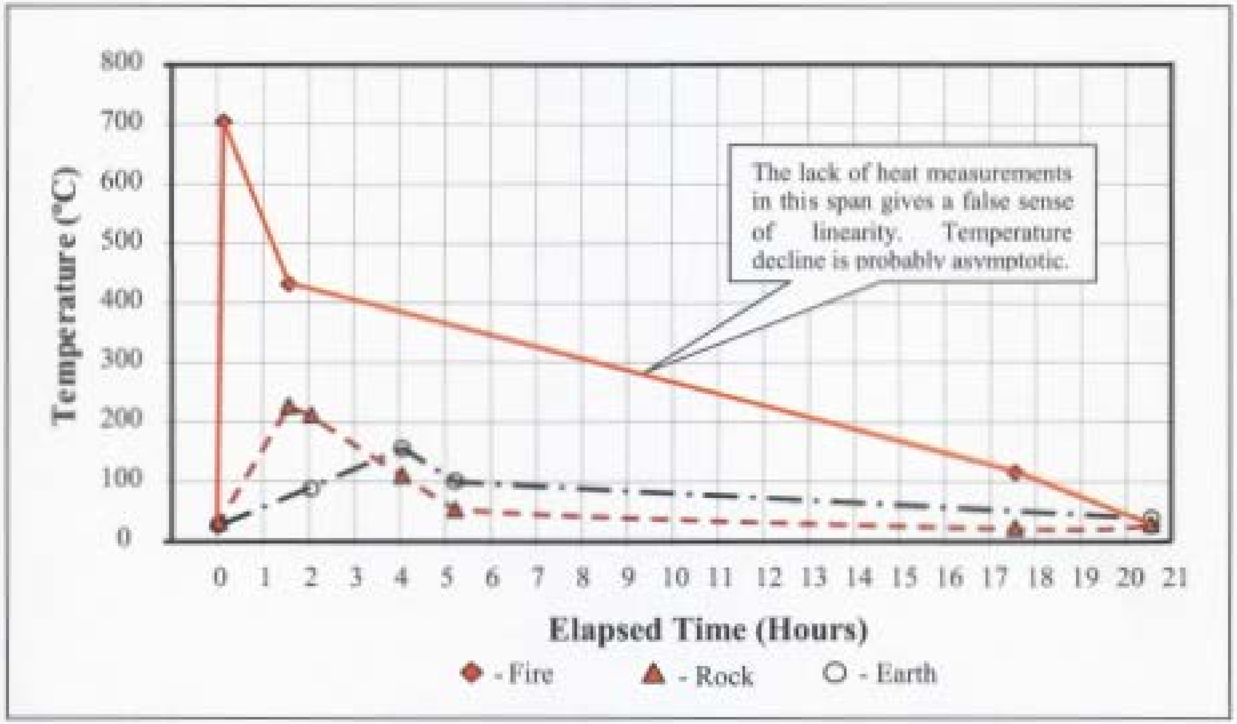


Figure 6.1: Graph of Temperatures, Experiment No. 1

Rocks directly in the fire rise more slowly in temperature than the fire itself, and the underlying earth more slowly still. Those rocks also cool more rapidly than the earth, presumably because of greater thermal conductivity and more complete exposure to the air. Obviously, the mass of the objects is important, as large items will heat more slowly and less deeply than smaller ones, if time and temperature are held constant.

Demonstrably, the burial of specimens beneath a layer of earth will moderate the thermal effects. Even a fairly thin covering of earth—as little as 3.8 to 5cm (1½ – 2 inches)—may offer enough insulation to retard successful heat-alteration. Damp earth is more heat-conductive than dry soil, but because of the generation of steam when heated, moist soil retards the elevation of temperatures to critical levels.

6.2.9.2) Weight Changes from Thermal Exposure: Previous experimenters have noticed weight loss in stone upon thermal alteration. Purdy (1974:37-40) attributed weight loss in heat-treated cryptocrystalline specimens to the release of water. She cautiously linked this water loss to improved knappability. Experimentation with heat-altered Hixton quartzite failed to produce any indication of weight loss associated with heating, even though specimens were weighed to 0.01g (Behm and Faulkner 1974:275). Evidently not all materials respond in identical ways.

Cuesta quartzite loses a small amount of weight when heated, presumably from the loss of interstitial moisture (cf. Purdy 1974:37-40; Table 6.6). The change is measurable on scales that can be read to 0.1g for pieces weighing more than 75g, or so. For smaller pieces, detecting the negligible change would require the use of an analytical balance. Such accuracy is unnecessary for the present undertaking. The mean weight loss is 0.4%. The accompanying graph is based on the sample data presented in Table 6.6. The graph shows that the changes become obvious only as the specimens begin to approach an initial weight of 1kg (Figure 6.2).

6.2.9.3) Color Changes from Thermal Exposure: Experimentation shows that heat can change the color of stones (Purdy 1974; Behm and Faulkner 1974). Usually, these changes manifest increased redness or a darkening of the natural hues, probably because heat causes chemical changes in iron compounds or other minerals in the natural stone matrix.

Table 6.6: Weight Changes in Cuesta Quartzite from Heating

Series	Specimen	Wgt. (g) Before	Wgt.(g) After	Change	% Change
Misc.	**5**	76.2	75.4	0.8	1.0%
3	**A**	148.4	148.0	0.4	0.3%
3	**B**	148.9	148.4	0.5	0.3%
1	**F**	153.5	152.9	0.6	0.4%
2	**P**	270.4	269.6	0.8	0.3%
3	**D**	299.7	299.2	0.5	0.2%
2	**V**	317.3	315.5	1.8	0.6%
2	**M**	324.2	323.8	0.4	0.1%
2	**R**	355.5	354.8	0.7	0.2%
2	**O**	383.3	382.2	1.1	0.3%
2	**S**	385.0	383.2	1.8	0.5%
Misc.	**1**	511.5	507.1	4.4	0.9%
Misc.	**7**	784.2	779.7	4.5	0.6%
Misc.	**3**	832.5	830.0	2.5	0.3%
Misc.	**2**	1270.1	1259.8	10.3	0.8%
Misc.	**6**	1367.4	1362.6	4.8	0.4%

In Cuesta quartzite, color changes first occur when the stone has been heated to critical temperature and held there for a time. The critical temperature appears to lie between 200° and 300°C, which is consistent with the results obtained by Behm and

Faulkner (1974:273) in their experimental firing of Hixton quartzite. As for Cuesta quartzite, small samples, say under 25g, will show reddening if held at this temperature or above for as little as five minutes, as shown by simple stove-top tests. Larger specimens require substantial fires or refractory ovens.

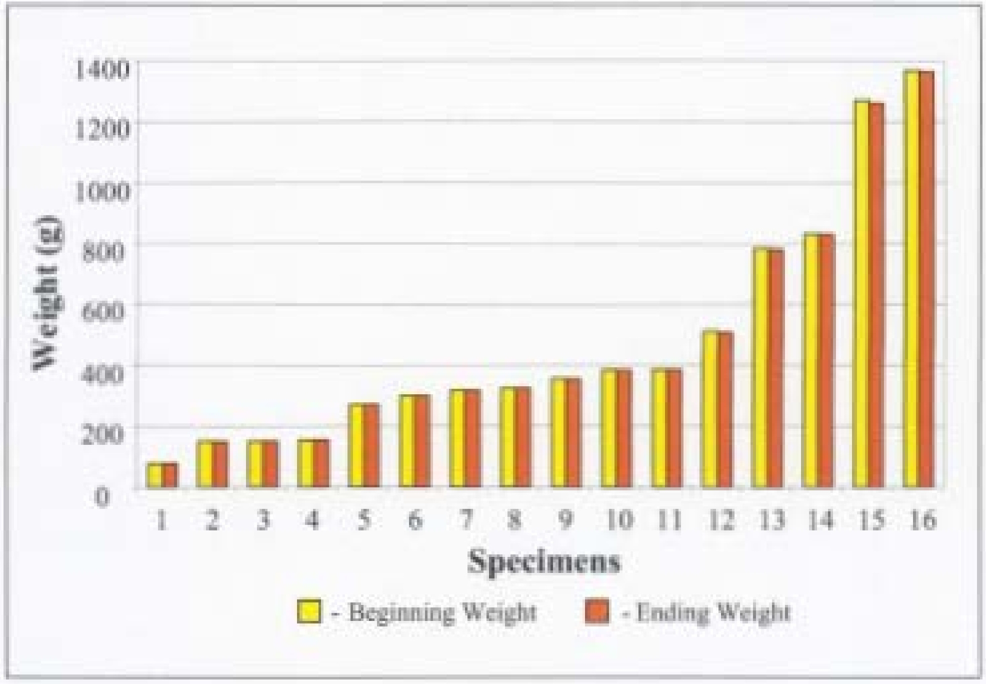


Figure 6.2: Weight Changes in Cuesta Quartzite from Heating

Based on test-flaking of heated Cuesta quartzite, the color penetration for a typical "burn" seems to be about 2mm on pieces that are not simply thin flakes. If the colored layer is removed, the underlying stone resembles the parent material in color, luster, and reflectivity. If additional heat is then applied—in sufficiently high temperatures and for a long enough term—the freshly exposed material will darken and redden.

Once color shifting has occurred, additional heating will not impart deeper, darker, or redder colors. The quartz crystals may appear to be somewhat more clarified and reflective, but that is the only visible change that occurs to material that has already been thermally altered. This effect, which I have not measured, is very subtle and may be more apparent than real.

6.3) Knapping Experiments

The flaking experiments utilized the services of four highly accomplished knappers: Jack Cresson, William Schindler, Scott Silsby, and Are Tsirk. Brief biographical sketches are offered below:

Having been engaged in replicative stonework for 40 years, Cresson has mastered the nuances of knapping. He is capable of working all of the stones known from antiquity in the region. He has successfully replicated all of principal stone implements known from temperate North America and many from the Old World. He specializes in working fractious materials such as quartz and coarsely grained quartzites, including Cuesta quartzite. He has been engaged in archaeological pursuits in New Jersey and the Middle Atlantic region since the 1960s.

William Schindler, also from New Jersey, has been knapping for approximately six years. He ordinarily works with argillite but is also experienced in knapping flint, jasper, and metasedimentary quartzite. His involvement with the present investigation marks his initiation into flaking Cuesta quartzite. He holds a Ph.D. in anthropology from

Temple University and teaches anthropology at Monmouth University in West Long Branch, N.J.

Scott Silsby, an accomplished naturalist, has been knapping for four decades. He is highly skilled in flaking refractory materials, such as greenstone and many varieties of quartzite. He is new to knapping on Cuesta quartzite. Although his anthropological experience is literally global, Silsby focuses on the archaeology of Virginia, his home state.

Are Tsirk is a physicist, who specializes in fracture analysis. He is also an anthropologist (M.A., New York University) and has been knapping for more than 30 years, with a particular interest in the mechanics of flaking. A native of Estonia, Tsirk is knowledgeable about both Old and New World cultures. His replications—mostly in obsidian, flint, and chert—extend to such objects as prismatic blades, bifaces, and flaked stone axes.

Cresson did the initial rough fracture of the Cuesta quartzite cobble, and blanked out the early-stage bifaces that he and the other knappers used for the reduction experiments. He also sorted the experimental debitage, employing the same categories used in our archaeological excavations. He then counted and weighed the specimens. I verified the accuracy of his results. In addition to working the Cuesta quartzite specimens, Cresson also made some small bifaces from cryptocrystalline pebbles for comparison against the quartzite pieces.

Each of the knappers was provided with two, closely matched, early-stage bifaces. In each pair, one was heat-treated and the other left untreated. The knappers were asked to attempt to replicate the common broad-bladed, contracting stemmed form so often associated with formalized bifaces in Cuesta quartzite.

They were instructed to use identical suites of knapping tools—hammerstones, organic billets, and pressure-flakers—for each trial. All of these flaking tools have analogues in ethnography and archaeology (see Holmes [1919: passim] for typical examples). All hammerstones used in this study were spheroidal in shape, consisting of quartzite or sandstone, and weighed between 320g and 410g. The organic hammers, which knappers call "billets," are roughly cylindrical in form. These percussors weighed between 170g and 610g.Wooden billets were composed of dense, native hardwoods, the most effective—and, therefore, the most highly favored—being dogwood (*Cornus florida*). Billets, made from the beams of moose (*Alces americana*) and white-tail deer (*Odocoileus virginianus*) antlers were used as well. Moose antler provides larger and denser percussors than deer antler.

Antler pressure flakers were also employed, either as unitary implements or as the working tip of composite tools, wherein the tip is lashed to a handle. The tines of deer antler (*Odocoileus virginianus*) are most commonly employed, because they work well and are readily available. Among knappers, the compound flakers are commonly called "Ishi sticks," in honor of Ishi, the renown Yahi Indian, who revealed the mysteries of aboriginal material culture to the Western World in the early 20th century (Kroeber 1964; Silsby 1994:282).

Knapping produces a great deal of dust, grit, and sandy particles in addition to flakes in a variety of sizes and shapes. The air-borne dust poses potential risks to pulmonary health, which are well known among knappers. Accordingly, each knapper worked outside in fresh air.

Outdoor knapping is conducive to lost pieces: flakes fly, small particles scatter, and dust is carried off with the breeze. Because the recovery of even tiny pieces becomes important for accurate interpretation, each knapper worked over a tarp so that the bulk of the debitage could be collected for inspection, counting, and weighing. In most cases, the debitage loss was minimal. However, in all cases used in this study, the replicated artifacts and associated debitage weighed less than the starting forms. Some loss is to be expected.

All of the recovered debitage was sorted into flake categories, counted, and weighed. Screening the smaller residues through a U.S. Standard No. 10 sieve permitted the separation of very small flakes from the sandy portion of the flaking debris. Flakes small enough to pass through the sieve have greatest dimensions of approximately 2mm. These flakes were retained with the sand fraction and weighed.

With the flake data in hand, the reduction from starting form to end-product could be calculated in terms of loss in overall size and weight. The products of the lengths, widths, and thicknesses of the various forms provides a convenient unit—herein called the "cube," for want of a better term—for comparing the rough sizes of the starting and ending forms. The cube is an expedient measure that approximates the size of the pieces involved. One might think of it as comprising the smallest box in which the bifaces could be placed with the most extreme points in any dimension in simultaneous contact with the corresponding walls of the box. Comparing the cubes of the starting and ending forms provides a rough measure of reduction in overall size, without having to calculate the actual volumes of the respective pieces. The following pages present the results of each knapper's efforts.

6.3.1) Results of Knapping by Jack Cresson

The following sections present the results obtained by Cresson in knapping both Cuesta quartzite and cryptocrystalline pebbles.

6.3.1.1) Untreated Specimen: The unheated Cuesta quartzite sample was Specimen B from Series 6, a Stage 2 biface, having the following dimensions: length, 124mm; width, 84mm; thickness, 27mm. It had a recorded initial weight of 303.9g.

Cresson was able to reduce the larger piece to a broad-bladed, contracting stemmed biface that measures 94 x 36 x 18mm. The length-to-width ratio is 2.6:1, while the width-to-thickness ratio is 2.0:1. Both lie within the limits observed archaeologically for these measures.

The elapsed time to reduce the Stage 2 biface to Stage 3/4 proportions was 19 minutes; another 38 minutes were required to complete the formalized biface. The total elapsed time is 57 minutes.

The effort produced 1,101 flakes of various types, plus an uncountable quantity of sandy debris. The flakes have a mean weight of 0.22g. The aggregate weight of the collected debitage is 242.3g, and the weight of the finished specimen is 45.8g. The total combined weight of all residues is 288.1g. The weight difference between starting and end forms is 258.9g., or a reduction of 85% by weight. The weight of unrecovered debitage is 15.8g. The cube of the formalized piece is approximately 22% of that of the parent biface; in other words, an approximate reduction of 78% of the volume was realized.

6.3.1.2) Treated Specimen: The heated sample was Specimen O from Series 2, a Stage 2 biface, having the following dimensions: length, 155.9mm; width, 80.4mm; thickness, 32.1mm. It had a recorded initial weight of 382.2g. (Plate 6.4, left).

Cresson succeeded in reducing the early-stage biface to a broad-bladed, contracting stemmed biface that measures 92.7 x 38.1 x 12.5mm. This biface has a length-to-width ratio of 2.4:1 and a width-to-thickness ratio of 3.0:1.The proportions reside within the limits observed in archaeological specimens (Plate 6.4, right).

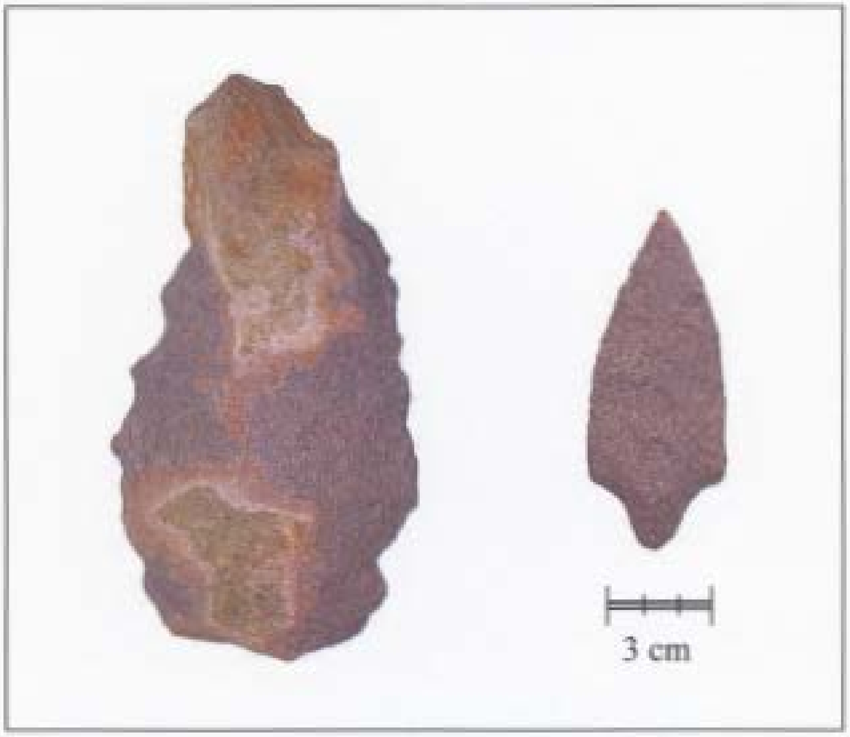


Plate 6.4: Reduction of Biface 2-O
(Knapped by Jack Cresson)

The elapsed time to reduce the Stage 2 biface to Stage 3/4 was 15 minutes; another 60 minutes were required to complete the formalized biface. The total elapsed time is one hour and 15 minutes.

The effort produced 1,927 flakes of various types, plus three large fragments and an uncountable quantity of very small flakes, grit and dust. The flakes have a mean weight of 0.16g. The aggregate weight of the collected debitage is 306.6g, and the weight of the finished specimen is 53.5g. The total combined weight of all products is 381.6g. The weight difference between starting and end forms is 318.7g, representing a loss of 83% by weight . The weight of debitage not recovered is 0.6g. The cube of the formalized piece is approximately 4% of that of the parent biface; that is, approximately 96% of the volume was lost during reduction.

6.3.1.3) Pebble-Derived Bifaces: Cresson produced three bifaces from small pebbles of chert and jasper (Plate 6.5). The pebbles were gathered from the surface of the beach along the Atlantic Ocean at Cape May, New Jersey. The largest measured 66.6 x 57.0 x 26.3mm. The specimens are in all respects typical of the cryptocrystalline pebbles from surficial geological deposits in southern New Jersey. Although archaeological evidence shows that pebbles were often heat-treated before being knapped, the samples used in this experiment were worked in an unheated state.

Plate 6.5: Bifacial Pebble Reduction
(Knapped by Jack Cresson)

The pebble, with a test flake removed, is at left. In the center is the biface core, at right, the finished biface.

Each was first split by the bipolar technique, wherein the pebble was held on a stone anvil while being struck from above with a hammerstone. This activity typically splits the pebble into two or more pieces or produces large flakes that can then be reduced by a combination of percussion- and pressure-flaking.

The mean time required to split the pebbles and to prepare the biface cores was 2.5 minutes. On average, the production of the finished bifaces required another 21.3 minutes, or a total mean time of 23.8 minutes per biface. Untitled and undated research notes provided by Cresson indicate that stemless bifaces (e.g., Teardrop and triangular bifaces) can be produced from pebbles in as little as nine minutes.

The mean values for cube and weight show that the formalized bifaces retain about 31% of the volume and about 69% of weight of the original pebbles. In other words, there is an average a loss of approximately 69% of the original cube and 31% of the original weight. By these measures bifacial pebble reduction is far more conservative than staged biface reduction from Cuesta quartzite cobbles.

6.3.2.)<u>Results of Knapping by William Schindler</u>

6.3.2.1) *<u>Untreated Specimen</u>:* The unheated sample was Specimen C from Series 7, a Stage 2 biface, having the following dimensions: length, 138mm; width, 75mm; thickness, 29. It had a recorded initial weight of 298.8g.

Schindler failed to produce a formalized specimen from the untreated biface. After 42 minutes, the specimen broke into four pieces. Schindler attributed the failure to internal flaws. Inspection of the pieces shows ferruginous zones with poorly cemented grains on both sides of the fracture planes. Thus, his assessment of the failure is vindicated. The flaws were not detectable from surface indications.

The effort produced 2,077 flakes of various types, four large fragments, plus an uncountable quantity of gritty debris, sand, and dust. The debitage has a mean weight of 0.14g. The aggregate weight of the collected debitage, including large fragments, is 295.8g. The difference between starting weight and debitage weight is 3.0g. Since no formalized biface was produced, the differences in cube and weight cannot be calculated.

Schindler reported near-frustration in attempting to knap this specimen. He stated that the material was extraordinarily tough and could not be made to flake without excessive force (in relation to that used by him in knapping argillite). The exercise was destructive of his flaking tools, especially the organic billets. He stated that the toughness of the stone led him to strike harder than is his custom, and that the failure to produce a formalized piece may be due in part to attempting to overpower the piece.

Nevertheless, in another attempt, Schindler succeeded in producing a formalized biface very similar to the sort requested. The end-product exceeds the upper limits of linear dimensions recorded among archaeological examples of contracting stemmed bifaces in Cuesta quartzite. The experimental specimen has a finished length of 76.4mm, a width of 41.7mm, and a thickness of 16.2mm. The maximum dimensions observed in archaeological examples are 72.8mm, 32.6mm, and 16.0mm for length, width, and thickness, respectively.

The length-to-width ratio of the experimental biface computes to 1.83:1 and the width-to-thickness ratio computes to 2.57:1. The stated length-to-width ratio lies within the range observed in archaeological collections as does the proportion of width to thickness.

Because of an apparent blunder in weighing the starting form, the proportional reduction in weight attendant upon formalization cannot be calculated. For this reason, this trial was excluded from the formal analysis. Still, the rest of the results are instructive and have been included here for the sake of comparison. The cube of the formalized piece is approximately 19% of that of the parent biface; in other words, an approximate reduction of 81% of the volume was realized.

6.3.2.2) Treated Specimen: The heated sample was Specimen P from Series 2, a Stage 2 biface, having the following dimensions: length, 138.9mm; width, 77.6mm; thickness, 25.2mm. It had a recorded initial weight of 269.6g (Plate 6.6, left).

Schindler used both hammerstones and organic billets for reducing the treated biface. Early in the process, the biface broke into three pieces for no apparent reason. These pieces measured approximately 83 x 58mm, 40 x 21mm, and 85 x 80mm respectively. Later Schindler supposed that excessive force—brought on by acclimatization to knapping the fractious, unheated specimen—may have been the cause of this failure. He was able to recover from the mishap and successfully reduced the largest fragment to a broad-bladed, contracting stemmed biface (Plate 6.6, right). The elapsed time to reduce the Stage 2 biface to Stage 3/4 was 45 minutes; only five additional minutes were required to complete the formalized biface. The total elapsed time is 50 minutes.

Plate 6.6: Reduction of Biface 2-P
(Knapped by William Schindler)

The effort produced 959 flakes and related pieces, plus an uncountable quantity of sandy debris and dust. The mean weight of all flakes is 0.24g. The aggregate weight of the collected debitage is 231.4g, and the weight of the finished specimen is 31.3g. Thus, the formalized biface represents about 12% of the starting weight of the parental early-stage biface (or a loss of 88% by weight). The total weight of all collected residues is 262.7g, a difference of 6.9g from the starting weight of 269.6g.

The formalized specimen has a finished length of 64.3mm, a width of 42.6mm, and a thickness of 11.8mm (Plate 6.6, right). The end-product exceeds the upper limits of width recorded among archaeological examples of contracting stemmed bifaces in Cuesta quartzite. However, both length and thickness fall within the observed range of variation in archaeological collections. The maximum dimensions observed in archaeological examples are 72.8mm, 32.6mm, and 16.0mm for length, width, and thickness, respectively.

The length-to-width ratio of the experimental biface computes to 1.5:1 and the width-to-thickness ratio computes to 3.61:1. Both of these ratios lie within the limits observed archaeologically. In comparison to the unheated specimen, Schindler remarked that the heated specimen was much easier to work at every level of reduction and with all of the tools employed.

The cube of the formalized piece is approximately 15% of that of the parent biface; in other words, an approximate reduction of 85% of the volume was realized.

6.3.3) <u>Results of Knapping by Scott Silsby</u>

6.3.3.1) <u>Untreated Specimen</u>: The unheated sample was Specimen R from Series 2, a Stage 2 biface, having the following dimensions: length, 107.6mm; width, 101.5mm; thickness, 30.4mm. It had a recorded initial weight of 354.8g.

Silsby was able to reduce the larger piece to a broad-bladed, contracting stemmed biface that measures 80.6 x 36.8 x 15.1mm. This specimen has a length-to-width ratio of

2.2:1 and a width-to-thickness ratio of 2.4:1. Both ratios accord with archaeological examples.

The elapsed time to reduce the Stage 2 biface to Stage 3/4 proportions was 36 minutes; another 27 minutes were required to complete the formalized biface. The total elapsed time is one hour and three minutes.

The effort produced 1,462 flakes of various types, plus an uncountable quantity of sand, grit, and dust. The flakes have a mean weight of 0.21g. The aggregate weight of the collected debitage is 306.8g, and the weight of the finished specimen is 45.9g. The total combined weight of all products is 344.5g. The weight difference between starting and end forms is 308.9g., or a reduction of 87% by weight. The weight of unrecovered debitage is 10.3g. The cube of the formalized piece is approximately 13.5% of that of the parent biface; in other words, an approximate reduction of 86.5% of the volume was realized during knapping.

6.3.3.2) *Treated Specimen:* The heated sample was Specimen T from Series 2, a Stage 2 biface, having the following dimensions: length, 135.4mm; width, 118.6mm; thickness, 30.5mm. It had a recorded initial weight of 515.0g (Plate 6.7, left).

Silsby succeeded in reducing the early-stage biface to a broad-bladed, contracting stemmed biface that measures 91.0 x 44.0 x 16.0mm. This specimen has a length-to-width ratio of 2.1:1 and a width-to-thickness ratio of 2.75:1. Both ratios accord with archaeological examples The intermediate form shows incipient shaping of the hafting element (Plate 6.7, center).

The elapsed time to reduce the Stage 2 biface to Stage 3/4 was 36 minutes; another 16 minutes were required to complete the formalized biface. The total elapsed time is 52 minutes.

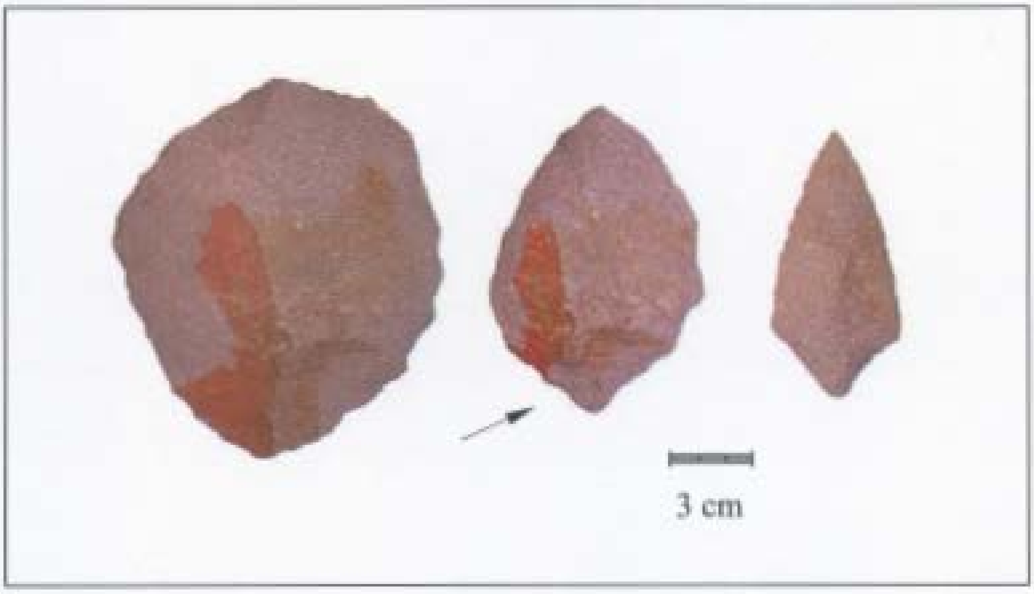


Plate 6.7: Reduction of Biface 2-T
(Knapped by Scott Silsby)

Note preliminary formation of the hafting element on the mid-stage biface (arrow).

The effort produced 2,943 flakes of various types, plus an uncountable quantity of sand, grit, and dust. These flakes have a mean weight of 0.15g. The aggregate weight of the collected debitage is 451.7g, and the weight of the finished specimen is 50.8g. The total combined weight of all products is 502.5g. The weight difference between starting and end forms is 464.2g, representing a loss of 90% by weight . The weight of debitage not recovered is 12.5g. The cube of the formalized piece is approximately 13% of that of the parent biface. Approximately 87% of the volume was lost during reduction.

6.3.4) Results of Knapping by Are Tsirk

6.3.4.1) Untreated Specimen: The unheated sample was Specimen N from Series 2, a Stage 2 biface, having the following dimensions: length, 127.0mm; width, 72.2mm; thickness, 28.3mm. It had a recorded initial weight of 379.7g (Plate 6.8, left).

Tsirk reported that early trimming went slowly and portions of the biface could not be thinned well. Three humps remained after 41 minutes of knapping. Subsequent attempts reduced the length to 75 mm, the width to 43mm, and the thickness to 18.0mm. At this point the biface broke diagonally, along a poorly cemented zone that is characterized by a rusty brown color (5YR 5/8; yellowish red in Munsell nomenclature). The larger fragment, the only one suitable for the attempt, could not be thinned. The final biface had a thick, ovate outline and measured 63.2mm in length, 36.5mm in width, and 16.8mm in thickness. The computed length-to-width ratio is 1.73:1 and the width-to-thickness ratio is 2.17:1. The piece does not conform to the template and must be regarded as unsuccessful (Plate 6.8, right).

The effort produced 2,239 flakes of various types, plus an uncountable quantity of tiny flakes, grit, and dust. These flakes have a mean weight of 0.15g. The aggregate weight of the collected debitage is 337.5g, and the weight of the finished specimen is 37.2g. The total accumulated weight is thus 374.7g. The final biface represents about 9%

of the starting weight of the parental early-stage biface (or a loss of 91% by weight). The cube of the formalized piece is approximately 15% of that of the parent biface; in other words, an approximate reduction of 85% of the volume was realized.

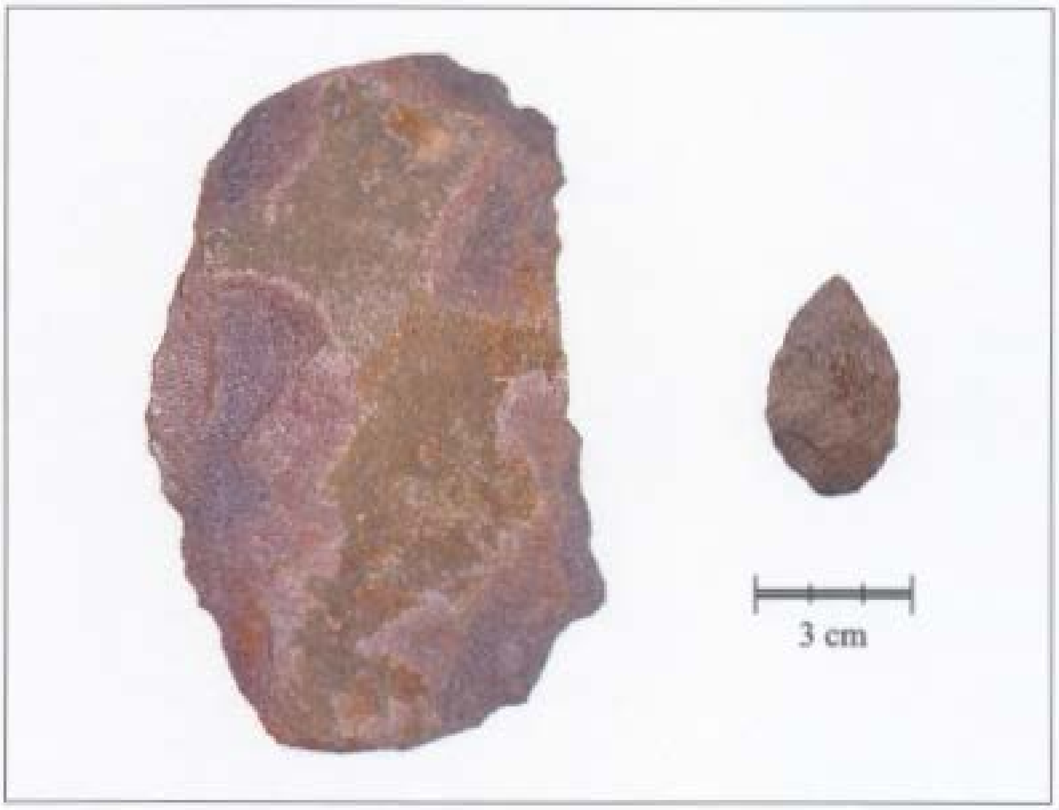


Plate 6.8: Reduction of Biface 2-N
(Knapped by Are Tsirk)

Because of inexperience in working Cuesta quartzite and flaws in the material, the knapper did not succeed in producing a biface according to the intended template.

6.3.4.2) *Treated Specimen:* The heated sample was Specimen B from Series 4, a Stage 2 biface, having the following dimensions: length, 130.0mm; width, 80.4mm; thickness, 24.3mm. It had a recorded initial weight of 296g.

Tsirk used stone hammers, organic billets, and pressure flakers in attempting to reduce the treated biface. Within 21 minutes of starting, the biface broke into three pieces upon impact from a moose antler percussor. Tsirk noted that the plano-concave geometry of the biface and a step-fracture produced earlier in reduction of the piece may have led to this result. He was able to continue knapping on the largest of the fragments, which measured approximately 76 x 57 x 20mm.

Within a minute, knapping on this piece led to its fracture as well, resulting in two pieces, both large enough to continue knapping. The larger piece measured approximately 58 x 43 x 10mm and the smaller about 45 x 26 x 10mm. The elapsed time to reach this point was 81 minutes.

Tsirk continued for another 53 minutes with an antler pressure flaker in an attempt to produce a serviceable biface, but "failed to achieve a target biface form by [the] inability to thin it sufficiently" (notes dated 11 January 2007). The piece is a rather thick biface, pyriform in plan and biconvex in both longitudinal and transverse sections. In an archaeological setting, this item would be classed as a biface reject.

Tsirk then continued working on the other fragment. This fragment also broke, about 15mm from the tip. Tsirk quit knapping when the piece could no longer be thinned. The end-product is a thick, irregularly convex stemmed biface, lenticular in longitudinal section and asymmetrically biconvex in transverse section. If recovered from an archaeological situation, this object would be classed as a biface reject.

The effort produced 2,850 flakes, mostly very small, and related pieces. In addition there was an uncountable quantity of sandy debris, grit, and dust. The mean weight of all flakes is 0.07g. The aggregate weight of the collected debitage is 200.0g, and the weight of the finished specimen is 20.2g. The total accumulated weight of debitage, biface rejects, and fragments is 220.2g, a difference of 0.6g from the starting weight of 220.8g.

The biface reject represents about 9% of the starting weight of the parental early-stage biface (or a loss of 91% by weight). The cube of the formalized piece is approximately 5% of that of the parent biface. Somewhat more than 95% of the volume was consumed in producing the end-product.

Despite problems in working with the stone, the width-to-thickness ratios of the biface rejects (2.11:1 – 2.17:1) exceed the minimum observed in archaeological collections, but this measure lies near the lower end of the range of variation for that measure among archaeological specimens.

6.3.5) General Observations

The knapping experiments show pronounced differences between the behavior of heated and unheated Cuesta quartzite. The differences are expressed in the difficulty of working the stone, the size and number of flakes, and the dimensions of end-products. These parameters will be considered in turn.

All of the knappers reported very great differences in working Cuesta quartzite before and after heat-alteration. Schindler reported that the material in its natural state was most intractable and frustrating to work. He noticed a great improvement in knappability in the thermally-altered specimen. Both he and Silsby related that the unheated stone caused excessive wear on their percussors, with particular regard to the organic billets.

Silsby was not flummoxed by working the untreated stone, probably because of technical virtuosity achieved in decades of knapping greenstone and other tough rocks. He remarked that, after heat-treatment, Cuesta quartzite behaved much better from a knapper's perspective. Tsirk observed that heat-treatment made Cuesta quartzite much easier to work in comparison with the untreated stone, which he described as "difficult to impossible" to flake. That his efforts yielded "essentially no success" can be attributed to the uneven quality of the stone and his inexperience in working fractious materials (Tsirk, notes dated 11 January 2007).

Consistent with Callahan's (1979:16 [Table 3], 167) assessment of the poor working qualities of quartzite in general, Cresson has noted that "untreated Cuesta [quartzite] represents the most difficult material worked by any group of prehistoric populations… [P]atterned evidence of heat-treating in every episode of use is not fortuitous" (Cresson, pers. comm. 4 April 2007).

Despite its intractability, Cuesta quartzite can be worked successfully in a "raw" state as demonstrated by the success of all of the experimental knappers in achieving bifacial forms. Only Tsirk failed to achieve the desired model, but he did, in fact, produce small bifaces. However, success is far more readily achieved after thermal alteration.

Another realization is that heat-treating does not appreciably speed the reduction from an early-stage form to a formalized specimen. It takes about an hour to reach the finished product whether the stone has been heated or not (Table 6.7). But thermal alteration does make the process much easier and demands less of the knapper and his tools. It also changes the appearance of the stone in what may have been symbolically significant ways .

Table 6.7: Time to Complete Formalized Bifaces
(Knapping Only, Recorded in Minutes)

Knapper	Unheated Stone	Heat-Treated Stone
Cresson	57	75
Schindler	N/A (failure)	50
Silsby	63	52
Tsirk	N/A (failure)	N/A (failure)

Because effective knapping must reduce bifacial thickness as much as possible without sacrificing either length or width, the width-to-thickness ratio is the critical point of comparison between the heated and unheated specimens. The following data are enlightening. Whether or not completed according to the desired template, the final bifaces produced from untreated Cuesta quartzite had the following width-to-thickness ratios: 2.0:1 (Cresson); 2.17:1 (Tsirk), 2.4:1 (Silsby); and 2.6:1 (Schindler),

By contrast, the width-to-thickness ratios achieved experimentally in formalized bifaces with thermally altered Cuesta quartzite range from 2.0:1 to 3.6:1. The mean value, excluding the unsuccessful trials, is 3.1:1. This figure is appreciably higher than the mean value obtained with untreated material (2.3:1).

Heating the stone enhances its knappability by diminishing fracture toughness. This loss of strength can be observed quite simply by attempting to break thin flakes between the fingers, as suggested by Callahan (1979:166). In my experience, untreated flakes are very difficult or impossible to break in this manner, whereas thermally altered flakes of the same size and shape will snap quite readily. This observation is consistent with Ebright's (1987) portrayal of heated quartzite flakes as brittle.

From the foregoing, one might posit that heat-treated Cuesta quartzite will break into more numerous and smaller fragments when knapped than the material in its native state. This situation appears not to be borne out by experimental data. The total number of flakes experimentally produced by knapping on untreated material is 8,458, whereas 7,196 flakes resulted from working thermally altered material (Table 6.8). Even restricting the count to the products of the Cresson and Silsby, who are the most experienced knappers of difficult stones, the results in relative terms remain unchanged. Together Cresson and Silsby produced 4,043 flakes from unheated Cuesta quartzite and only 2,761 flakes from the thermally altered material.

Table 6.8: Counts and Weights for Heated and Unheated Cuesta Quartzite				
Parameter	**Heated**	**Unheated**	**H/U Ratio**	**U/H Ratio**
Number	7,196	8,458	0.85	1.18
Weight (g)	915.7	899.5	1.02	0.98

The difference in weight between the heat-treated and raw materials is modest. The flakes of untreated stone have a total weight of 899.5g as opposed to 915.7g for the treated material (Table 6.8). The mean weight per flake in untreated Cuesta quartzite is 0.11g, while for treated stone it is 0.13g. The ratio of weights for heated vs. unheated stone is 1.18 and the inverse ratio is 0.85. Although this outcome differs from expectations—heated flakes were expected to be lighter—the differences are negligible, and given the small sample size, not amenable to statistical evaluation.

The untreated stone breaks into marginally more but somewhat lighter flakes than does the thermally altered material. Because of the toughness of the stone, untreated Cuesta quartzite can only be knapped by very vigorous hammering, which results in greater fragmentation. The number of flake fragments produced in untreated stone is 659 in contrast to a total of 543 fragments for the heat-treated material, a ratio of 1.21:1. The fragments derived from the unheated stone have a combined weight of 145.6g as opposed to a total of 168.5g for the thermally altered material. For weight the same ratio is 0.86:1. While the foregoing results might not seem to accord with the adduced weakening of the stone by heating, it might be reasonably argued that the excessive force needed to detach flakes from the untreated stone is the principal cause of flake fragmentation.

Along these lines, it is noted that unheated specimens show a greater incidence of detached quartz grains in the finest fraction of debitage than the heat-treated stone. Batches weighing 1g each were measured from each of eight samples, which included four each of treated and untreated stone from various biface reduction experiments. When examined under low power magnification (up to 10x), discrete quartz grains could be segregated and counted among the micro-debitage in most of the samples. Detached grains that retained their natural geometry or that were represented by an estimated minimum of half their original size were counted. These grains were free-standing or contained residual cement on less than half of their outer surfaces.

Most samples yielded one, two, or three grains per lot. One sample yielded none, and another produced 21 grains. The last-mentioned yield, from Specimen N of Series 2, was aberrant. It will be remembered that this piece could not be successfully reduced by the knapper, Tsirk, because it contained zones of incomplete cementation. This piece was unsuitable for knapping. If the high and low values are discounted from further consideration, then the remaining results indicate a marginally greater detachment of quartz grains from the silica matrix among the untreated stone, as compared to their thermally altered counterparts. However, the distribution is statistically insignificant under Chi-square ($X^2 = 0.2528$, df = 2, and $p \leq 1$).

When compared to the staged process of biface reduction in Cuesta quartzite, the manufacture of bifacial implements from pebbles of cryptocrystalline materials proceeds quickly and with relative simplicity. Whereas an hour or so is required to make a quartzite biface—discounting time engaged in heat-treatment—a serviceable biface can be rendered from a pebble in a matter of minutes. The time differential results from foreshortening the process of repetitious thinning and shaping. When pebbles provide the raw material, the size of the end-product is limited inherently, but the stones are ubiquitous, especially on the coastal plains, and easily gathered from the ground surface or from virtually any stream bed. The economic advantages of utilizing pebbles are important in understanding the demise of Cuesta quartzite exploitation (see Chapter 7).

6.4) General Conclusions and Assessment

Heating improves the workability of Cuesta quartzite, as it does many other lithic materials. Some studies have indicated only limited improvement in the knapping qualities of quartzites as a result of thermal alteration. For instance, Crabtree (1967) reported that silicified sandstone (i.e., orthoquartzite) cemented with chalcedony responds favorably, whereas metaquartzites do not. Ebright (1987:33) noted the same phenomenon, and related the improvement in knappability to heat-fluxing of the silica matrix.

Behm and Faulkner (1974) observed that heating Hixton quartzite yielded no appreciable gain in its workability among *inexperienced* knappers (emphasis added). Behm also informed me that heat will destroy the opal cement that binds much of the Hixton material together, whereas facies of the same stone cemented with chert-like substances would be likely to see improved flaking qualities (Jeffrey Behm, pers. comm., 30 April 2007). Ebright (1987) saw no particular improvement in the knappability of

Hardyston quartzite although the color did change (from a smoky gray) to a uniform pinkish hue.

Partially based on this sort of information and partly on the basis of his long experience, Errett Callahan (1979:169) long ago advanced the opinion that "heat treating will not improve the working quality of quartzite [all varieties included]," adding that "heat treating is no substitute for knapping ability… There is no substitute for effort, thoughtful and concentrated knapping, and awareness of percussor capabilities in working the tougher materials." Callahan has been reluctant to modify this opinion over the years (Jack Cresson, pers. comm., 26 April 2007).

While not disputing the value of knapping skill, Jack Cresson—himself a highly accomplished knapper—stated emphatically, "Hixton [quartzite] flakes superbly without thermal alteration, but [with heat-treatment,] it becomes very colorful and a pressure flaker's dream. The same holds true for Cohansey [quartzite]… Think of Hixton as the best grade of Cohansey without any extraneous inclusions" (Jack Cresson, pers. comm., 4 April 2007).

Cuesta quartzite ranks at the top of the list of tough materials. Of this stone, Jack Cresson has said, "In my opinion, untreated Cuesta represents the most difficult material worked by any group of prehistoric populations. That it co-occurs with patterned evidence of heat-treating in every episode of use is not fortuitous" (Jack Cresson, pers. comm., 4 April 2007). But with heat-treatment, Cuesta quartzite becomes far easier to work, as all of the knappers who experimented with it in the present research have attested.

Successfully producing bifaces from Cuesta quartzite requires a complex protocol, involving gathering the stone, heating it, and reducing it by stages. Bifaces can be rendered from locally available cryptocrystalline pebbles more easily and far more quickly than from Cuesta quartzite. These differences help to explain the eventual shift away from Cuesta quartzite for the manufacture of bifacial implements.

6.5) Summary

Experimentation in thermally altering Cuesta quartzite and in knapping it has added nuances to our understanding of how this material was used in antiquity. Fire is useful for modifying the physical appearance and knapping qualities of Cuesta quartzite. Typical changes include imparting increased redness and luster, and making the stone easier to flake. Experimental knappers attest particularly to the relative ease of knapping Cuesta quartzite once it has been successfully heat-treated. The changes attendant upon thermal alteration can be accomplished in relatively little time and carry potential symbolic as well as practical implications. In comparison to cryptocrystalline pebbles, Cuesta quartzite is difficult to work, but it can be rendered into larger implements than is possible with pebble stock.

Chapter 7: Synthesis

This chapter offers a synthesis of archaeological and experimental findings. It discusses the congruencies between archaeological and experimental data, along with data gaps and inconsistencies between the two. Then the technological sequence for Cuesta quartzite utilization is reconstructed, with respect to the major artifact types, bifaces and hammerstones. Integrating archaeological and experimental data, the interpretation explores the aboriginal Cuesta quartzite technology in terms of the stages involved in working the material and in regard to the decisions that directed the steps taken. The interpretation further suggests that both artisans and the lithic material were agents in a complex relationship that was imbued with symbolic meaning, especially with respect to the importance of color and fire. A rationale is offered for the initial exploitation of Cuesta quartzite in relation to other materials. An interpretation for the decline of its use is also presented. Both the ascendancy and decline are seen in economic terms. The chapter ends with a general summary.

7.1) Data Congruencies and Inconsistencies

For the most part, the experimental and archaeological data are in accord with one another. Experimental knappers have been able to replicate, with a high degree of formal fidelity, virtually the full range of artifacts known to have been made anciently in Cuesta quartzite. No attempts were made to reproduce notched bifaces and certain other forms, such as Teardrops and triangular points, which appear only occasionally in the archaeological record. It seems reasonably certain that competent experimental knappers could easily reproduce them. Indeed, it would probably be easier and quicker to make them than the larger stemmed bifaces, because they could be fashioned from rather small flakes, without having to pursue the reduction of larger bifacial cores.

Another point in common between experimental and archaeological assemblages is a high degree of failure. All archaeological knapping stations show many early-stage bifaces in fragmentary condition or so seriously flawed in their geometry as to compel their rejection. If we suppose that most of the ancient knapping was conducted by accomplished artisans, the inescapable conclusion is that working with Cuesta quartzite was (and is) frequently met with failure.

Except for Cresson, the knappers who participated in this study had no prior experience with flaking Cuesta quartzite. All, including Cresson, experienced some difficulty in working the material, particularly in its natural state. That other knappers with no practical experience in working this stone (Schindler and Silsby) were able to fashion acceptable facsimiles demonstrates that novices to this material can succeed, given a good grasp of knapping principles and perseverance.

The failure of knappers to replicate the intended form can reflect the composition of the stone, which can—and frequently does—possess flaws that are not visible at the outset. This situation seems to have resulted in Tsirk's inability to produce a formalized biface of the intended form. As shown by numerous archaeological examples, this outcome was common in antiquity.

On the basis of our experiments, it is only marginally possible to differentiate the debitage produced by individual knappers. Cresson, Schindler, and Silsby all produced roughly comparable numbers of flakes, and the weights per flake produced are also similar. Tsirk's efforts produced a great number of flakes, but this outcome is at least partially attributable to the poor quality of the stone with which he worked. Table 7.1 summarizes the results.

Table 7.1: Flake Counts and Weights by Knapper

Knapper	**Count**	**Mean Wgt. (g)**
Cresson	3,028	0.17
Schindler	3,034	0.10
Silsby	2,207	0.15
Tsirk	2,594	0.07

It seems highly unlikely that the products of the individual experimental knappers could be recognized without very sophisticated analysis (cf. Young and Bonnichsen 1984, 1985), were they to occur in archaeological settings, especially in the imbricated subterranean deposits that characterize the majority of sites upon the coastal plains of New Jersey.

Generally, our archaeological data do not support the kinds of analysis that would lead readily to the identification of individual knappers, at least by examining the quality of their flakes and end-products. (In contrast, see Grimm [2000] for a plausible example of apprentice vs. expert flint working on the same site). Yet, in most archaeological situations in New Jersey, the extent of debitage concentrations and the number of flakes involved clearly indicate limited operations, which would suggest the activity of very few or even solitary knappers in any given component.

An illuminating aspect of the experimentally produced debitage is the rather large volume of the smaller flake fractions, much of which consists of flakes under 6.4mm (1/4-inch) in greatest dimension, down to particles that amount to little more than dust. This realization is nothing new. Jeffrey Kalin (1981) demonstrated long ago that knapping in poorly structured materials (quartz, in his case) produces huge numbers of tiny flakes, which would never be recovered by conventional archaeological techniques. The sandy residues of the sort produced by experimental knapping would be virtually invisible in archaeological settings on the coastal plains of New Jersey, simply because they could not be differentiated from the finer geological particles (Fladmark 1982). This situation would be true even given discriminate separation by water or chemical flotation (cf. Struever 1968).

We cannot claim that the ancient techniques of stoneworking have been duplicated, although in some measure this must be true. For example, to judge from the cross-assemblage similarities of flake sizes and geometry, much of the modern knapping must be close in technique and instrumentation to that practiced in antiquity. In this regard, flakes are better indicators of process than finished bifaces (Crabtree 1972:3; Flenniken and Raymond 1986:604; Frison 1968; Ritchie and Gould 1986:35). In addition, in terms of metric dimensions and proportions, most of the experimentally produced bifaces bear a strong similarity to those observed archaeologically. If subjected to long-term weathering, these bifaces would be impossible to distinguish from aboriginal specimens.

Experimentation provides insights into knapping processes, which otherwise would remain nebulous or entirely unknown. Indeed, replicative experimentation holds the key to understanding the technological sequence of Cuesta quartzite reduction. It has also been valuable in assessing the utility of analytical indices, as discussed in the following section.

7.2) Evaluation of Analytical Indices

The following pages will offer an assessment of the analytical indices employed in this thesis. These indices include: 1) proportional flake analysis and 2) the flake-to-biface ratio. I also assess the utility of graphing flakes by selected types.

7.2.1) Proportional Flake Analysis

Proportional flake analysis compares the ratio of flakes derived from earlier in the knapping process to those that represent later stages of reduction. In the present work, 17 sites yielded data amenable to proportional flake analysis. Two sites yielded maximum ratio values between 1.0:1 and 2.0:1 for either earlier or later stage knapping. The range from 2.0:1 to 3.0:1 was represented in six sites, while six more produced values in the range of 3.0:1 to 4.0:1. No sites had indices with values between 4.0:1 and 5.0:1, and only one yielded an index greater than 5.0:1. In short, very strong differentials in the ratios were not observed (Table 7.2).

Table 7.2: Proportional Flake Analysis for Cuesta Quartzite

SITE	E/S	DEC	PRI	THI	L/S	Total	Earlier [1]	Later [2]	E/L	L/E
BU-226	0	59	69	272	454	854	128	726	0.18	**5.67**
GL-33	0	0	100	106	264	470	100	370	0.27	**3.70**
GL-344	18	4	30	110	75	237	52	185	0.28	**3.56**
BU-475	0	3	224	178	572	977	227	750	0.30	**3.30**
BU-492	2	3	18	12	65	100	23	77	0.30	**3.35**
BU-456 [3]	0	2	10	6	27	45	12	33	0.36	**2.75**
BU-277	0	0	69	61	107	237	69	168	0.41	**2.43**
GL-45	45	114	388	663	668	1,878	547	1,331	0.41	**2.43**
BU-714 [3]	4	1	17	28	13	63	22	41	0.54	**1.86**
BU-466 [4]	0	27	228	182	277	714	255	459	0.56	**1.80**
BU-403	0	63	664	544	648	1,919	727	1,192	0.61	**1.64**
GL-32 [3]	5	7	4	6	13	35	16	19	0.84	**1.19**
BU-90	113	21	85	76	65	360	219	141	**1.55**	0.64
GL-30 [3]	0	2	25	9	4	40	27	13	**2.08**	0.48
GL-31 [3]	0	0	21	5	5	31	21	10	**2.10**	0.48
BU-407	0	5	250	46	61	362	255	107	**2.38**	0.42
BU-473	0	0	46	10	7	63	46	17	**2.71**	0.37
GL-383 [3]	3	0	4	1	1	9	7	2	**3.50**	**0.29**
Experimental	156	0	16	492	595	1,259	172	1,087	0.16	**6.32**

Notes:

[1] Earlier stage flakes = Multi-stage , decortication, and primary flakes

[2] Later stage flakes = thinning and late-stage flakes

[3] Very small sample (<100 specimens)

[4] Partial data: from activity area only

Shading indicates sites at or near natural deposits of Cuesta quartzite.

Ratios in **bold face** indicate the *apparently* emphasized stage of flaking.

E/S = early-stage flakes; DEC = decortication flakes; PRI = primary flakes; THI = thinning flakes; L/S = late-stage flakes.

This outcome is at variance with the results of experimental knapping in which the later-stage flakes outnumber the earlier ones by a factor of more than six to one (Table 7.2). The experimental data are more comprehensive than could be expected in most archaeological assemblages, because a conscious effort was made to collect all debitage associated with the knapping experiments. This scale of collecting is a practical impossibility in conventional archaeological research, particularly in the field of CRM. In light of experimental findings, I would regard ratios of less than 3.0:1 as being weak *independent* indicators of specific flaking activity on most of the sites examined in this work, especially when small samples are involved (see below).

Proportional flake analysis can be imprecise for a variety of reasons. The samples of suitable flakes in the sites under consideration are generally small. Twelve of the seventeen sites (>70%) yielded fewer than 500 identifiable flakes (other than fragments), and only two produced more than 1,000 flakes. In addition, there can be some inaccuracy in classifying archaeological flakes as to their position in the reduction process. For instance, some small flakes, which are usually classified as elements of late-stage flaking, can result from trimming in the earlier stages of bifacial reduction. In addition, large flakes or flake blanks, which would indicate early-stage processing, could have been removed for use as expedient tools or for off-site biface manufacture.

Moreover, various stages of production might have occurred at different—though not necessarily distant—locations. If one or another of those stations were not included in the sample, the results would be erroneous to a certain degree.

Finally, dichotomizing the flaking process into earlier and later categories eliminates consideration of the middle range of the reduction sequence, which is best represented by thinning flakes. Plotting the percentages of primary, thinning, and late-stage flakes can and should be done to provide a more nuanced sense of the entire reduction sequence (Table 7.2, Figure 7.1; see interpretations, below).

To judge solely from the results of proportional flake analysis, all sites appear to reflect multi-stage processing, in most cases not strongly skewed in favor of earlier or later production. However, proportional flake analysis by itself can only be used as a general guide to ancient knapping behavior. The results of the percentage calculations for primary, thinning, and late-stage flakes helps to provide a more balanced view of the knapping process, as will be seen below.

7.2.2) Flake-to-Biface Ratio

The flake-to-biface ratio is a means of gauging the intensity of biface manufacture and rejuvenation at site where both flakes and bifaces occur in a particular material. Like proportional flake analysis, this index is an inexact measure of biface knapping. As shown in Table 7.3, there is a great deal of variability in the flake-to-biface ratios between the sites examined in this study. This variability suggests that this index might not be a reliable *independent* measure of biface manufacture or repair. In light of experimental work, I would consider values of less than 60:1 to be weak indicators of biface knapping on any given site.

The flake-to-biface ratio can be heavily skewed upwards by the selective removal of finished artifacts at the hands of collectors, or anciently by members of the native population, but the extent of such removals cannot be known in archaeological situations. A downward distortion would result from an incomplete sampling of flakes, which could result from small excavations or the effects of erosion and earthmoving. Therefore, this index is likely to be most informative in undisturbed sites, where sampling is comprehensive and obtained at random.

Table 7.3: Bifaces and Flake-to-Biface Ratios

Site	Bifaces			Flake/Biface Ratio
	Early-Stage	Mid-Stage	Formalized	
BU-226	0	0	0	N/A
GL-31	2	0	2	12.8:1
GL-32	2	0	0	28.5:1
GL-383	4	0	0	11.3:1
GL-30	4	0	1	7.9:1
BU-473	6	0	0	458.0:1
BU-492	7	0	0	210.3:1
GL-344	10	0	2	23.3:1
BU-456	12	0	0	28.2:1
BU-403	15	1	1	128.8:1
BU-277	16	1	1	288.0:1
GL-33	17	0	0	46.0:1
BU-714	19	0	0	12.8:1
GL-45	33	0	0	68.4:1
BU-407	43	0	0	103.0:1
BU-475	44	0	1	14.8:1
BU-90	53	2	0	106.2:1
BU-466	68	1	3	37.6:1

Note: Shading indicates sites at or near natural deposits of Cuesta quartzite.

There is a very weak, statistically insignificant correlation between biface numbers and the flake-to-biface ratios as presented in Table 7.4. The correlation coefficient is: $r(15) = -0.1300$, $p > 0.05$.

Table 7.4: Biface and Index Summary

SITE	E/S BIF	M/S BIF	FORM BIF	E/L FLK	L/E FLK	F/B RATIO
28-BU-475	44	0	1	0.30	3.30	14.8
28-BU-90	53	2	0	1.55	0.64	106.2
28-BU-277	16	1	1	0.41	2.43	288.0
28-BU-407	43	0	0	2.38	0.42	103.0
28-BU-492	7	0	0	0.30	3.35	210.3
28-BU-466	68	1	3	0.56	1.80	37.6
28-BU-473	6	0	0	2.71	0.37	458.0
28-BU-456	12	0	0	0.36	2.75	28.2
28-BU-714	19	0	0	0.54	1.86	12.8
28-BU-403	15	1	1	0.61	1.64	128.8
28-BU-226	0	0	0	0.18	5.67	N/A
28-GL-30	4	0	1	2.08	0.48	7.9
28-GL-31	2	0	2	2.10	0.48	12.8
28-GL-32	2	0	0	0.84	1.19	28.5
28-GL-33	17	0	0	0.27	3.70	46.0
28-GL-45	33	0	0	0.41	2.43	68.4
28-GL-383	4	0	0	3.50	0.29	11.3
28-GL-344	10	0	2	0.28	3.56	23.3

E/S BIF = early-stage biface; M/S BIF = mid-stage biface; FORM BIF = formalized biface.
E/L FLK = earlier/later flake ratio; L/E FLK = later/earlier flake ratio; F/B RATIO = flake/biface ratio.
Shading highlights data from sites that were essentially undisturbed.

The correlation between flake ratios and flake-to-biface ratios is even weaker: r (15) = 0.1178, p> 0.01. These results do not inspire confidence in the general utility of the these ratios with regard to interpreting the sites in question. The relative frequencies of primary, thinning, and late-stage flakes appear to hold the greatest interpretive promise, especially when considered in relation to the flake and biface assemblages, as well as the spatial relationships between the sites and known sources of Cuesta quartzite,

7.3) Summary of Archaeological Interpretations

The following pages will interpret the sites presented earlier in this study. These interpretations follows from a consideration of the observed archaeological assemblages in concert with the various analytical devices previously described.

Tabular data and a triangular graph facilitate the presentation. Table 7.5 shows the percentages of primary, thinning, and late-stage flakes, along with the experimental results. Figure 7.1 depicts the same data graphically. All sites with suitable flake samples are included, even if those samples are quite small. Incalculable sampling errors probably influence the proportions of flake types at all sites. Nevertheless, the results are informative.

Each corner of the graph represents 100% of the designated flake types, and the opposite boundary represents a value of zero. The dashed gridlines mark increments of 10% along each axis. As a point of reference, the plot for our experimental data (black triangle at point J) shows 30.0% primary flakes, 31.7% thinning flakes, and 38.3% late-stage flakes.

Table 7.5: Percentages of Primary, Thinning, and Late-Stage Flakes

SITE	PRI	THI	L/S	SITE	PRI	THI	L/S
28-GL-344	14.0	51.2	34.8	**EXP'L**	30.0	31.7	38.3
28-GL-32	17.0	26.0	57.0	**28-BU-466**	34.0	25.8	40.2
28-BU-492	19.0	12.6	68.4	**28-BU-403**	35.8	29.3	34.9
28-GL-33	21.3	22.6	56.1	**28-BU-90**	37.6	33.6	28.8
28-GL-45	22.6	38.6	38.8	**28-GL-30**	66.0	24.0	10.0
28-BU-456	23.0	14.0	63.0	**28-BU-407**	66.8	13.5	19.7
28-BU-475	23.0	18.3	58.7	**28-GL-383**	67.0	17.0	16.0
28-BU-277	29.1	25.7	45.2	**28-GL-31**	68.0	16.0	16.0
28-BU-714	29.3	48.3	22.4	**28-BU-473**	73.0	16.0	11.0

PRI = primary flakes, **THI** = thinning flakes, **L/S** = Late-stage flakes; **EXP'L** = experimental flakes.

The graph reflects the percentage of early, middle, and late stages of bifacial flaking for each plotted point. Although some sites clearly have a differential focus, all sites and the experimental data show mixed flake assemblages. This outcome is to be expected when multiple stages of bifacial reduction occur at the same location. This graphical approach offers somewhat more refined insights than proportional flake analysis, which merely casts the data into two mutually exclusive categories (i.e., early vs. late stage knapping).

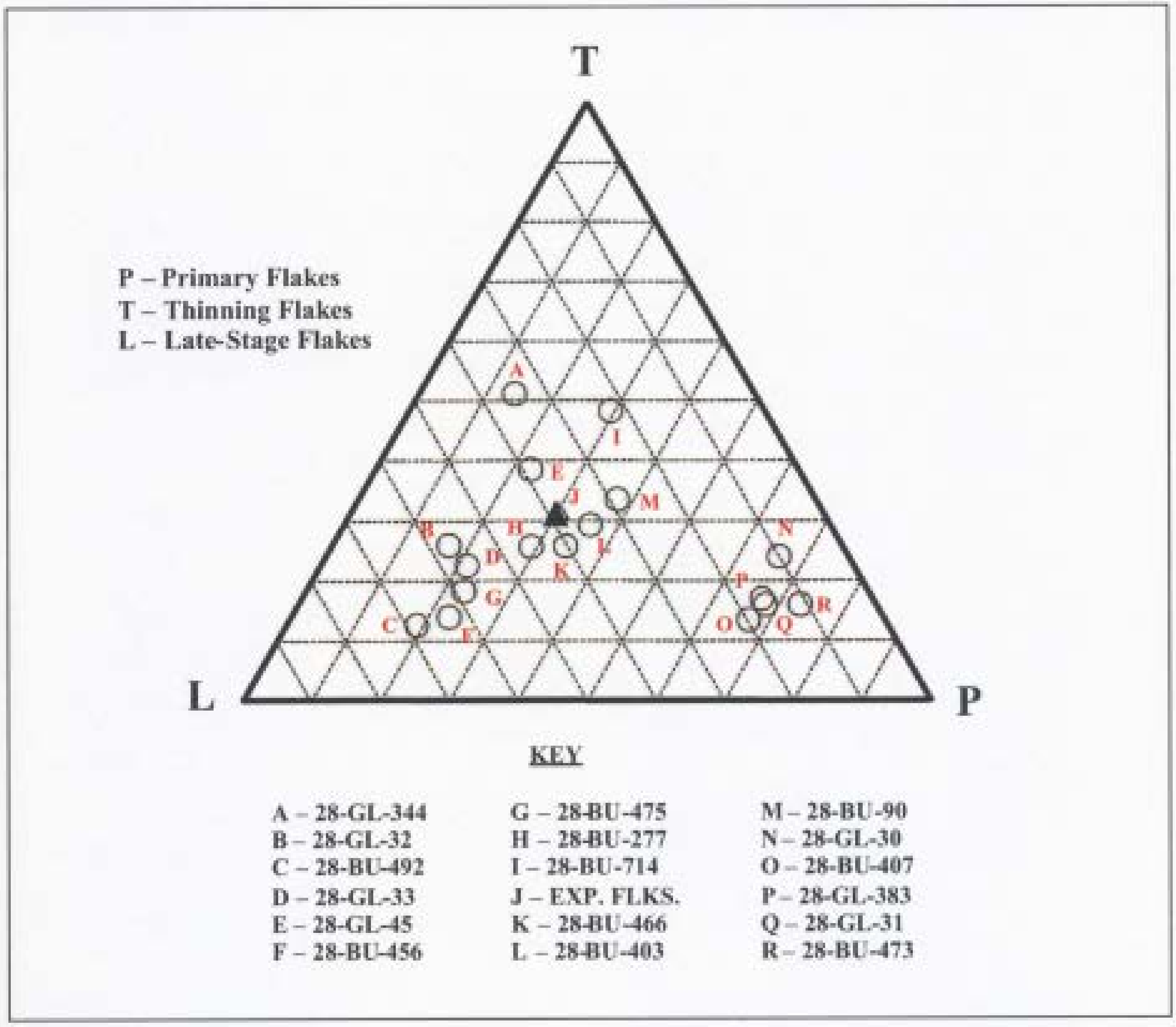


Figure 7.1: Percentage of Primary, Thinning, and Late-Stage Flakes

Considered in concert with other evidence, the graph suggests the following interpretations. Sites 28-BU-407 (O), 28-BU-473 (R) and 28-GL-383 (P) have relatively high proportions of primary flakes as residues of early-stage production. This distribution is consistent with deposits of quartzite cobbles at these locations. Early-stage forms also constitute a large portion of Cuesta quartzite bifaces from these sites. The bifacial products and sharp flake debris could have been used on-site, but the productivity probably exceeded local requirements. Thus, it seems likely that production was at least partly geared to the distribution of bifaces and flakes to consumers off-site.

The apparent predominance of primary flakes at Sites 28-GL-30 (N) and -31 (Q) probably reflect tool use rather than biface production per se, as no cobbles are at hand, and only small numbers of early-stage bifaces are present. This pattern is consistent with the importation of early-stage bifaces and large flakes for use as tools. The sample of flakes from Site 28-GL-383 (P) is too small to be definitive.

Sites 28-BU-492 (C), 28-BU-475 (G), 28-BU-456 (F), 28-GL-33 (D), and 28-GL-32 (B), have somewhat higher proportions of late-stage flakes than other stations. The first two sites are located at or near Cuesta quartzite deposits, and the flaking debris can be taken to indicate a refinement of early- and mid-stage bifaces. Early-stage bifaces are strongly in evidence. Site 28-GL-33 (D) also resides at a cobble bed, and the simultaneous presence of numerous early-stage bifaces strongly suggests early-stage processing at that site as well.

The distribution of flakes at 28-GL-32 (B), not near a known cobble source, probably reflects the maintenance of tools and weapons. The proportion of late-stage flakes may denote the trimming or resharpening of unfinished bifaces during their use. The small sample of flakes in Cuesta quartzite (N = 55) at this site militates against decisive interpretation. However, intensive knapping in Cuesta quartzite is not indicated. At 28-BU-456 (F), the assemblage of unbroken flakes is limited to 45 specimens, which is too small for confident analysis.

Sites 28-GL-344 (A) and 28-BU-714 (I) display a slight majority of thinning flakes, which suggests an emphasis on middle-stage biface reduction. Site 28-BU-714 (I) yielded many early-stage bifaces but relatively few unbroken flakes (N = 63), possibly indicating that unfinished bifaces had been imported for use as general purpose tools. This interpretation is consistent with a relatively high percentage of thinning flakes, which would make sharp cutting tools. These flakes could have been imported or produced on the site by reducing the early-stage bifaces.

Site 28-GL-344 (A) was an extensively excavated knapping station, which produced evidence of a broad range of biface reduction and formalization. The percentage calculations for the flakes at this site are consistent with this evidence as is the biface assemblage.

All other sites reflect multiple stages of bifacial reduction, concentrated near the center of the percentage distribution. Sites 28-GL-45 (E), 28-BU-277 (H), 28-BU-466 (K), and 28-BU-90 (M) occupy locations at or near Cuesta quartzite deposits. The mixed nature of staged biface reduction at these locations is consistent with their proximity to geological sources. Inasmuch as our experimental knapping (J) involved the full range of flaking, from early-stage reduction to formalization, its position near the center of the graph is to be expected.

The results of experimental knapping also accord well with the findings at the other sites in this group. Before excavation, sites 28-BU-403 (L) and 28-BU-466 (K) were virtually undisturbed, and the resemblance of their flake distributions relative to our experimental data is remarkable.

The source of quartzite used at site 28-BU-403 (L) is not known. However, considering the rather well balanced nature of flaking debris at this site, the geological deposits may be expected to be near at hand.

When the data permit analysis, the artifacts can be seen to vary in relation to their distance from the source of Cuesta quartzite. As previously noted, quartzite cobbles occur along the banks of a tidal slough that separates sites 28-GL-33 and 28-GL-45, along Raccoon Creek in Gloucester County. In Burlington County, several sites occupy locations that also produce Cuesta quartzite in natural deposits. Although it has not been possible to demonstrate that these deposits are the actual sources of raw material at any of the sites in question, that assumption is made here with due caution.

Among the sites in Gloucester County, only those remote from quartzite sources produced finished or formalized artifacts, whereas those at or close to the assumed source yielded debitage and bifaces in an early stage of reduction. This relationship is plainly seen in Table 7.4 and Table 7.6. Figure 7.2 graphs the quantity of Cuesta quartzite bifaces and flakes relative to the distance from the geological source.

Temporarily discounting the data from 28-GL-383, which was incompletely explored, the correlation coefficient of distance to source and total implements in Cuesta quartzite calculates to: $r(3) = -0.7272$, $p > 0.01$, while the correlation of distance to artifact density is: r (3) = -0.7142, $p > 0.01$. Although these are strong inverse relationships, they are not significant statistically, possibly because of the small samples involved. On the other hand, the correlation between distance and flake-to-biface ratios is strong as well as statistically significant: r (3) = -0.9298, $p < 0.05$.

Table 7.6: Artifacts in Relation to Distance from Source, Gloucester County (Excludes Sites with No Known Quartzite Sources)

Site	Distance to Source (meters)	Bifaces	Flakes	Cores and Cobble Tools	Total Implements	Relics per m^2	Flake/Biface Ratio
28-GL-33	0	26	1,201	1	1,228	15.33	46.2
28-GL-45	0	65	4,445	0	4,510	61.16	68.4
28-GL-383	0	13	161	16	190	N/A [1]	11.3
28-GL-32	460	2	57	3	62	0.65	28.5
28-GL-31	610	4	51	1	56	0.70	12.75
28-GL-30	915	6	55	2	63	0.85	7.9

[1] The size of this site is unknown because of limited investigation.

If the data from 28-GL-383 are included, the correlation coefficient for distance to total implements becomes: r (4) = -0.5492, $p > 0.05$, while that for distance and flake-to-biface ratio becomes: r (4) = -0.6361, $p > 0.05$. These are moderate correlations, which are not statistically significant. The coefficient for distance to artifact density cannot be determined for want of adequate data about the size of 28-GL-383.

The stretch of Raccoon Creek in proximity to these sites is not known to contain any Cuesta quartzite deposits other than those at 28-GL-33 and -45. This situation would appear to strengthen the analytical value of these data. A similar analysis is not possible for 28-GL-344 because the associated geological source remains unknown.

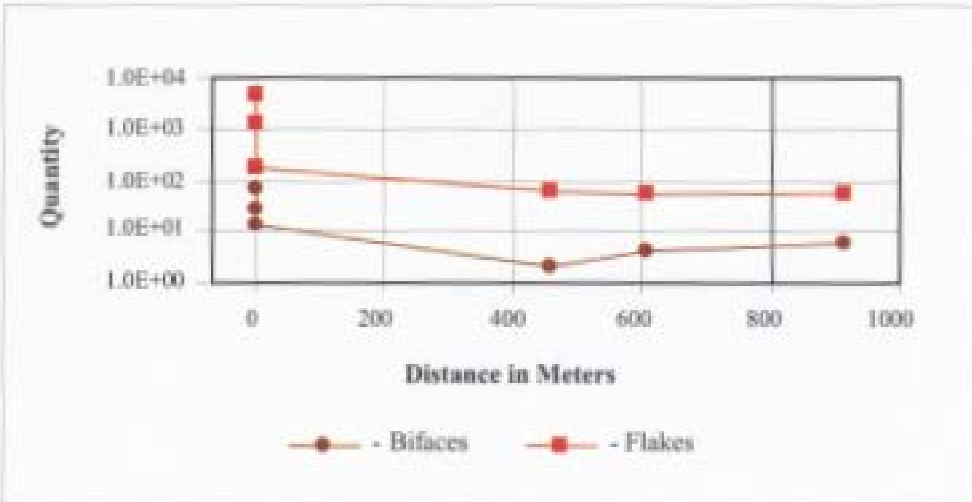


Figure 7.2: Bifaces and Flakes Relative to Distance from Source for Six Sites in Gloucester County

In Burlington County, six archaeological sites coincide with geological deposits of Cuesta quartzite. These sites include the following: 28-BU-475, 28-BU-90, 28-BU-277, 28-BU-407, 28-BU-492, and 28-BU-473. Because all values for distance are zero, it is not possible to calculate correlation coefficients for these sites. For the remaining sites in Burlington County, the geological sources are uncertain. This situation requires that the Gloucester County sites stand as exemplars for the relationship between artifact frequency and the distance from the probable geological sources of Cuesta quartzite.

Although the available data are not as strong as one might hope, it does seem that the character of artifacts in Cuesta quartzite varies with respect to distance from the geological sources. Sites at source locations show a greater number of early-stage bifaces in relation to formalized specimens. These sites also exhibit a high incidence of flaking debris, as well as generally higher flake-to-biface ratios (Table 7.4 and Table 7.6).

The apparent emphasis on later-stage flaking at a number of sites near geological sources—28-GL-33 and 28-BU-475, for example—clearly suggests that at least some semi-finished or finished specimens were exported for use at more distant locations. This interpretation helps to explain the observed paucity (or complete absence) of formalized bifaces at these sites. Sampling biases introduced by modern relic-hunting remains an unresolved issue.

Sites that occur at a distance from the geological sources tend to show more (though not many) formalized bifaces, as well as fewer flakes. Those flakes tend to be larger specimens, derived from early- and mid-stages of knapping. This situation suggests that these flakes were imported or maintained for potential use as expedient tools. Likewise, the occasional appearance of early-stage bifaces at remotely situated sites suggests their use as general-purpose tools or as cores for the production of useful flakes. Primary reduction is not indicated. This conclusion is bolstered by the relatively low flake-to-biface ratios at these sites (Table 7.3). This interpretation remains to be tested at sites where biases from heavy collecting pressure in modern times is not a factor.

In summary, it can be said that the reduction of Cuesta quartzite at or near natural sources was directed to the manufacture of a range of easily transportable bifacial products. Some of those artifacts were doubtless used at the knapping site, but others were probably taken away to serve the needs of populations in residence at more distant locations. At this point, the discussion turns to a reconstruction of the technology of Cuesta quartzite utilization.

7.4) Technological Sequence for Cuesta Quartzite

This section details the reconstructed operational sequence for the exploitation of Cuesta quartzite. The technological chain consists of the following major links or nodes: 1) discovery and recognition of Cuesta quartzite as a resource; 2) the acquisition and selection of the material for cultural uses; 3) its reduction for specific purposes, primarily for the production of bifacial implements in a range of styles and functions and for hammers; 4) repair, rejuvenation of used or damaged pieces; and 5) eventual discard. The following discussion treats each of these elements on the basis of archaeological observations and insights gained from experimentation. A schematic representation appears at the end of this chapter (Figure 7.3).

7.4.1) Discovery, Recognition, and Acceptance

The technological sequence of Cuesta quartzite reduction begins with the recognition of the material as a potential resource. To utilize this material, human populations must first have defined and understood its natural distribution and useful properties. Since it occurs widely in surficial scatters along the flanks of the Cuesta, the discovery of the stone as a substance could scarcely have been much of a challenge. However, its discovery as a resource is another matter entirely. In other words, its potential uses as tool-stone may not have been so apparent. For utilization to proceed on anything but a casual scale there must have been a substantive recognition of its value in an economic and social context.

Despite its obvious presence, a conscious decision to use the stone would have depended upon at least three considerations. First, understanding its working properties was necessary, and that knowledge presupposes some level of prospecting and exploratory knapping among ancient populations. Since archaeological evidence clearly suggests that at least limited use of Cuesta quartzite occurred by Early/Middle Archaic times, the knapping skills necessary to work this fractious stone existed well before it became a locally (or regionally) popular material.

Second, the use of the material must have been considered in light of the availability and costs of acquiring alternate materials. By the time of the Cuesta quartzite efflorescence, beginning six or seven millennia ago, other materials such as jasper, rhyolite, and argillite were already in widespread use. As at least some of these lithic resources occurred only within limited geological formations, networks for their acquisition and distribution must have been created previously (Stewart 1987a). The maintenance of such networks must have entailed both material and social costs. A decision to use a comparatively difficult material, such as Cuesta quartzite, must have been attended with some thought about the offsetting advantages. The trend towards increasing populations in the region during Archaic times may have been a stimulus to the use of Cuesta quartzite.

Finally, the material must have possessed qualities that were consistent with prevailing concepts of artifact design and use. The parent stone must have been large enough to accommodate the intended size of the finished artifacts, and the material must have been suited to the intended functions. Both of these desiderata were satisfied, the refractory aspects of workability notwithstanding.

Once the potential applications of Cuesta quartzite were realized, a decision to make use of the stone must have occurred, or it would have been left untouched, at least in archaeologically visible ways. It may be, and probably was, the case that initial efforts at working this difficult material were nugatory or abortive despite its local abundance. Without archaeological traces this speculation cannot be effectively confirmed or denied.

7.4.2) Acquisition and Selection

The acquisition of Cuesta quartzite required access to one or more sites where the material occurs in nature. Archaeological evidence clearly suggests that certain sites have coincident cultural and geological deposits. Whether the first use of the stone occurred because it was at hand is not known, and is probably unknowable. Some sites, such as 28-BU-475 witnessed human occupation well before the period described by the use of Cuesta quartzite (see Chapter 4). In other cases, at least, one might suppose that the natural presence of quartzite was an inducement for settlement at particular sites.

Once the decision had been made to use Cuesta quartzite, the criteria concerning selection came to the fore. On the basis of archaeological examples and the knowledge gained through experimental knapping, the selection was largely guided by auditory, visual, and tactile senses. Modern knappers often tap the stone and listen closely to the resulting sound. Lithic materials that have more or less homogeneous structure and lack internal flaws produce clearer, more resonant tones when struck than stones of poorer quality. Experienced knappers develop an ear for this sort of resonance. There is no way of knowing if ancient knappers followed this routine, but it would seem very likely that they did.

Although there are exceptions, most archaeological examples of bifaces in Cuesta quartzite consist of finer grained materials, whereas hammers tend to be made from stone of coarser composition. Accordingly, texture was doubtless an important variable in material screening.

In the same vein, it is likely that color, luster, and brilliance contributed to the selection process. It has been shown that Cuesta quartzite witnesses changes in these properties when the stone has been heat-treated (Chapter 6). With experience, knappers learn the approximate degree of shift that may be expected in these qualities from raw materials of differing compositions. Hence, initial selection was probably regulated to a large extent on the basis of external appearances. Because modifications in visual properties correlate with changes—usually improvement—in knappability, it seems inescapable that color (and the ability to modify it by fire) also had symbolic importance, a point taken up later in the discussion.

The sense of feel is important to knappers. The relative coarseness of the stone's texture can offer subtle clues to the knapper concerning the composition and knappability of the material. Its heft gives a sense of density, which can help screen materials with substantial internal flaws.

7.4.3) <u>Reduction</u>

The manner of reducing Cuesta quartzite for artifact production depended largely upon the size of the target piece. Very large cobbles or boulders have rounded surfaces with rather large diameters. The circumference of these masses presents little vulnerability to fracture by percussion, even when they are struck forcefully with hammers of considerable size and weight. The only practical way to break them is by rapid thermal expansion, and that is accomplished by building a hot fire along one side or on top of the mass. Once the surface is hot, it may crack, as shown by experimentation (Chapter 6). It is well known that quenching a hot rock with cold water will virtually ensure fracture (Holmes 1919:364-365; Purdy 1974:42), but it seems likely that this practice would be more easily accomplished now than in ancient times, when the energy needed to haul water—not to mention the cost of creating containers—might have been conserved for other uses.

In any case, smaller cobbles can be broken either by heat or by direct percussion. Heating Cuesta quartzite until it cracks or breaks outright guarantees a diminution of fracture toughness, which seems to have been a desired goal anyway. Blocky or cuboidal fragments can be made into bifaces or hammerstones, at the preference of the artisan. Pieces detached directly by percussion include blocky masses and large flakes or flake blanks. Either serves for the production of bifaces, whose reduction sequence we now consider.

7.4.3.1) Biface Reduction: Biface reduction involves producing an implement according to an acceptable template or design. It is assumed from archaeological examples that the prototypical end-product follows a broad-bladed, contracting stemmed style, roughly equivalent to Coe's Morrow Mountain I form (Coe 1964: 37-43). Bifacial reduction apparently defaulted to implements of this form unless the starting piece—either a bifacial core or a large flake blank—were to fracture, whereupon the default would shift to a smaller, narrow-bladed, contracting stemmed, or possibly a side-notched form. Other, demonstrably rare forms—such as Teardrop, Fishtail-variant, of triangular bifaces—were at least occasionally produced, as shown by collections research.

Biface production begins with selecting a suitable piece of stone as the starting form. This piece may be a rough block or a flake blank. In most cases, heat-treatment follows, but if only a rough core is required—say for use as a hammer or chopper—heating the piece may be omitted or delayed.

7.4.3.1.1) Heat Treatment: If the decision is made to heat the piece, the artisan must choose the manner of heating. In aboriginal times, an open wood fire was the only means available. A general lack of pit features on Cuesta quartzite production sites indicates that thermal alterations were accomplished directly upon the ground. It is assumed that, for the sake of economy, multiple pieces were processed together and that other tasks requiring heat—such as cooking—may have transpired concomitantly, as in our experiments (Plate 7.1).

Plate 7.1: Cooking during Heat-Treatment
(Fire Experiment on 19 September 2006)

Heat treatment can be accomplished directly beneath the burning fuel or beneath an insulating layer of sand or ashes. The artisan must decide this matter. While larger masses can withstand thermal shock, experimentation shows that insulation is beneficial (or even necessary) for treating smaller pieces. Without insulation smaller, thin-edged objects may suffer destructive levels of heat.

The duration of firing is another variable. If only physical considerations apply, then the exposure may be longer or shorter, depending upon the size and shape of the pieces being treated. Obviously, smaller artifacts would require shorter exposures than larger ones. Experimental work shows that very small pieces can be thermally altered in a matter of minutes, whereas pieces having the size of small cobbles might require hours. Experiments also repeatedly demonstrate that prolonged heating—for more than a few hours, or days on end—is not required for successful heat-alteration (Griffiths et al. 1985; also see Chapter 6, this thesis).

But the nature of the rock being processed is not the only consideration. The prevailing socio-religious views may require longer or shorter exposures. One can only suppose that the prolonged firings of knappable rocks sometimes recorded in ethnohistorical accounts were cultural imperatives (Steward 1938:337; Hester 1972). The character of ancient social directives regarding the thermal alteration of Cuesta quartzite cannot be reconstructed in detail from the present archaeological data.

7.4.3.1.2) Knapping Early-Stage Bifaces: The reduction of larger lithic masses to bifacial forms requires the preparation of early-stage bifaces. If the starting form is a smallish flake blank previously produced then this step is minimized or eliminated altogether. The production of early-stage bifaces begins with hammerstone percussion, and entails the following tasks, which must be satisfactorily completed to continue toward an acceptable end-product: edge- trimming, reduction in thickness, and the achievement of an oval form.

First, the edge irregularities and residual cortex must be trimmed away, usually by means of direct hammerstone percussion. This work produces debitage in the form of angular edge fragments and other early-stage flakes. If flaking produces very weak or thin edges, they must be removed, either with a soft stone hammer or an organic billet. Organic billets can be used to detach stacked masses behind the incipient biface edge. Abrading the stacks with a hammerstone—a technique that Jack Cresson calls "dorsal ridge abrasion"—helps to release them (Jack Cresson, pers. comm.). Although it can be obvious on certain smooth stones, such as rhyolite, the application of this technique is difficult to see on Cuesta quartzite specimens because of the natural coarseness of the stone. But abrasion can sometimes be felt on archaeological, as well as experimental flakes. Therefore, this aid to biface thinning was both known and practiced anciently. The application was used at any stage of reduction, when the removal of step-fractured or stacked masses became necessary.

Bifacial thinning requires maximizing the removal of thickness without unduly sacrificing length or width. Flakes must reach as far toward the center of the broad faces as possible. As accomplished experimentally, this is ordinarily done with hammers, supplemented at the knapper's discretion with the use of organic billets. Flaking tends to follow the pronounced ridges between flake scars. Similar choices must have presented themselves anciently. The close similarity in size and shape of the earlier debitage between archaeological and experimental assemblages shows this correspondence to be the case. The geometry of the biface at this point does not require special preparation of striking platforms.

In addition to thinning, the goal of early-stage knapping is to achieve a symmetrical, oval form, suitable for further reduction. This goal is achieved through the coordinated shaping and thinning of the overall form. When successful, the early-stage bifaces in Cuesta quartzite resemble Abbevillian handaxes, and have width-to-thickness ratios in the range of 2.00:1 to 3.00:1. They are roughly intermediate to Callahan's (1979:9-10, 30-31, 1989:6) Stage 2 and Stage 3 bifaces. Generally, because of the fractious nature of the stone, thinner profiles cannot be achieved experimentally, and were rarely achieved archaeologically so far as our data indicate.

If knapping succeeded in producing a suitable early-stage biface, then reduction to a mid-stage form would follow (see following section). However, in the event of undue fracture or some other disabling problem, such as the accumulation of a stack that could not be reduced, the knapper would once again face a choice. Further work on the piece might be abandoned and the piece discarded. On the other hand, if fracture left pieces large enough to offer the promise of success with an acceptable alternate form, then reduction might continue. Rather than producing the typical broad-bladed contracting stemmed form, the knapper might default to a narrower design, either with a stemmed or notched tang.

Before proceeding to further reduction, the knapper would decide whether reheating would be necessary or desirable. Based on experimental experience, the choice would be determined by appearance and the ease of flaking. Criteria respecting the visual characteristics of Cuesta quartzite include color, luster, and the reflectivity of the embedded quartz grains. All of these aspects vary with the degree of thermal penetration, itself regulated by the intensity and duration of the fire, the size and shape of the stone, and the length of exposure, as well as the position of the rock in relation to the heat. Experimentation in open wood fires demonstrates a color penetration of approximately 2mm on early-stage bifaces (Chapter 6).

Color changes attendant upon heating to critical temperatures include increased redness or a darkening of the hues present in the rock in its natural state. The composition of most Cuesta quartzite is quite similar as far as petrological testing can determine, but minor dissimilarities in such substances as iron oxides can affect the colors achieved by heating. Luster also increases with heating. This change is expressed only on the interior fabric and not on the exterior surface, unless the natural surface has been removed by flaking after previous episodes of heating. Heating tends to purify the quartz grains, which results in an enhanced reflectivity. All of these factors—which have a rather mystical property—give visual clues to the success of a heat-treating session.

The final proof of successful thermal alteration comes when the knapper takes one or more test flakes, which will show the degree to which heating has (or has not) improved the flaking qualities of the stone. In the case of previously heated bifaces, routine knapping provides a sufficient test of flaking quality.

If desired from a practical standpoint, or if required by tradition, the biface would be heated again before moving onto the production of a mid-stage biface. Evidence from archaeology strongly indicates reheating at every stage of reduction. This observation leads me to believe that repeated thermal alteration was programmatic and quite possibly sustained as a cultural imperative.

A critical decision at the end of early-stage knapping concerns the possible distribution of the unformalized bifaces. Several archaeological knapping stations appear to have been established at or near sources of Cuesta quartzite for the purpose of manufacturing early-stage bifaces for distribution to remote sites. Intermediate and finalized production transpired at other sites, such as 28-GL-344 (see Chapters 4 and 5). An inverse relationship between the amount of Cuesta quartzite debitage and the distance to known sources has been demonstrated, along with a direct relationship between the extent of formalization and distance to source locations (Chapter 5). The appearance of formalized bifaces in Outer Coastal Plain sites—for example, at Indian Head (28-CU-79) and the Blue Hole (28-CA-29) sites—well beyond the natural distribution of Cuesta quartzite indicate that a distribution network existed in antiquity.

7.4.3.1.3) Knapping Mid-Stage Bifaces: Whether or not at the sites of original reduction, early-stage bifaces were typically reduced to forms intermediate to their formalized counterparts. Such forms are called mid-stage bifaces.

In knapping mid-stage bifaces, the artisan would employ both hammerstones (with variable size and hardness) and organic billets, of which wood or antler might be selected according to criteria established by habit or tradition. Pressure flakers may also be employed, especially for platform preparation and to push off thinning or shaping flakes.

The geometry of the biface now requires the preparation of striking platforms to control the size and proportions of the flakes. Striking platforms can be prepared by selective flaking so as to isolate the point of attack. This work can be accomplished with hammers or pressure flakers. The artisan may choose to abrade the platform—or to nibble away with small pressure flakes—to ensure good contact between the flaking tool and the work piece. As usual, flaking follows the flake ridges, but with good control, the flakes now carry in broad, thin arrays toward or beyond the midline of the broad faces.

Using the chosen percussor, the knapper would then proceed to trim edge irregularities so as to transform the sinuous edge on the early-stage biface to a straighter configuration, well balanced along the center line in an edge-on view. This work would entail the application of percussion and some pressure work using platforms, prepared if necessary, as described above.

Simultaneously, secondary thinning would continue apace. As the work advances, the flake scars proliferate, and the flake scar concavities become flattened and less pronounced. That is, the surface topography shows progressively reduced relief. Any surface irregularities that might thwart reduction, such as stacking, require attention, and dorsal ridge abrasion may prove helpful to successful thinning.

Mid-stage bifaces are relatively refined, having a resemblance to Acheulean handaxes; they are equivalent to the products of Stage 3 in Callahan's (1979:9-10, 30-31 1989:6) scheme. In Cuesta quartzite, the ordinary width-to-thickness ratio remains in the range of 2.00:1 to 3:00:1. As previously noted, this tendency toward residual thickness is inherent to the stone.

If the reduction succeeds to this point, the question of distribution again would arise. Mid-stage bifaces might be saved for allocation or delivery, or reduction might continue to formalization. If any stations specialized in the production of mid-stage bifaces, there is scant archaeological evidence of it. Fragments might be recycled into smaller formalized implements, but by this stage, the prospects for recovering from material failures become fairly remote. This situation is demonstrated by Are Tsirk's experience in knapping Cuesta quartzite (see Chapter 6). Failures most likely lead to discard.

As noted above, reheating of the successful mid-stage bifaces would be considered before moving on to the production of preforms. Similar judgments would be involved.

7.4.3.1.4) Knapping Preforms: In making preforms, the knapper would follow the same principals and techniques as when producing mid-stage bifaces, but the focus shifts to refined thinning. When successfully completed, the preforms resemble the end-product, except that the formalization of the hafting element remains to be accomplished. In this form the bifaces are consistent with Stage 4 in Callahan's nomenclature (Callahan 1979:9-10, 30-31 1989:6).

If the knapper experiences difficulties in refining the mid-stage biface, additional heat-treating might be attempted to rescue the effort. If the preform has been created without mishap, then yet another round of thermal alteration still might be undertaken before final formalization to facilitate the concluding flaking, especially by pressure. If, on the other hand, the intended preform were to break, one or more of the fragments might be retained for future work and rejuvenated by firing—depending on size and condition—but as with failures at the mid-stage of reduction, rejection would be more likely.

The question of continued knapping or distribution to consumers also arises at this point. The data are slender. Only one complete preform was found, at the Deknight Farm in Cumberland County. This site also yielded five formalized bifaces and three other bifaces of late-stage form (either unfinished or fragmented), but no early-stage bifaces. This situation suggests that the site—which lies beyond the natural distribution of Cuesta quartzite—received late-stage and possibly formalized bifaces from remote production sites.

7.4.3.1.5) Knapping Formalized Bifaces: As just noted, the formalization of bifaces from preforms requires the creation of a hafting element as well as final straightening and sharpening of the point and cutting edges. At this point the question of function arises, and that, in turn, may have determined the form of the hafting element.

One might suppose that, in relation to stemmed tangs, notched hafts would result in sturdier bindings, which would be serviceable in operations, such as slicing and sawing, that would require reciprocal motions. Stemmed bifaces would be most secure in end-on applications of force, such as piercing or unidirectional cutting. The functional differences cannot be reconstructed from edge wear for the want of unambiguous data. Nevertheless, one must suppose that the differences in form arose from choice or preference within a cultural tradition.

In any case, the tools likely to have been employed include small hammers, organic billets, pressure flakers, or all three. These implements would have been deployed according to the discretion of the artisan, but their application and the choice of hafting design would have been influenced by cultural tradition.

To create the haft would require that the knapper remove the basal corners of the preform, in the case of stemmed bifaces, or to reduce the lower margin from both sides in the case of notched bifaces. Specialized notches have never been observed archaeologically on Cuesta quartzite bifaces, so there is little need or prospect of explicating notching techniques. A further step, sometime employed, is to dull the edges of the hafting zone, presumably to protect the bindings from damage.

Experimental knappers indicate that production of the hafting fixture would be undertaken earlier rather than later in biface knapping, because the reduction in dimensions by knapping entails the risk of breakage. Succeeding at roughing out the haft before finishing the rest of the implement would save the effort lost if a nearly finished biface were to break while creating a stem or notched tang. In our experimental work, this strategy is evident in Silsby's work (Figure 6.7, center), even though he makes no overt mention of it in his commentary. Archaeologically, the order of precedence can be most readily seen in notched bifaces, several of which show well developed hafts prior to final thinning or blade shaping (see Chapter 3).

If bifaces broke during stemming or notching operations, the blade might still be recycled by reshaping the base. This sort of behavior might well result in some of the smaller specimens observed in collections. Some bifaces that snapped across the blade prior to completion were simply abandoned at the knapping station (see an example from site 28-GL-344, discussed in Chapters 3 and 5).

Successfully completed bifaces could be saved for distribution, exported to other locations, or used immediately. Except when they broke in manufacture, formalized artifacts rarely occur on production sites, and the mechanisms for their distribution to consumers or the relationships between artisans and consumers remain nebulous.

The relative difficulty of working Cuesta quartzite as opposed to other materials has been rather convincingly demonstrated by experimentation. The concentration of production sites near sources of raw material, together with the dissemination of finished products into terrain well beyond the limits of the natural distribution, suggests the possibility that Cuesta quartzite bifaces were produced by specialists. As attractive as this surmise may be, the archaeological data are too exiguous to admit of confirmation.

7.4.3.2) *Biface Use:* At every stage of refinement, from early-stage biface to formalized implement, bifaces had functional edges and surfaces, which could have been, and demonstrably were, used for a variety of useful work. The cruder forms would serve as rough stone tools for hammering, chopping, and shredding tasks. The worn edges and surfaces would disappear as the implement progressed along its trajectory toward finalization, if not abbreviated by failure and discard. Naturally, bifaces only show the most recent activities that are recorded by scars upon their surfaces. Hence, the most revealing artifacts are ones that were lost or discarded while still carrying telltale evidence of former uses.

While evidence from edge attrition is not strong (because of the nature of the stone), many Cuesta quartzite bifaces show evidence of reworking and, resharpening. The most common indicators of reworking are a foreshortening and a narrowing of the blade with respect to the hafting element. As explained in Chapter 3, the dimensions of bifaces are subject to reduction; in particular, changes in size of the blade are disproportionate to those affecting the stem, because the hafting element is not reworked, unless broken, while the blade can be—and often was—repeatedly sharpened or repaired.

Several bifaces have tips modified for specialized use as gravers. Other well worn, formalized bifaces have been rendered serviceable late in their use lives as drills or perforators. Repeated sharpening and retooling eventually leads to a loss of practical functionality; the implements simply become too short for further useful work. When bifaces arrive at this condition, they are discarded.

Although several examples show tip damage from use as projectiles fairly early in their use-life, a practical consideration delays such applications until other utility becomes impracticable. In other words, tasks that pose relatively little risk of breakage are often performed before an implement is given over to projectile hunting. This sequencing of tasks would maximize the likely service life of bifaces. Again, if broken while serviceable dimensions survive, projectile points, like other bifaces can be repaired, resharpened, and returned to duty. Some appear to have been maintained until no hint of usefulness remained.

7.4.3.3) Hammerstone Production: Hammerstone manufacture was integral to the technological sequence for Cuesta quartzite and shares many aspects in common with the manufacture of bifacial implements. Taking as a given the awareness and recognition of the stone as a resource, the remaining steps involved in the manufacture of hammers include selection of starting forms, heat-treatment, rough shaping, and use. These steps would have been interspersed with episodes of heating or reheating until the desired mechanical characteristics were obtained.

7.4.3.3.1) Acquisition and Selection: Initial breakage of Cuesta quartzite cobbles, either by fire or by direct percussion creates blocky fragments that make good hammerstone blanks. As thermal alteration can modify the toughness of the stone to the knapper's advantage, utilization of fire-broken specimens yields an automatic benefit. If the object has not been previously heated, the artisan may make a trial by some tentative knapping, and if the stone is found to be too hard, it can be softened by one or more episodes of heating, following the routine already described. Obviously, if the hammer possesses satisfactory properties, then no additional thermal alteration would be required.

Also as previously observed, there seems to be a preference for rather coarse-grained quartzite for use as hammers. Evidently, the larger quartz grains provide advantages to the knapper, perhaps because the grains make better purchase with the surface of the work piece than does the cement binding.

7.4.3.3.2) Reducing in Size and Shape: Although ready-made fragments might serve handily as hammerstones, often some shaping would be necessary to achieve a balanced form and an appropriate size and shape. The knapper has to consider the proper size and form of the hammer as well as its toughness and tooth, that is, the ability to grab a platform so as to detach a flake effectively. Rudimentary shaping and sizing can be accomplished by preliminary percussion trimming, by use, or by a combination of the two.

The more a hammer is in service, the more its surface abrades and fits the purposes of the knapper. As explained in Chapter 3, the edges of a hammer wear quickly to form facets, which in turn describe angular points of juncture. As the hammer is used, the facets become more numerous as well as broader, and the angular points become more obtuse. As the implement is turned in the hand while knapping, the original cuboidal or tabular form becomes progressively rounded. In extreme cases the remnant hammers are tiny objects—only about the size of a golf ball—and nearly spherical in their dimensions.

7.4.3.4) Hammerstone Use: Archaeological evidence indicates at least two distinctive kinds of hammerstone utilization. The first is expedient use and the other is extended use. As with many other materials, Cuesta quartzite could have been, and was pressed into immediate service for the satisfaction of rough work—hammering, pounding, knapping, and so forth. Many cobble tools show battered edges and surfaces that indicate ephemeral use of this sort.

If a knapper were to find a particularly good piece of Cuesta quartzite, it might be husbanded for an extensive period, in extreme cases, perhaps for decades. This is particularly true of flaking hammers, the ones that we call faceted hammerstones, because of their characteristic form (see Chapter 3 for a detailed description). Hammers of this sort are archaeologically associated with knapping not only Cuesta quartzite but argillaceous shale as well.

If modern knappers provide a reliable basis for making such judgments, it can be said that favored hammers would have been maintained for as long as they gave service and perhaps longer, if the artisan developed a sentimental attachment (Jack Cresson, pers. comm., 26 January 2007). Eventually all hammerstones came to be lost, abandoned, or discarded.

7.5) Discussion

The sequence of operations for knapping Cuesta quartzite is similar to those outlined for other materials (Callahan 1979, 1989; Cresson 1982, 1990; Ebright 1987; Truncer 1990). In all of these sequences, knapping begins with relatively large masses. Because of the extent of reduction in volume—which, as we have seen, can exceed 90% of the original size—knappers have a sensible adage, "Start big!" Reduction proceeds selectively, and knowledgeably, reducing the bifaces by stages according to a set of culturally defined and socially accepted criteria, which are made manifest in archaeological deposits.

All of the reconstructed sequences give a sense, perhaps falsely, of rigidity in prescribed protocols. This effect arises when one looks at archaeological production primarily as a series of discrete artifact types. Experimentation moderates this sense of inflexibility, because actually coping with technological problems (for which there are archaeological analogues) shows that solutions can be achieved without violating the general thrust of the reduction sequence.

For example, failure in biface production—whether by material flaws or poor execution—leads to consideration of ways to redeem the situation. A fractious biface can often be made more tractable by reheating. If a biface breaks and leaves salvageable remnants, the knapper may elect to follow a trajectory to a biface design that is different from, but closely related to, the one originally intended. With respect to Cuesta quartzite, this situation gives rise to two primary styles of contracting stemmed points, one broad-bladed (the apparent default design), and the other narrow-bladed (the apparent alternate design).

A point of interpretive clarity arises from this recognition. That is, because the two end-products differ in appearance, they could be classified independently. Archaeologists, who are given to classifying things as a matter of routine, may interpret these two forms as separate types. And if the "one type, one culture" rule were to apply (cf. Coe 1964), the archaeologist might interpret the two "types" as denoting two separate archaeological cultures or time periods. But insights gained by the coupling of archaeological and experimental data show clearly that the two "types" in the present instance are very likely contemporaneous products of a single cultural milieu.

Further, the question of the duality of types is complicated by the simple fact that the slender contracting biface form can develop by repetitious resharpening and repair of the broader form, as necessitated by the circumstances of its life as a useful implement. In other words, there are two trajectories by which the narrow-bladed form can arise. The first is by compensation for production errors, and the second as a result of retooling.

In either case, the two "types" are part and parcel of a single knapping tradition. Others have shown that smaller versions of intended biface forms eventuate from failure to achieve the ideal form, from resharpening successfully produced implements, or from reworking fragments. Cresson (1982, 1990) and (Truncer 1990) respectively detail the retooling of broadspears and Fox Creek bifaces. Cross (1999) has demonstrated how fragmented Neville-Stark bifaces were reworked into smaller forms following a modified version of the original template. Further substantiation comes from consideration of the morphological statistics presented in Chapter 3.

As a result of looking at Cuesta quartzite reduction in light of its technological sequence, I have come to view the relationship between the artisan and the medium as one that transcends simple exploitation. Rather, I believe that a profound relationship existed between the ancient knapper and the stone, as it does among archaeologists and their lithic partners today .

The relationship between the human and the stone can be understood as one of mutual agency or of participation in an actor-network. The knapper taps on a rock; the rock responds with a sound. If the knapper finds satisfaction in the response, the rock becomes a participant in the manufacturing process. Otherwise, the artisan searches for another partner.

Keenly aware of color, the artisan chooses a stone that holds promise as expressed through visual clues. Based on my experience as a hunter, the blotchy red patches that occur on some Cuesta quartzite specimens remind me of drops and splatters of blood along the trail of a mortally wounded deer. The portents of using this stone for a weapon tip are powerful.

Perhaps, when knapping begins, the rock appears lifeless. The knapper warms the rock in a fire, which imparts color—usually redness—and luster. Now awakened or revived, the rock responds favorably to the knapper's manipulations. The warmth of the color, the lustrous texture, the sparkling quartz grains all strike a mystic chord. Fire restores life and hope.

Now, we will never know what passed through the minds of ancient people, and I would not argue for absolute psychic unity among all humans. Still, color symbolism is as close to universal in human experiences as one might hope to realize, as shown by Turner's (1967) classic ethnography of Ndembu ritual, as well as numerous examples in North America and elsewhere (Hamell 1983, 1992; Hall 1997; Miller and Hamell 1986; Mooney 1891; Morphy 1999; Taçon 1999; Jones and MacGregor 2002; Kraft 2001; Loring 2002).

Humans are attracted to, make special use of, and prize objects that are bright or brilliant. Among Australian aborigines, quartzite is thought to contain the powers of the ancestors, and the brightest and most colorful materials are believed to be the most potent (Taçon 1999:120-121). The connection made with ancestral powers through color acts as a unifying agent in social identity and group continuity (Taçon 1999:123). This pattern extends well back into antiquity. Indeed, as Jones and Bradley (1999:113) point out, color is important but so is brilliance; "brightness imbues any color with power," a point underscored by Morphy (1992).

According to Mooney (1891), among the Cherokee, red symbolizes success and triumph. Decorating a person or thing transfers the powers or properties of the color to that which has been so decorated. According to Kraft (2001:384-385), the Lenape viewed color with similar symbolic meanings.

Thus, I believe that color was important anciently, that the ability to manipulate color, luster, and brilliance was tantamount to the ability to exercise power, at least in symbolic terms. This power was exercised in the manipulation of Cuesta quartzite at virtually every stage of its reduction from raw material to finished product, and even upon disposal of the expended implements.

Sharing these views served to knit individuals and social groups together, or to distinguish them from others, who may have held different beliefs and perspectives. In either case, the relationships between people and objects help to define social traditions and to foster cohesion within the group.

But what about change? The question remains as to why native knappers took to the use of a material so tough and inherently difficult to work as Cuesta quartzite, especially as other, more compliant materials occurred with abundance in the region. In part, one must appreciate that humans are, by nature, inquisitive, and the detailed exploration of their surroundings is characteristic. Indeed, it would be astounding if Cuesta quartzite were to be overlooked as an element of the landscape irrespective of its potential as an economic resource. Its use came about, I believe in part as a result of change in the prevailing tradition.

The period of Cuesta quartzite exploitation began about 6,600 years ago and continued for some five thousand years, discounting for the moment poorly documented artifacts of apparently early form. During this period, the aboriginal population of what is now New Jersey appears to have reached a peak, at least if penetration of environmental recesses is any indication (Stewart 1991:68). Even a cursory glance at trait tables from the statewide Indian Site Survey (1936-1942) shows that stemmed points of Late Archaic/Early Woodland typology—the types most commonly represented in Cuesta quartzite—are the most numerous of all biface types encountered in most assemblages in the region (Knowles 1941a). And later studies, especially those driven by bureaucratic imperatives, show this distribution to extend well into the headwaters of most streams (Stewart 1991; also see NJDEP 1979-1985 for a catalogue of site reports). Never before or since—at least during prehistoric times—did the population expand so deeply into the far reaches of the landscape (see Chapter 2).

This distribution strongly suggests that the period of Cuesta quartzite use corresponded to a time of increased competition for space and economic resources. Accordingly economic motives were likely driving factors in the decision to develop an effective technological means for utilizing Cuesta quartzite. Mastering the use of Cuesta quartzite lightened the burdens associated with acquiring argillaceous materials, metasediments, or quarried cryptocrystalline rocks from distant sources. Associated accommodations in terms of social networks must have existed but cannot be reconstructed on the basis of existing archaeological data.

At a time when material culture prescribed the use of implements of a relatively large size that could not be readily fashioned from the smaller cobbles and pebbles on the coastal plains, Cuesta quartzite provided a ready, local resource. Cuesta quartzite served more as a supplement to other materials, such as argillite and argillaceous shale, than as a substitute for them. The inherent toughness of the quartzite made it applicable to rough service work for which the less tenacious materials were poorly suited. The same quality—toughness—made the stone effective for use as hammers for processing other widely used materials, such as argillaceous shale. What is more, by careful thermal alteration, the toughness of the hammers could be customized to a range of applications.

If the current range of radiocarbon dates gives a proper estimation, the use of Cuesta quartzite persisted until approximately 1,600 years ago, or well into the period ordinarily associated with Middle Woodland cultures. This period witnessed the transition between the last of the formal, staged biface reduction technologies—emblematically represented by the Fox Creek and Jack's Reef cultures (Ritchie 1965:232-253; Ritchie and Funk 1973; Thomas and Warren 1970; Williams and Thomas 1982)—and the expedient knapping of much smaller bifaces from cryptocrystalline pebbles, which are ubiquitous upon New Jersey's coastal plains (Stewart 1987b;Mounier 2003a:28).

The discovery of pebble-knapping by direct entry or bipolar reduction in the region extends back to Paleoindian times (Cavallo 1981; Stewart 1987b:33), but the apparent preference for large implements among early cultures led to the persistent use of high quality, quarry-derived materials (Kraft 1973). Resorting to the wholesale use of pebbles for formalized implement manufacture during Woodland times marked a dichotomous event in stonework in the region. On the one hand, the progressive knapping of bifaces from carefully prepared preforms was supplanted by the decidedly inelegant—

almost haphazard—flaking of pebbles (Stewart 1987b; Cresson 1988). On the other hand, the new expedient approach to knapping opened up the mineral content of the entire coastal plains province to human exploitation on a large scale. This change effectively eliminated the need to endure or to sustain the complicated technology embodied in Cuesta quartzite knapping. Furthermore, the time required to fashion a typical biface was reduced from approximately one hour to a matter of minutes (see Chapter 6).

A more prosaic and expedient style of knapping—which could be practiced with little instruction by the general population—eventually replaced the specialized and rather nuanced skills needed to work Cuesta quartzite. At the very least, the recruitment and training of knappers must have changed appreciably. Thus, we can assert that the network of social relationships and traditions changed when the cryptocrystalline pebble supplanted the Cuesta quartzite cobble as the artisan's partner in the agency of knapping. This change appears to correlate with the apparent diminution of territorial ranges concomitant with groups settling into localized districts in late prehistoric and early historic times (Wallace 1947; Stewart 1987a). The use smaller bifaces, typically of triangular form, seems to correlate with the introduction of the bow and arrow into the region (Kraft 2001:30; Ritchie 1965:passim). In the absence of confirmatory data regarding the appearance of archery, this point remains an open question.

The simple, pebble-based knapping technology proved to be highly effective and persisted into the historic period. After the European incursion, in the seventeenth century, all aboriginal knapping technologies became extinct regionally, and can now be glimpsed only through archaeological inquiry and experimentation. Using those techniques, this thesis marks an attempt to make manifest—if only imperfectly—that which formerly was entirely unknown.

7.6) Summary

This chapter has presented a synthesis of archaeological and experimental findings highlighting the congruencies and difference between the two with respect to the aboriginal exploitation of Cuesta quartzite. The technological underpinnings for Cuesta quartzite utilization was reconstructed, giving details for the sequences governing the production of bifaces and hammerstones. Based on observations of modern knappers, it was suggested that both artisans and the lithic material acted as agents in a complex relationship that was imbued with symbolic meaning. The role of color and fire are especially important in understanding the utilization of this material. The initial exploitation of Cuesta quartzite arose as a supplement to other lithic materials during a period of exploration, population expansion, and competition for scarce resources. Changes in artifact design concepts—and the recognition that the coastal plains of the region offered an inexhaustible supply of lithic raw materials in the form of cryptocrystalline pebbles—led to the decline in the use of Cuesta quartzite and eventually to its virtual abandonment for stone tool production. Changes in socio-economic relationships, including those that defined the agency of knapping, doubtless attended the indicated technological shifts. Combining traditional archaeology with experimentation in a meaningful theoretical context has illuminated the aboriginal exploitation of Cuesta quartzite in southern New Jersey.

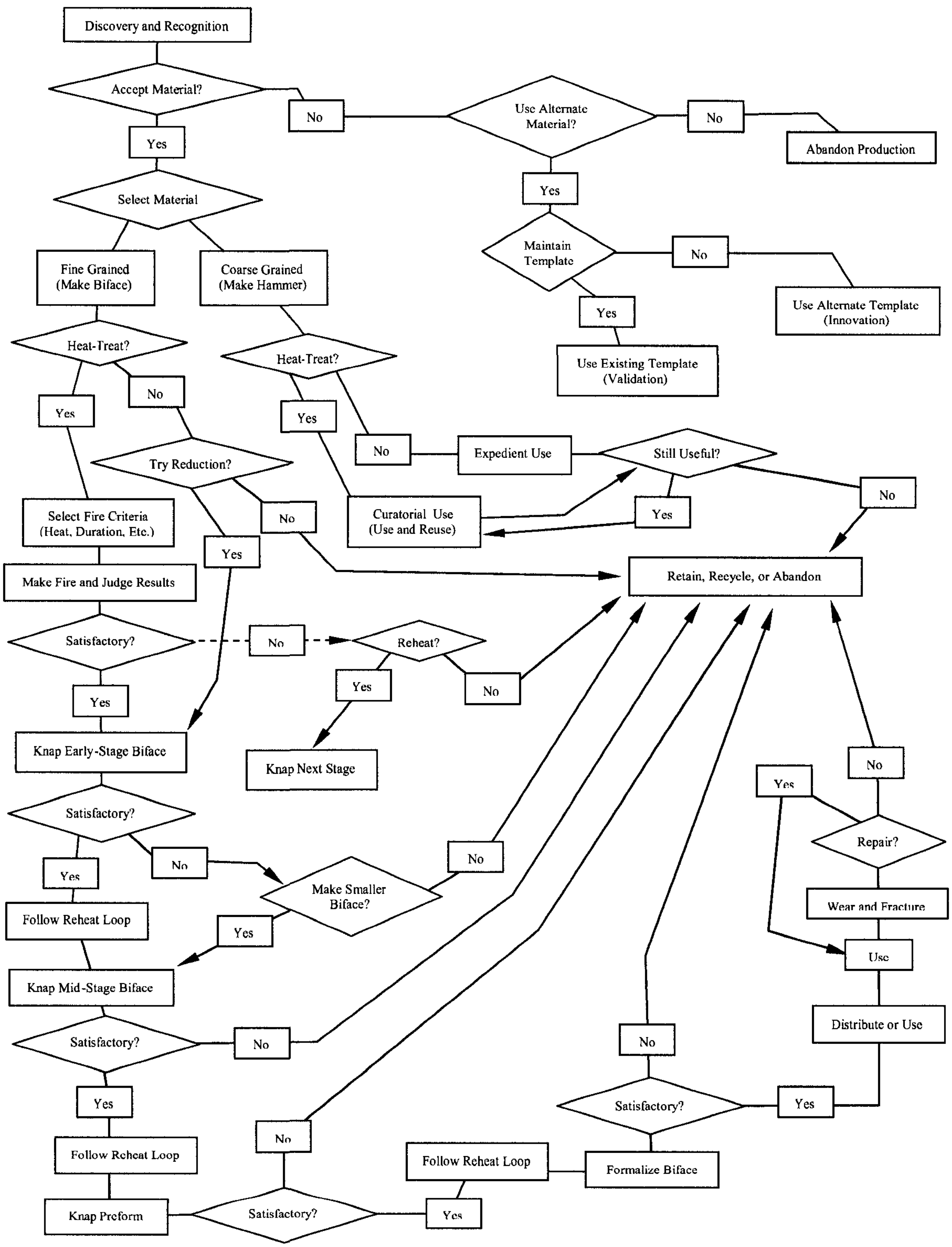


Figure 7.3: Technological Sequence for Cuesta Quartzite Reduction

Notes: The rectangles represent actions or intentions. The rhomboids represent choices or decisions. Reduction from flake blanks would begin at the “Knap Preform” step and carry on to completion or failure.

Conclusions

This thesis concerns the aboriginal exploitation of Cuesta quartzite in southern New Jersey over a period of about five millennia, from ca. 6600 to 1600 B.P. Technically an orthoquartzite or a form of silcrete, Cuesta quartzite has a natural distribution that generally coincides with the Cuesta, the asymmetrical ridge that separates the Inner and Outer Coastal Plains of southern New Jersey. I have placed the use of Cuesta quartzite in antiquity into an anthropological context by analyzing the technology underlying its exploitation. The study of the sequential reduction of Cuesta quartzite for bifacial implements and hammerstones provides a theoretical framework for defining and interpreting the technical processes and socially bounded decisions involved in the transformation of the stone from raw material to finished products, and eventually to their entry into the archaeological record.

The research was undertaken with several goals in mind. By means of petrographic analysis, I sought to examine the relationships between the natural and cultural distributions of Cuesta quartzite. I also wanted to learn about the physical properties that made the stone attractive to human use. These properties include such things as mineral composition and the sizes of rock available for knapping. These characteristics must have influenced the range of artifacts that could have been produced as well as their form and functions, not to mention the mechanisms involved in the reduction process.

I sought to explore the intricacies of the ancient Cuesta quartzite technology and, particularly, to understand the probable sequence of operations that comprised the reduction process. Virtually all archaeological bifaces show evidence of thermal alteration at every stage of reduction. Hammerstones also frequently show evidence of exposure to fire. Accordingly, the role of heat-treatment was explored experimentally and the results compared against archaeological specimens.

In order to understand the ancient process of bifacial reduction by knapping, I employed the services of four accomplished knappers to attempt replications of formalized specimens recovered from archaeological sites. Direct observations of knappers while they gathered stone and worked it aided me in interpreting ancient human behavior in theoretical terms.

I was concerned with understanding the economic decisions that affected the use of Cuesta quartzite in terms of its initial exploitation, its transformation into tools and weapons, and its eventual abandonment as a raw material. This concern led me to place Cuesta quartzite into an archaeological context with regard to culture history, regional trends in settlement patterns, and inferred demographic conditions. Finally, I attempted to tie all of the foregoing elements into a plausible interpretive synthesis.

Chapter 1 reviewed the theoretical framework in detail and discussed the methods and instrumentation employed in this research. That chapter also contained general information about Cuesta quartzite in its natural and cultural contexts, both of which were treated in more detail in subsequent chapters.

Chapter 2 summarized the physiographic and geological framework in which the ancient quartzite-using cultures of New Jersey operated. Of the five physiographic provinces, the Inner and Outer Coastal Plains are the most important to this study because it is here that Cuesta quartzite exists in both geological and archaeological contexts. The chapter further outlined the use of Cuesta quartzite and other lithic materials by archaeologically recognized cultures.

In addition to exploring the cultural and geological contexts of Cuesta quartzite, I have presented data concerning its geochemical composition as revealed by petrological analysis. Two analytical techniques—X-ray fluorescence and laser ablation microprobe-inductively coupled plasma mass-spectrometry—revealed that Cuesta quartzite is very similar in composition to other orthoquartzites from various places in New Jersey and elsewhere. These assays showed little difference in the mineralogy of samples from various sites; yet, paradoxically, the composition is too varied to permit identifying discrete geological sources for archaeological specimens.

Despite its occasional use at earlier and later dates, it seems very clear that an efflorescence in the employment of Cuesta quartzite occurred between three and five thousand years ago. Typical diagnostic artifacts are stemmed bifaces, characteristic of Late Archaic/Early Woodland types. The first radiometrically dated use occurred around 6600 B.P., but the appearance of diagnostic artifacts of early forms suggest even earlier, albeit sporadic, utilization. The material shows up in contexts dated as recently as 1,600 years ago, but, by then, its use was restricted to sites where the material occurred (and still occurs) in obvious surficial deposits. In addition, by late prehistoric times, the traditional bifacial forms had been abandoned; the material is more often found as hearth rock or expediently produced flakes.

Using data drawn from collections and from controlled archaeological excavations, Chapter 3 provided descriptions of Cuesta quartzite artifacts. The artifacts were divided into three principal classes, viz., bifaces, debitage, and hammerstones. The predominant bifacial forms are stemmed and notched styles, whose linear and proportional dimensions strongly suggest staged reduction from cobbles by knapping within a single cultural tradition. Repetitious heat-treatment—doubtless with symbolic and ritual overtones—characterized this tradition. Variations in hafting elements are seen as signaling functional, rather than cultural differences. Thus, I conclude that the various forms—particularly, the stemmed varieties—represent points along a technological continuum rather than discrete archaeological types.

Debitage is fairly limited to a small number of definitive flake types. Inasmuch as the flakes themselves are often the most common artifacts in archaeological sites, their analysis assumes critical importance. The analysis of flakes—and particularly, their proportional frequencies—can indicate the character of knapping that transpired at any given site. Dichotomizing flake assemblages into earlier and later categories gives at least an impressionistic idea of knapping behavior. More nuanced interpretations can be obtained by graphing the relative percentages of early-, middle-, and late-stage flakes. Similarly, the ratios of flakes to implements can inform on the nature of reduction strategies.

As analytical indices both proportional flake ratios and flake-to-biface ratios work best in undisturbed sites for which statistically valid samples exit. Most of the sites examined in this study have been farmed for centuries and subjected to long periods of uncontrolled artifact collecting. These circumstances diminish the quality of the available data. Relic hunting is particularly detrimental to analyses based on flake-to-biface ratios, because of the selective removal of finished artifacts. Consequently, the usefulness of these indices is limited on most sites. On the other hand, data from essentially undisturbed stations—such as 28-BU-403—provide information that can strengthen the interpretations of other sites.

The following interpretations appear to be valid. At most sites, the assemblages reflect multiple stages of bifacial reduction. Early-stage reduction most often occurred at sites where Cuesta quartzite also existed in geological deposits. In the absence of formalized specimens at such sites, evidence of later-stage processing—for instance, a high ratio of later- to earlier-stage flakes—suggests the conscious removal of semi-finished or formalized specimens for use at other locations. When early-stage bifaces appear on sites remote from any known geological source, the importation of those bifaces can be assumed. The bifaces could have served as general-purpose tools and as cores for the production of flake tools. Similarly, early-stage and thinning flakes may have been transported as expedient tools.

Inferences concerning intended tool types can influence functional interpretations. Evidently, the bifaces were used for a variety of cutting, graving, and piercing functions, as well as for projectile hunting. The evidence of such uses is clearly shown by specialized shaping on the tips of certain implements and by typical fracture patterns. Because of its inherent toughness and granular composition, wear patterns from abrasion are difficult to observe. The various site reports, presented in Chapters 4 and 5, contain appropriate interpretations of the assemblages.

Cuesta quartzite makes good hammerstones, which can be fashioned from blocky fragments, simply by use or by selective trimming of larger masses. There is some evidence that hammerstone blanks were made from fire-shattered cobble fragments. Hammers often show prolonged use, materialized in a transition from a tabular or cubical form to a spheroidal, or even spherical, shape.

As with bifaces, the use of fire to modify the physical qualities of hammers is a hallmark of the aboriginal use of Cuesta quartzite. I suspect that repeated episodes of heating served to "temper" the hammerstones to achieve a desired level of toughness, consistent with the materials being knapped.

Experimental work shows that hammers of Cuesta quartzite are especially useful for knapping argillaceous materials. This observation helps to explain the frequent archaeological association of Cuesta quartzite hammers with bifaces in argillaceous shale and argillite. Spherical hammers seem to reflect a long use-life, which implies the possibility of their maintenance as heirlooms by successive generations of knappers.

Chapters 4 and 5, segregated along geographic lines, provided the archaeological basis for interpreting Cuesta quartzite artifacts from sites in Burlington, Gloucester, and other counties on the coastal plains of New Jersey. These chapters present detailed data from 20 sites at which Cuesta quartzite was an important lithic material. Data from these archaeological excavations are especially important because the associated artifacts have good provenience, which is almost universally lacking among specimens held in private collections.

Chapter 6 recounted experimentation dealing with the thermal alteration and knapping of Cuesta quartzite. The various experiments added a degree of subtlety to our understanding of how this material was used anciently. Fire modifies the physical appearance and knapping qualities of Cuesta quartzite. Typical changes include an increased redness and luster, not to mention the sparkling effect gained by the enhanced clarity of the entrained quartz grains. These visible changes are linked to physical modifications that make the stone easier to flake. Every modern knapper who worked with the stone attested to the relative ease of knapping heat-treated Cuesta quartzite. The changes resulting from thermal alteration can be accomplished in relatively little time and carry potential symbolic as well as practical implications.

The behavior of modern knappers clearly suggests that humans develop intimate relationships with the inanimate elements of their environment. Among contemporary knappers these relationships are most obviously revealed by their gestures and speech while gathering stone and working with it. There is no reason to suppose that ancient knappers did not also deal with lithic materials in a similar manner. These dealings—which can be expressed in terms of agency theory or actor-network theory—extend beyond mere practicalities to include nuanced interactions, involving the appreciation of sound, texture, and color, as well as metaphysical associations. These last may involve concepts of revitalization, animation, responsiveness to stimuli, and the acquisition of symbolic or ritual power.

The humans who participate in these behaviors and experience these perceptions share social bonds, which extend to their non-human partners, in this case, to the stones themselves. Modern knappers often experience a camaraderie with each other and with the stones that they work. This amity is sometimes challenged by or tempered with tensions, overt frustration, or even hostility. Knappers often ascribe to the stone the characteristics of humans and relate to it accordingly.

Collegial relationships among knappers tend to reinforce group cohesion and to distinguish the members of the cohort from the society at large or from others, who belong to other social groups altogether. Membership further encourages adherence to a favored pattern of behavior—whether it be a technological solution to knapping or some other socially directed routine—and tends to perpetuate it. But the desire or need for change can lead to innovation.

I believe that the exploitation of Cuesta quartzite represents a case of innovation in which the existing technology—based on the staged reduction of large bifaces from non-local materials—was modified to suit the exigencies of a changing social environment. The expansive use of Cuesta quartzite coincides with a time of apparently expanding human populations, which is represented archaeologically by an increasing occupation of riverine settlements, extending from tidewater into the headwaters of the Delaware River and various coastal streams.

Competitive interactions between diverse human groups for limited lithic resources apparently encouraged the ancient occupants of the coastal plains to diversify their search for knappable stone. They developed the technological means to acquire and utilize Cuesta quartzite, which is locally abundant along the flanks of the Cuesta. This development lessened the costs—whether social or economic—associated with the acquisition of long-favored, exotic materials, such as argillite and quarried jaspers.

Thus, Cuesta quartzite became a common supplement to other widely used materials, which could be obtained only at a distance, and, presumably, only at some cost through intermediaries. Taking recourse to Cuesta quartzite would have diminished social and economic pressures associated with acquiring traditional tool-stone, while simultaneously leading to adjustments in the existing supply and distribution networks.

Cuesta quartzite had the obvious economic advantage of being widely available to knappers on the coastal plains. In addition, it was tough and strong, and occurred in a form that placed no crippling constraints on the sizes of the implements that could be produced under existing, staged biface reduction schemes. Furthermore, it was useful for hammerstones as well as for bifaces. The major disadvantage is that the material is not easy to knap, especially when compared to argillaceous and cryptocrystalline materials.

Still, during the period of its greatest use, knappers clearly became expert at working Cuesta quartzite by developing a complex technology based on traditional staged reduction, interspersed with repetitious heating. The modified technology embraced many branching points at which the knappers could cope with the manifold problems associated with working this fractious stone—uneven quality, a high rate of accidental fragmentation, and so forth.

The new approach must have had a strong symbolic component, doubtless with ritual manifestations that we cannot now reconstruct. The role of color and fire are especially important in understanding the utilization of this material. It is further assumed, but not directly demonstrable, that the vigorous use of Cuesta quartzite involved social networks, whose members at the very least engaged in the recruitment and training of knappers, as well as the distribution and use of products.

Later, a new technological tradition—following yet another operational sequence—came to favor the manufacture of small, easily produced tools and weapons from cryptocrystalline pebbles. Because of the relatively small size of the available pebbles, this change necessarily deemphasized large bifacial forms, which had dominated biface design concepts for millennia. Although there is not yet any compelling information on this point, the use smaller bifaces, typically of triangular form, may correlate with the regional appearance of the bow and arrow.

The new approach to knapping capitalized on the abundance of cryptocrystalline pebbles throughout the region. Cuesta quartzite eventually fell into disuse for stone tool production, except at sites coincident with natural deposits. As always, changes in the predominant technology must have affected socio-economic relationships, including those involving the agency of knapping and membership in the knapping community.

This investigation has focused on a widely-used but hitherto poorly studied material. Collections research was critical to the success of this study because the collections revealed a wider range of variation in bifacial forms than I have seen in many years of archaeological excavation. The collections also broadened the geographic scope of the study beyond the limits of my previous exposure. These data significantly augmented those obtained through my researches in the field of CRM. Archaeology in that context offers access to significant data from frequently small and unglamorous sites that are often overlooked in traditional academic archaeology.

Integrating these elements with traditional archaeology and experimentation in a meaningful theoretical context has illuminated the aboriginal exploitation of Cuesta quartzite in southern New Jersey. In so doing, I believe, this thesis marks a contribution to archaeology in the region.

References

Ahearn, Laura M.

2001 Language and Agency. *Annual Review of Anthropology* 30: 109-137.

Ahler, Stanley A.

1971 *Perkiomen Projectile Point Form and Function at Rodgers Shelter, Missouri*. Missouri Archaeological Research, Series 8. Columbia, Missouri.

____

1989 Mass Analysis of Flaking Debris: Studying the Forest Rather Than the Trees. In *Alternative Approaches to Lithic Analysis*, edited by D.O. Henry and G.H. Odell, American Anthropological Association, Archaeological Papers 1, pp. 85-118.

_______, and Robert C. Christensen

1983 Experimental Knapping with KRF and Midcontinent Cherts: Overview and Application. In *Experiments in Lithic Technology*, edited by D.S. Amick and R.P. Mauldin, BAR International Series 528. Great Britain, pp. 119-234.

Andrefsky, William A.

2001 *Lithic Debitage: Context, Form, Meaning*. University of Utah Press: Salt Lake City.

Archaeological Interpretive Management, Inc.

1989 *Phase Ia, Ib, II: Cultural Resource Survey, Kings Grant/Phase II, Kings Grant Equities, Inc., Block 54: Lots 1, 1A, 2; Block 57, Lot 1A, Evesham Township, Burlington County, New Jersey.*

Audouze, Francoise

2002 Leroi-Gourhan, a Philosopher of Technique and Evolution. *Journal of Archaeological Research* 10(4): 277-306).

Bamforth, Douglas B.

2006 The Windy Ridge Quartzite Quarry: Hunter-Gatherer Mining And Hunter-Gatherer and Use on the North American Continental Divide. *World Archaeology* 38(3): 511–527

Barclay, Katherine

2001 Scientific *Analysis of Archaeological Ceramics: A Handbook of Resources.* Oxbow Books: Oxford.

Becker, G. S.

1976 *The Economic Approach to Human Behavior.* University of Chicago Press.

Behm, Jeffrey A., and Alaric Faulkner

1974 Hixton Quartzite: Experiments in Heat Treatment. *Wisconsin Archaeologist* 55(4):271-276.

Binford, Lewis

1980 Willow Smoke and Dogs' Tails: Hunter Gatherer Settlement Systems and Archaeological Site Formation. *American Antiquity* 45:4-20.

Blackwelder, Eliot

1929 Fire as an Agent in Rock Weathering. *Journal of Geology* 35:134-140.

Bleed, Peter

2001 Trees or Chains, Links or Branches: Conceptual Alternatives for Consideration of Stone Tool Production and Other Sequential Activities. *Journal of Archaeological Method and Theory* 8(1): 101-127.

Bonfiglio, Anthony, and John H. Cresson.

1982 Geomorphology and Pinelands Prehistory: A Model of Early Aboriginal Land Use. In *History, Culture and Archaeology of the Pine Barrens: Essays from the Third Pine Barrens Conference*, John W. Sinton, pp. 15-67. Stockton State College, Center for Environmental Research: Pomona, New Jersey.

Bottoms, Edward

1968 Bertie County Oolitic Quartzite and Its Aboriginal Utilization in Eastern Virginia and North Carolina. *The Chesopeian* 6:32-43.

Bradbury, Andrew P. and Philip J. Carr

1999 Examining Stage and Continuum Models of Flake Debris Analysis: An Experimental Approach. *Journal of Archaeological Science* 26(1):105-116.

———

2004 Combining Aggregate and Individual Methods of Flake Debris Analysis: Aggregate Trend Analysis. *North American Archaeologist* 25(1)65-90.

Bradley, Bruce

2005 *Experimental Technology and Replicas.* Electronic document, accessed September 23, 2005. http://www.primtech.net/info/replicas.html.

Broyles, Bettye J.

1966 Preliminary Report: The St. Albans Site (46Ka27), Kanawha County, West Virginia. *West Virginia Archaeologist* 19:1-43.

———

1971 Second *Preliminary Report: The St. Albans Site, Kanawha County, West Virginia.* Report of Archaeological Investigations, No. 3. West Virginia Geological and Economic Survey.

Byrne, D.

1980 Dynamics of Dispersion: the Place of Silcrete in Archaeological Assemblages from the Lower Murchison, Western Australia. *Archaeology and Physical Anthropology* 15:110-119.

Callahan, Erret

1974 *Experimental Archaeology Papers, No. 3.*Virginia Commonwealth University, Richmond.

1976 *Experimental Archaeology Papers, No. 4.*Virginia Commonwealth University, Richmond.

———

1979 The Basics of Biface Knapping in the Eastern Fluted Point Tradition: A Manual for Flintknappers and Lithic Analysts. *Archaeology of Eastern North America* 7: 1–180.

———

1989 *Primitive* Technology*: Practical Guidelines for Making Stone Tools, Pottery, Basketry, Etc. the Aboriginal Way.* Second Edition. Piltdown Publications: Lynchburg, Virginia.

Carozzi, Albert V.

1993 *Sedimentary Petrology.* Prentice Hall: Englewood Cliffs, New Jersey.

Catts. W. P., L. Rappleye-Marsett, J. F. Custer, K. Cunningham, and J. Hodny

1988 *Final Archaeological Investigations of The Route 7 South Corridor, Route 13 to 1-95, New Castle County, Delaware.* University of Delaware, Department of Anthropology Center for Archaeological Research: Newark, Delaware.

Cavallo, John A.

1981 Turkey Swamp: A Late Paleo-Indian Site in New Jersey's Coastal Plain. *Archaeology of Eastern North America* 9:1-17.

———

1987 *The Area B Site (28Me1-B), Data Recovery.* Trenton Complex Archaeology: Report 8. Revised edition 1996. The Cultural Resource Group, Louis Berger & Associates: East Orange, New Jersey.

Clark, C.C., IV, and Diane, Halsall.

1999 Sophistication of Archaeological Interpretation: The Critical Role of the Public. Paper presented at the Middle Atlantic Archaeological Conference. April 9-11, 1999. Harrisburg, Pa.

Coe, Joffre, L.

1964 *Formative* Cultures *of the Carolina Piedmont.* Transactions of the American Philosophical Society, New Series. Volume 54, Part 5: Philadelphia.

Cook, George H.

1868 *The Geology of New Jersey.* New Jersey Geological Survey: Trenton.

Cooper, Cheryl Lynn

1998 *Prehistoric Aboriginal Fauna Exploitation: The Evaluation of a Foraging Theory Model using Geographic Information System Analysis of Archaeological Faunal Remains.* Ph.D. Thesis, University of New England. Electronic Document, accessed November 20, 2005. www.vvm.com/~huckerby/DOCUMENTS/97toc.html.

Crabtree, Don E.

1966 A Stoneworker's Approach to Analyzing and Replicating the Lindenmeier Folsom. *Tebiwa* 9: 3-39.

____

1972 *An Introduction to Flintworking.* Occasional Papers, Idaho State University Museum, #28. Idaho Museum of Natural History: Pocatello.

_______, and B. R. Butler

1964 Notes on Experiments in Flintknapping: 1–Heat Treatment of Silica Materials. *Tebiwa* 7:1-6.

Cresson, Jack

1975 Cuesta Quartzite: A Unique Quartzite Found on the New Jersey Coastal Plain. Paper presented at Archaeological Society of New Jersey. Meeting. April 19, 1975. Trenton, New Jersey.

____

1982 Middle Woodland Fox Creek Lithic Technology. Unpublished manuscript in possession of the author.

———
1984 Middle Woodland Lithic Technologies: A Chapter in Deciphering a Unique Extractive Process and Production of Rhyolite Fox Creek Primary Quarry Bifaces. Paper presented at the 1984 Middle Atlantic Archaeological Conference. Rehoboth, Delaware.

———
1988 Unique Pebble Core Technologies from the New Jersey Coastal Plains. Paper presented at Mid-Atlantic Archaeological Conference, Rehoboth Beach, Delaware. 26 March 1988.

———
1990 Broadspear Lithic Technology: Some Aspects of Biface Manufacture, Form, and Use History with Insights towards Understanding Assemblage Diversity. In *Experiments and Observations on the Terminal Archaic of the Middle Atlantic Region*, edited by Roger W. Moeller. Bethlehem, Connecticut: Archaeological Services. Pp. 105-130.

———
1994 Platforms to Prehistory. *Bulletin of Primitive Technology* 7:70-76.

———
1995a Notes on Cuesta Quartzite and Argillaceous Shale. Unpublished notes, dated April 2, 1995.

———
1995b Letter to Philip Perazio, dated April 7, 1995. Copy provided by Jack Cresson.

———
1995c Untitled Research Notes, dated 1995. Copy provided by Jack Cresson.

———

1997 *UFO's and the Four-F's of Stone: Unidentified Flake Objects and the Force, Fractures, Facets, and Flakes of Stone.* Pamphlet from the Lithic Workshop Session, Middle Atlantic Archaeological Conference Meeting. Ocean City, MD. (7 March 1997).

———

2000 Reading Flakes and Decoding Fractures: An Introduction into the Language of Flakes and Lithic Residues. Pamphlet from the Lithic Workshop Session, Middle Atlantic Archaeological Conference Meeting. Ocean City, MD. (24 March 2000).

———

2004 Cuesta Quartzite: The Ultimate Cooking Rock, A Unique Orthoquartzite from the New Jersey Coastal Plain: Experiments and Observations. Paper presented to the Middle Atlantic Archaeological Conference, March 13, 2004. Rehoboth Beach, Delaware.

Cresswell, Robert

1993 Of Mills and Waterwheels. In *Technological Choices*, edited by Pierre Lemonnier, pp. 181-213. Routledge: New York and London.

Cross, Dorothy

1941 *The Archaeology of New Jersey, Volume One*, with chapters by Henry B. Kümmel, Horace G. Richards, and Nathaniel Knowles. Archaeological Society of New Jersey and New Jersey State Museum: Trenton.

____

1956 *The Archaeology of New Jersey, Volume Two*, The Abbott Farm. Archaeological Society of New Jersey and New Jersey State Museum: Trenton.

Cross, John

1999 "By Any Other Name ...": A Reconsideration of Middle Archaic Lithic Technology and Typology in the Northeast. In The Archaeological Northeast, edited by M.A. Levine, K.E. Sassaman, and M.S. Nassaney, pp. 57-73. Bergin and Garvey: Westport, CT.

Custer, Jay F., F., Henry. H. Ward, and Scott. C. Watson

1986 Archaeology of Delmarva Chalcedony Complex. *Bulletin of the Archaeological Society of Delaware* 20.

Deetz, James

1967 *Invitation to Archaeology*. Natural History Press: Garden City, New York.

Dibble, H.L.

1994 Middle Paleolithic Scraper Reduction: Background, Clarification, and Review of Evidence to Date. *Journal of Archaeological Method and Theory* 2(4): 299-368.

Didier, Mary Ellen

1975 The Argillite Problem Revisited: An Archaeological and Geological Approach to a Classical Archaeological Problem. *Archaeology of Eastern North America* 3:90-101.

Dincauze, Dena F.

1971 An Archaic Sequence for Southern New England. *American Antiquity* 36:194-198.

Dixon, John C.

1994 Duricrusts. In *Geomorphology of Desert Environments*, edited by Athol D. Abrahams and Anthony J. Parsons, pp. 93-105. Chapman & Hall: London.

Dobres, Marcia-Anne

1995 Gender and Prehistoric Technology: On the Social Agency of Technological Strategies. *World Archaeology* 27(1):25-49.

_______, and C. R. Hoffman

1994 Social Agency and the Dynamics of Prehistoric Technology. *Journal of Archaeological Method and Theory* 1: 211–258.

_______, and John E. Robb (editors)

2000 *Agency in Archaeology*. London: Routledge.

_______, and John Robb (editors)

2005 "Doing" Agency: Introductory Remarks on Methodology. *Journal of Archaeological Method and Theory* 12(3):159-166.

Domanski, M., and J. A. Webb.

1992 The Effects of Heat Treatment on Siliceous Rocks Used in Prehistoric Technology. *Journal of Archaeological Science* 19(6):601-614.

Domanski, M., J.A. Webb, and J. Boland

1994 Mechanical Properties of Stone Artefact Materials and the Effect of Heat Treatment. *Archaeometry* 36:2: 177-208.

Dunn, Robert A.

1984 Form and Function of the Perkiomen Broadpoint. *Pennsylvania Archaeologist* 54(3-4): 11-18.

Dunning, Arthur

1964 The Tallahatta Formation in Clark County, Alabama. *Journal of Alabama Archaeology* 10(2):50-60.

Ebright, Carol A.

1987 Quartzite Petrography and Its Implications for Prehistoric Use and Archeological Analysis. *Archaeology of Eastern North America* 15:29-45.

Edmonds, Mark

1990 Description, Understanding and the Chaîne Opératoire. *Archaeological Review from Cambridge* 9(1):55-70.

Enloe, J. G.

1991 *Subsistence Organization in the Upper Paleolithic: Carcass Refitting and Food Sharing at Pincevent*, Ph.D. Dissertation, Department of Anthropology, University of New Mexico, University Microfilms: Ann Arbor, Michigan.

———

1992 Subsistence organization in the early Upper Paleolithic: Reindeer hunters of the Abri du Flageolet. In *Before Lascaux: Complex Record of the Early Upper Paleolithic*, edited by H. Kneicht, A. Pike-Tay, and Randy White, CRC Press: Boca Raton, Florida.

Fladmark, K. R.

1982 Microdebitage Analysis: Initial Considerations. *Journal of Archaeological Science* 9:205-220.

Flenniken, J. Jeffrey, and Anan W. Raymond.

1986 Morphological Projectile Point Typology: Replication Experimentation and Technological Analysis. *American Antiquity*, 51(3):603-614.

French, Hugh M., and Mark Demitroff.

2001 Cold-Climate Origin of the Enclosed Depressions and Wetlands ('Spungs') of the Pine Barrens, Southern New Jersey, USA. *Permafrost and Periglacial Processes* 12:337-350. John Wiley & Sons, Ltd: London.

Friedman, Melvin.

1954 Miocene Orthoquartzite from New Jersey. *Journal of Sedimentary Petrology* 24(4):235-241.

Friedman, Milton, and Rose D. Friedman

1980 *Free to Choose*. Harcourt Brace: New York.

Frison, George C.

1968 A Functional Analysis of Certain Chipped Stone Tools. *American Antiquity* 33:149-155.

Geselowitz, Michael N.

1993 Archaeology and the Social Study of Technological Innovation. *Science, Technology and Human Values* 18(2):231-246

Gnaden, Denis, and Simon Holdaway

2000 Understanding Observer Variation When Recording Stone Artifacts. *American Antiquity* 65(4):739-747.

Goodman, Mary Ellen.

1944 The physical properties of stone tool materials. *American Antiquity* 9:415-33.

Gregg, Michael L., and Richard J. Grybush

1976 Thermally Altered Siliceous Stone from Prehistoric Contexts: Intentional versus Unintentional Alteration. *American Antiquity* 41(2):189-192

Griffin, James B. (editor)

1952 *Archeology of Eastern United States*. University of Chicago Press.

Griffiths, D. R., C.A. Bergman, C.J. Clayton, K. Ohnuma, G.V. Robins, and N.J. Seeley

1987 Experimental Investigation of the Heat Treatment of Flint. In *The Human Uses of Flint and Chert*, edited by G. De G. Sieveking and M. H. Newcomer, pp. 43-52. Cambridge University Press: Cambridge.

Grimm, Linda

2000 Apprentice Flintknapping: Relating Material Culture and Social Practice in the Upper Paleolithic. In *Children and Material Culture,* edited by Joanna Sofaer Derevenski, pp. 53-71, Routledge: New York.

Hall, Robert L.

1997 An Archaeology of the Soul: North American Indian Belief and Ritual. University of Illinois Press: Urbana

Hamell, George R.

1983 Trading in Metaphors: The Magic of Beads. In *Proceedings of the 1982 Glass Trade Bead Conference. Research Records No. 16*, edited by C.F. Hayes III, pp. 5-28. Rochester Museum and Science Center. Rochester, N.Y.

———

1992 The Iroquois and the World's Rim: Speculations on Color, Culture, and Contact *American Indian Quarterly*, Vol. 16(4):451-469.

Hanson, Bradley R.

2007 Reconstructing Late Archaic Technology: An Experimental Study of Flaked Stone in The Upper Peninsula of Michigan. Electronic document, accessed 1 April 2008: www.soa.ilstu. edu/downloads/anthro_theses/reconstructing_late_archaic_technology.pdf

Hatch, James W., and Patricia E. Miller

1985 Procurement, Tool Production, and Sourcing Research at the Vera Cruz Jasper Quarry in Pennsylvania. *Journal of Field Archaeology* 12(2):219-230.

Hester, Thomas R.

1972 Ethnographic Evidence for the Thermal Alteration of Siliceous Stone. *Tebiwa* 15:63-65: Pocatello, Idaho.

Hodder, Ian

1999 *The Archaeological Process: An Introduction.* Blackwell: Oxford.

Holmes, William Henry

1892 Aboriginal Quarries of Flakable Stone and Their Bearing upon the Question of Paleolithic Man. Abstract in *Proceedings of the American Association for the Advancement of Science* 41:279-280.

———
1893 Distribution of Stone Implements in the Tide-water Country. *American Anthropologist* 6:1-14.

———
1894 Natural History of Flaked Stone Implements. *Memoirs of the International Congress of Anthropology*, Chicago. Pp. 120-139.

———
1919 *Handbook of Aboriginal American Antiquities, Part 1.* The Lithic Industries. Bulletin 60. Bureau of American Ethnology: Washington, D.C.

Hotchkin, Wayne, and F. Dayton Staats
1983 The Edmunds Rock Shelter. *Bulletin of the Archaeological Society of New Jersey* 39:1-4.

Howard, Jeffrey L.
2005 The Quartzite Problem Revisited. *The Journal of Geology* 113:707–713.

Hummer, Chris C.
1994 Defining Early Woodland in the Delaware Valley: The View from the Williamson Site, Hunterdon County, New Jersey. In *Recent Research into the Prehistory of the Delaware Valley,* edited by Christopher Bergman and John Doershuk, pp. 141-151. A special issue of *Journal of Middle Atlantic Archaeology* 10.

Hunt, Charles B.

1967 *Physiography of the United States*. W.H. Freeman and Company: San Francisco.

Hurst, Stance, and Karin J. Rebnegger

1999 *The Hidden Virtues of Ogallala Quartzite*. Paper presented at the 57th Annual Plains Anthropological Conference.

Jarvis, Hugh

1988 *INAA Characterization of Onondaga Chert: Preliminary Study in Western New York*. M.A. Thesis, State University of New York at Buffalo: Buffalo, New York.

———

1990 Instrumental Neutron Activation Analysis of Onondaga Chert in the Niagara Frontier. *Ontario Archaeology* 51:3-15.

Johnson, L. Lewis

1976 A History of Flint-Knapping Experimentation, 1838-1976. *Current Anthropology* 19(2):337-372.

Jones, Andrew, and Richard Bradley

1999 The Significance of Colour in European Archaeology. *Cambridge Archaeological Review* 9(1):112-114.

Jones, Andrew and Gavin MacGregor (editors)

2002 *Colouring the Past: The Significance of Colour in Archaeological Research*. Berg Publishers: Oxford.

Julig, Patrick J.

2002 *The Sheguiandah Site: Archaeological, Geological and Paleobotanical Studies at a Paleoindian Site on Manitoulin Island, Ontario.* Mercury Series, Archaeological Survey of Canada Paper 161. Canadian Museum of Civilization, Hull, QC.

Kalin, Jeffrey.

1981 Stem Point Manufacture and Debitage Recovery. *Archaeology of Eastern North America* 9: 134-175.

Keeley, Lawrence H.

1980 *Experimental Determination of Stone Tool Uses.* University of Chicago Press: Urbana.

Kier, Charles F., Jr.

1949 Cohansey Quartzite and the Riggins Farm. *Bulletin of the Archaeological Society of New Jersey* 2:1-7.

_______, and Fred Calverley.

1957 The Raccoon Point Site, an Early Hunting and Fishing Station in the Lower Delaware Valley. *Pennsylvania Archaeologist* 27(2):1-100.

Kinsey, W. Fred, III

1959 Recent Excavations on the Bare Island in Pennsylvania: The Kent-Halley Site. *Pennsylvania Archaeologist* 29:109-133.

_______ (editor)

1972 *Archaeology of the Upper Delaware Valley.* The Pennsylvania Historical and Museum Commission. Anthropological Series. No. 2: Harrisburg.

Knowles, Nathaniel.

1941a Comparative Petrology and Typology. In *Archaeology of New Jersey, Volume One*, edited by Dorothy Cross, pp. 153-176. Archaeological Society of New Jersey and New Jersey State Museum: Trenton.

____

1941b Vertical Distribution of New Jersey Artifacts. In *Archaeology of New Jersey, Volume One*, edited by Dorothy Cross, pp. 185-206. Archaeological Society of New Jersey and New Jersey State Museum: Trenton..

Kraft, Herbert C.

1973 The Plenge Site: A Paleo-Indian Site in New Jersey. *Archaeology of Eastern North America* 1(1):56-117.

____

1974 Indian Prehistory of New Jersey. In *A Delaware Indian Symposium*, edited by Herbert C. Kraft. The Pennsylvania Historical and Museum Commission. Anthropological Series. No. 4. pp. 1-55: Harrisburg:

____

1975 *The Archaeology of the Tocks Island Area*. Seton Hall University Museum Archaeological Research Center: South Orange:

____

1990 The Terminal Archaic in the Upper Delaware Valley: A Broad and Narrow Perspective. In *Experiments and Observations on the Terminal Archaic of the Middle Atlantic Region*, edited by Roger W. Moeller. Archaeological Services, pp. 63-83: Bethlehem, Connecticut.

____

2001 *The Lenape—Delaware Indian Heritage: 10,000 B.C. – A.D. 2000*. Lenape Books: N.P.

________, and Michael Blenk.

1974 The Teardrop Point. *Bulletin of the Archaeological Society of New Jersey* 30:13-14.

Kroeber, Theodora

1964 *Ishi in Two Worlds*. University of California Press: Berkeley and Los Angeles.

Krynine, Paul

1948 The Megascopic Study and Classification of Sedimentary Rocks. *Journal of Geology* 56:130-165.

Kümmel, Henry B.

1940 *The Geology of New Jersey*. Department of Conservation and Development. Bulletin 50: Trenton.

———

1941 Geography of New Jersey. In *Archaeology of New Jersey., Volume One*, edited by Dorothy Cross. Archaeological Society of New Jersey and New Jersey State Museum. pp. 7-12: Trenton.

Lacaille, A.D.

1939 Aspects of Intentional Fracture (Being notes on the flaking of some rocks other than flint as exemplified by some Scottish artifacts). *Glasgow Archaeological Society, Transactions* 9:313-341.

Lamplugh, G.W.

1902 Calcrete. *Geological Magazine* 9:575.

LaPorta, Philip

1989 The Stratigraphic Relevance and Archaeological Potential of Chert Bearing Carbonates within the Kittatiny Subgroup. In *Field Trip Guide Book*, edited by Dennis Weis, pp. 240-269. New York State Geological Association: Middletown.

———

1994 Lithostratigraphic Models and the Geographic Distribution of Prehistoric Chert Quarries within the Cambo-Ordovician Lithologies of the Great Valley Sequence, Sussex County, New Jersey. In *Recent Research into the Prehistory of the Delaware Valley*, edited by Christopher Bergman and John Doershuk, pp. 47-66. A special issue of *Journal of Middle Atlantic Archaeology* 10.

Lavin, Lucianne M.

1983 *Patterns of Chert Acquisitions among Woodland Groups within the Delaware Watershed: a Lithologic Approach.* Ph.D. Dissertation, New York University.

_______, and Donald R. Prothero

1987a Microscopic Analysis of Cherts within and Adjacent to the Delaware River Watershed. *Man in the Northeast* 21: 3-17.

_______, and Donald R. Prothero

1987b Identification of "Jasper" Sources in Parts of the Northeast and Mid-Atlantic Regions. *Bulletin of the New Jersey Archeological Society* 42: 11-23.

_______, and Donald R. Prothero

1992 Prehistoric Procurement of Secondary Sources: The Case for Characterization. *North American Archaeologist* 13(2):97-113.

Law, John

2003 "Notes on the Theory of the Actor Network: Ordering, Strategy and Heterogeneity," published by the Centre for Science Studies, Lancaster University, Lancaster LA1 4YN, at http://www.comp.lancs.ac.uk/sociology/papers/Law-Notes-on-ANT.pdf

Lechtman, Heather N.

1977 Style in technology: some early thoughts. In *Material Culture: Styles, Organization, and Dynamics of Technology*, edited by Heather N. Lechtman and R. S. Merrill. West Publishing: St Paul.

Lemonnier, Pierre

1992 *Elements for an Anthropology of Technology.* Anthropological Papers, Museum of Anthropology, No. 88. University of Michigan. University of Michigan Museum of Anthropology: Ann Arbor, Michigan.

_______ (editor)

1993 *Technological Choices: Transformations in Material Culture since the Neolithic.* Routledge: London and New York.

Lenik, Edward J.

1990 The Mountainside Park Site: A Hilltop Procurement-Processing Camp Overlooking the Former Glacial Lake Passaic Basin. *Bulletin of the Archaeological Society of New Jersey* 45:29-41.

____

1991 Patterns of Lithic Resource Selection in the Highlands Region of Northern New Jersey and Southeastern New York. *Bulletin of the Archaeological Society of New Jersey* 46:13-17.

Leroi-Gourhan, André

1943 *L'Homme et a Matiere*. Albin Michel: Paris.

____

1945 *Milieu et Techniques*. Albin Michel: Paris.

____

1993 *Gesture and Speech.* Translated by Anna Bostock Berger. MIT Press, Cambridge, Massachusetts.

Liebekneckt, W., R. Hunter, I. Burrow, M. Tompkins, P. Madrigal, B. Blades, G. Mellin, F. Dunsmore, S. Fehrenbach, B. Seidel, and J. Schuldenrein.

1997 *Puncheon Run Connector, Dover, Kent County, Delaware, Phase I and II Archaeological Data Recovery (First Phase), The Puncheon Run Site (7K-C-51), The Hickory Bluff Prehistoric Site (7K-C-411), The Dawson House Site (7K-C-414), the Nixon Mill Site (7K-C-413).* Delaware Department of Transportation: Dover, Delaware.

Loring, Stephen

2002 And They Took Away the Stones from Ramah. In *Honoring Our Elders: A History of Eastern Arctic Archaeology*, edited by William W. Fitzhugh, Stephen Loring, and Daniel Odess, pp. 163-185. Contributions to Circumpolar Anthropology 2, National Museum of Natural History. Smithsonian Institution: Washington, D.C.

Luedtke, Barbara E.

1976 *Lithic Material Distribution and Interaction Patterns during the Late Woodland Period in Michigan.* Unpublished Ph.D. Dissertation, University of Michigan, Department of Anthropology. Ann Arbor, Michigan.

———

1978 Chert Sources and Trace-Element Analysis. *American Antiquity* 43(3):413-423.

———

1979 The Identification of Sources of Chert Artifacts. *American Antiquity* 44(4):744-757.

———

1985 Untitled Notes on Glacial Transport of Lithic Materials. *Newsletter of the Chert Group* 2(2):2-4.

———

1992 *An Archaeologist's Guide to Chert and Flint.* Institute of Archaeology, University of California: Los Angeles.

Lutz, H. J.

1934 Concerning a Geological Explanation of the Origin and Present Distribution of the New Jersey Pine Barren Vegetation. *Ecology* 15(4):399-406.

Magne, Martin P.R.

1985 *Lithics and Livelihood: Stone Tool Technologies of Central and Southern Interior B.C.*, Archaeological Survey of Canada, Mercury Series 133. Ottawa.

M'Guire, J. D.

1891 The Stone Hammer and Its Various Uses. *American Anthropologist* IV(4):307-309.

Mandeville, M. D.

1973 A Consideration of Thermal Pretreatment. *Plains Anthropologist* 18:177-202

Manson, Carl.

1948 Marcey Creek Site: An Early Manifestation in the Potomac Valley. *American Antiquity* 13:223-227.

Mason, Owen K., and Jean S. Aigner

1987 Petrographic Analysis of Basalt Artifacts from Three Aleutian Sites. *American Antiquity* 52(3): 595-607.

McBryde, Isabel

1997 "The Landscape is a Series of Stories:" Grindstones, Quarries, and Exchange in Aboriginal Australia: A Lake Eyre Case Study. In *Siliceous Rocks and Culture*, edited by A. Ramos-Millan, and M.A. Bustillo, pp. 587-607. Editorial Universidad de Granada, Spain.

McCann, Catherine

1950 The Ware Site, Salem County, New Jersey. *American Antiquity* 15: 315-321.

Mercer, Henry C.

1893 The Result of Excavations of the Ancient Argillite Quarries recently discovered near the Delaware River on Gaddis Run. *Proceedings of the American Association for the Advancement of Science* 42:304-307.

———

1894 Indian Jasper Mines in the Lehigh Hills. *American Anthropologist* 7:80-92.

Miller, Christopher L., and George R. Hamell

1986 A New Perspective on Indian-White Contact: Cultural Symbols and Colonial Trade. *The Journal of American History* 73(2):311-328.

Milnes, A.R., and C.R. Twidale.

1983 An overview of silicification in Cenozoic landscapes of arid central and southern Australia. *Australian Journal of Soil Research* 21:387-410.

Minard, James P.

1965 *Geological Map of the Woodstown Quadrangle, Gloucester and Salem Counties, New Jersey.* U.S. Geological Quadrangle Map GQ-404. Washington, D.C.

Mooney, James.

1891 *The Sacred Formulas of the Cherokees*. 7th Annual report, Bureau of American Ethnology. pp. 302-397.

Morphy, H.

1992 From Dull to Brilliant: The Aesthetics of Spiritual Power among the Yolungu. In *Anthropology, Art, and Aesthetics*, edited by J. Coote and A. Shelton. Oxford University Press: Oxford.

Morris, George, Wilbert F. Reed, Cindy Karageanes, and Guy DiGiugno

1996 The Ware Site Ceramics: A Proposed Chronological Sequence. *Bulletin of the Archaeological Society of New Jersey* 51:17-34.

Moulton, Anne L., and Thomas S. Abler

1991 Lithic Beings and Lithic Technology: References from Northern Iroquois Mythology. *Man in the Northeast* 42:1-7.

Mounier, R. Alan

1972a The Question of Man's Antiquity in the New World: 1840-1927. *Pennsylvania Archaeologist* 42:59-69.

———

1972b The Blue Hole Site. *Bulletin of the Archaeological Society of New Jersey* 29:14-27.

———

1974a Archaeological Investigations in the Maurice River Tidewater Area, New Jersey. *Man in the Northeast* 7:29-56.

———

1974b Aboriginal Use of Petrified Wood in New Jersey. *Bulletin of the Archaeological Society of New Jersey* 30:25-26.

———

1975a Prehistoric Archaeological Survey of Parcel A, Beckett New Town Development, Gloucester County, New Jersey. In *Cultural Resource Survey of Beckett New Town Development, Gloucester County, New Jersey.* Bureau of Archaeology and Ethnology, New Jersey State Museum: Trenton.

———

1975b The Indian Head Site Revisited. *Bulletin of the Archaeological Society of New Jersey* 32:1-14.

———

1990a. *The Abature Site (28-MO-134), Report of Archaeological Data Recovery, Route 18, Section 3C, Eatontown Borough, Monmouth County, New Jersey.* Report to New Jersey Department of Transportation.

———

1990b. *Archaeological Data Recovery, Site 28-BU-403 (Black Run Site No. 4), Kings Grant, Phase II Development, Evesham Township, Burlington County, New Jersey.* Report to Kings Grant Equities, Marlton, New Jersey.

———

1991 *Report of Archaeological Data Recovery, Route 55 Freeway, Section 13A, Deptford Township, Gloucester County, New Jersey.* Report to New Jersey Department of Transportation. Trenton.

———

1992 *An Archaeological Survey of Riding Run Estates, Block 15, Lots 11A, 11B, 17-19, Evesham Township, Burlington County, New Jersey.* Report to DBC Development, Inc. Mt. Laurel, New Jersey.

———

1995 *A Stage II Archaeological Survey of Riding Run Estates, Block 15, Lots 11A, 11B, 17-19, Evesham Township, Burlington County, New Jersey.* Report to DBC Development, Inc., Mt. Laurel, New Jersey.

———

1996a *A Stage II Archaeological Survey of Medford Township Park, Medford Township, Burlington County, New Jersey.* Report to Township of Medford, Burlington County, New Jersey.

———

1996b *Data Recovery at Site 28-BU-277, Elmwood Estates, Block 19, Lot 3A, Evesham Township, Burlington County, New Jersey..* Report to Mainstreet I Associates, Cherry Hill, N.J.

———

1997a *Report of Archaeological Data Recovery, Site 28-GL-31, Logan Township, Gloucester County, New Jersey.* Report to Liberty Property Trust, Malvern, Pennsylvania.

———

1997b *Report of Archaeological Data Recovery, Site 28-GL-33, Logan Township, Gloucester County, New Jersey.* Report to Liberty Property Trust, Malvern, Pennsylvania.

———

1998a *Report of Archaeological Data Recovery, Sites 28-GL-29 and 28-GL-30, Logan Township, Gloucester County, New Jersey.* Report to Liberty Property Trust, Malvern, Pennsylvania.

———

1998b *Archaeological Data Recovery at The Baseman Site, Block 18, Lots 1, 2, and 4, Evesham Township., Burlington County, New Jersey.* Report to Evecan, L.L.C., Haddon Heights, N.J.

———

1998c *Summary Report of Archaeological Research at Medford Township Park (Site 28BU466), Medford Township, Burlington County, New Jersey.* Report to Township of Medford, Burlington County, New Jersey.

———

1998d *Data Recovery at Site 28BU407, Block 17, Lot 11, Evesham Township, Burlington County, New Jersey.* Report to Troth Associates, L.L.C., Marlton, New Jersey.

———

2000a *Report of Archaeological Data Recovery, Site 28-GL-32, The Groppenbacher Farm, Logan Township, Gloucester County, New Jersey.* Report to Liberty Property Trust, Malvern, Pennsylvania.

———

2000b *Report of Archaeological Data Recovery, Site 28-GL-45, Logan Township, Gloucester County, New Jersey.* Report to Liberty Property Trust, Malvern, Pennsylvania.

———

2000c *Stage I/II Archaeological Survey of Block 19.01, Lot 3, Evesham Township, Burlington County, New Jersey.* Report to Elmwood Holdings LLC, Voorhees, New Jersey.

———

2000d *Archaeological Data Recovery at Site 28-BU-492, Block 16, Lot 3, Evesham Township, Burlington County, New Jersey.* Report to the Corrupt Pulaski Construction , Company, Mercerville, N.J

———

2000e *Report of Archaeological Data Recovery Sites 28-BU-225 and 28-BU-226, and Relict Charcoal Kilns in the Highbridge Lakes Development, Medford Township, Burlington County, New Jersey.* Report to Main Line Realty Group, West Berlin, New Jersey.

———

2001 *Archaeological Data Recovery at Block 19.01, Lot 3, Evesham Township, Burlington County, New Jersey.* Report to Elmwood Holdings LLC, Voorhees, New Jersey.

____

2003a *Looking Beneath the Surface: The Story of Archaeology in New Jersey.* Rutgers University Press: New Brunswick, New Jersey.

____

2003b *Data Recovery at the Hidden Creek Development, Block 908, Lots 13.01, 13.04, 13.07, 13.08, 15 and 17, Medford Township, Burlington County, New Jersey.* Report to Cave Holdings, Medford, New Jersey.

____

2005 *Archaeological Data Recovery at Site 28-BU-456, Northside School Project, Medford Township, Burlington County, New Jersey.* Report to Dante Guzzi Engineering, Medford, N.J.

____

2006a *A Stage I Archaeological Survey of Block 5, Lot 6, and Block 6, Lots and 13, South Harrison Township, Gloucester County, New Jersey.* Report to Top Dog Land Development, Voorhees, N.J.

____

2006b *Archaeological Data Recovery at Site 28-GL-344, The Grande at Elk, Elk Township, Gloucester County, New Jersey.* Report to Camco Management, LLC. Haddonfield, N.J.

________, and Jack Cresson.

1988 A Case of Lachrymose Archaeology in Southern New Jersey. *Newsletter of the Archaeological Society of New Jersey* 146:5-8.

_______, and John W. Martin

1992 *Report of Archaeological Data Recovery, Route 55 Freeway, Section 2, Franklin and Elk Townships, Gloucester County, New Jersey.* Report to New Jersey Department of Transportation. February, 1992.

_______, and John W. Martin.

1994 For Crying Out Loud!: News About Teardrops. *Journal of Middle Atlantic Archaeology* 10:125-140.

Munsell Soil Color Company.

1975 *Munsell Soil Color Charts.* Macbeth Division of Kollmorgen Corporation: Baltimore, Maryland.

____

1988 *Munsell Soil Color Charts.* Macbeth Division of Kollmorgen Corporation: Baltimore, Maryland.

____

1992 *Munsell Soil Color Charts.* Macbeth Division of Kollmorgen Corporation: Baltimore, Maryland.

Nassaney, Michael S., and Kendra Pyle

1999 The Adoption of the Bow and Arrow in Eastern North America: A View from Central Arkansas. *American Anti*quity 64:243-263.

NJDEP (New Jersey Department of Environmental Protection)

1979-85 *Annotated Bibliography: Cultural Resource Survey Reports Submitted to the New Jersey State Historic Preservation Officer*. Five Volumes. On file with New Jersey Historic Preservation Office. Trenton

O'Connell, James F.

1977 Aspects of Variation in Central Australian Lithic Assemblages. In *Stone Tools as Cultural Markers: Change, Evolution, and Complexity*, edited by R.V.S. Wright, pp. 269-281. Australian Institute of Aboriginal Studies. Humanities Press: New Jersey.

Odell, George H.

1988 Addressing Prehistoric Hunting Practices through Stone Tool Analysis. *American Anthropologist* 90: 335-356).

———

2001 Stone Tool Research at the End of the Millennium: Classification, Function, and Behavior. *Journal of Archaeological Research* 9(1):45-100.

Orlove, Benjamin S.

1980 Ecological Anthropology. *Annual Review of Anthropology* 9:235-273.

Paton, R.

1994 Speaking through Stones: A Study from Northern Australia. *World Archaeology* 26:172-184.

Patterson, Leland W.

1990 Characteristics of Bifacial Reduction: Flake-Size Distribution. *American Antiquity* 55(3):550-558.

Pond, Alonzo W.

1930 *Primitive Methods of Working Stone, Based on Experiments of Halvor L. Skavlem.* Long Museum Bulletin 2. Beloit College: Beloit, Wisconsin.

Prothero, Donald R., and Lavin, Lucianne M.

1990 Chert Petrography and Its Potential as an Analytical Tool in Archaeology. In *Archaeological Geology of North America*, edited by N.P. Lasca and J. Donahue, pp., 561-564, Geological Society of America Centennial, Special Vol. 4: 633.

Purdy Barbara A.

1973 Fractures for the Archaeologist. In *Lithic Technology: Making and Using Stone Tools*, edited by Earl Swanson, pp. 133-141. Moulton Publishers: The Hague.

———

1974 Investigations concerning the Thermal Alteration of Silica Minerals: An archaeological Approach. *Tebiwa* 17(1):37-66.

———

1981 Pyrotechnology: Prehistoric Applications to Chert Materials in North America. In *Early Pyrotechnology: The Evolution of the First Fire-Using Industries*, edited by T. A. Wertime and S. F. Wertime, pp. 331-44. Smithsonian Institution: Washington, D.C.

____

1984 Quarry Studies: Technological and Chronological Significance. In *Prehistoric Quarries and Lithic Production,* edited by Jonathan E. Ericson and Barbara A. Purdy, pp. 119-127. Cambridge University Press: Cambridge.

________, and H. K. Brooks

1971 Thermal Alteration of Silica Minerals: An Archaeological Approach. *Science* 173:322-25.

Ramenofsky, Ann F.

1987 *Vectors of Death: The Archaeology of European Contact.* Albuquerque: University of New Mexico.

Reuther, Joshua D., and S. Craig Gerlach

2005 Testing the "Dicarb Problem": A Case Study from North Alaska. *Radiocarbon* 47(3):359-366. Tucson: University of Arizona.

Richards, Horace G.

1935 A New Miocene Locality in New Jersey. *American Midland Naturalist* 16(2):208-209.

____

1941 Petrology of Artifacts. In *Archaeology of New Jersey, Volume One*, edited by Dorothy Cross. Trenton: Archaeological Society of New Jersey and New Jersey State Museum. pp. 19-22.

Ritchie, Duncan, and Richard Gould.

1986 Back to the Source: A Preliminary Account of the Massachusetts Hill Quarry Complex. In *Stone Tool Analysis: Essays in Honor of Don E. Crabtree*, edited by Mark G. Plew, James C. Woods, and Max G. Pavesic, pp. 35-53. University of New Mexico Press: Albuquerque.

Ritchie, William A.

1932 *The Lamoka Lake Site*. Researches and Transactions of the New York State Archaeological Association, Volume 7, Number 4. Rochester.

____

1959 *The Stony Brook Site and its Relation to Archaic and Transitional Cultures on Long Island*. Albany: New York State Museum and Science Service. Bulletin 372.

____

1961 *A Typology and Nomenclature for New York Projectile Points.* Albany: New York State Museum and Science Service. Bulletin 384.

____

1965 *The Archaeology of New York State*. Garden City: Natural History Press.

_______, and Robert E. Funk

1971 Evidence for Early Archaic Occupations on Staten Island. *Pennsylvania Archaeologist* 41:45-59.

_______, and Robert E. Funk.

1973 *Aboriginal Settlement Patterns in the Northeast.* New York State Museum and Science Service. Memoir 20: Albany, New York

Robbins, Maurice.

1972 Some Early House Floors. *Bulletin of the Massachusetts Archaeological Society* 32(1-2):1-12.

Robichaud, Beryl, and Murray F. Buell.

1973 *The Vegetation of New Jersey.* Rutgers University Press: New Brunswick, New Jersey.

Sackett, J. M.

1977 Meaning of Style in Archaeology. *American Antiquity* 42:369-380.

Salisbury, Rollin D., and George N. Knapp.

1917 *The Quaternary Formations of Southern New Jersey.* Reports of the State Geologist, Vol. VII. Trenton.

Sanger, David, and Bonnie Newsom

2000 Middle Archaic in the Lower Piscataquis River, and Its Relation to the Laurentian Tradition in Central Maine. *The Maine Archaeological Society Bulletin* 40(1):1-22.

Saul, John M.

1964 *Study of the Spanish Digging Aboriginal Flint Quarries of Southeastern Wyoming.* National Geographic Research Reports.

Schelling, T. C.

1978 *Micromotives and Macrobehavior.* Norton: New York.

Schindler, D. L., J. W. Hatch, Conran A. Hay, and Richard C. Brandt

1982 Aboriginal Thermal Alteration of a Central Pennsylvania Jasper: Analytical and Behavioral Implications. *American Antiquity* 47:526-544.

Schlanger, N.

1994 Mindful Technology: Unleashing the Chaîne Opératoire for an Archaeology of the Mind. In *The Ancient Mind: Elements of Cognitive Archaeology*, edited by Colin. Renfrew and E.B. Zubrow, pp. 143-151, Cambridge University Press: Cambridge.

Schrabisch, Max.

1915 *Indian Habitations in Sussex County, New Jersey.* Geological Survey of New Jersey. Bulletin 13: Union Hill.

———

1917 *Archaeology of Warren and Hunterdon Counties, New Jersey.* Trenton: New Jersey Division of Geology, Bulletin 18.

Sharrock, F.W.

1966 *Prehistoric Occupation Patterns in S.W. Wyoming and Cultural Relationships with the Great Basin and Plains Culture Areas.* University of Utah, Department of Anthropology. Anthropology Papers No. 77.

Shott, Michael J.

1994 Size and Form in the Analysis of Flake Debris: Review and Recent Approaches, *Journal of Archaeological Method and Theory* 1(1):69-110.

Sidoroff, Maria-Louise

2005 *The Process Behind Form and Decoration: Defining North Coast Ceramic Technological Style, Peru.* Unpublished Ph.D. Dissertation. Union Institute & University. Cincinnati, Ohio

Silsby, Scott

1994 Stone Points. In *The Traditional Bowyer's Bible, Volume Three*, edited by Jim Hamm, pp. 275-326. Bois d'Arc Press: n.p.

Sinclair, Anthony

2000 Constellations of Knowledge: Human Agency and Material Affordance in Lithic Technology. In *Agency in Archaeology*, edited by Marcia Anne Dobres and John Robb, pp. 196-212. Routledge, London and New York.

Skinner, Alanson B., and Max Schrabisch

1913 *Preliminary Report of the Archaeological Survey of the State of New Jersey.* New Jersey Geological Survey. Bulletin 9. Trenton.

Skolnick, Herbert.

1965 The Quartzite Problem. *Journal of Sedimentary Petrology* 35: 12-21

Stephenson, Robert L., and Alice L.L. Ferguson

1963 *The Accokeek Creek Site: A Middle Atlantic Seaboard Culture Sequence.* University of Michigan Museum of Anthropology, Anthropological Papers No. 20: Ann Arbor.

Steward, Julian H.

1938 *Culture Element Distributions XIII: Nevada Shoshoni.* University of California Anthropological Records 4:299-359.

Stewart, R. Michael

1987a Rhyolite Quarry and Quarry-Related Sites in Maryland and Pennsylvania, *Archaeology of Eastern North America* 15:7-57.

———

1987b Middle-Late Woodland Cobble/Core Technology in the Delaware Valley of the Mid-Atlantic Region. *Bulletin of the Archaeological Society of New Jersey* 42:33-43.

____

1991 Early Prehistoric Cultures and Interior Site Settings in Southern New Jersey. *Bulletin of the Archaeological Society of New Jersey 46:59-70.*

____

1998 *Ceramics and Delaware Valley Prehistory: Insights from the Abbott Farm.* Trenton Complex Archaeology: Report 14. East Orange, N.J.: The Cultural Resource Group, Louis Berger & Associates, and the Archaeological Society of New Jersey.

________, Chris C. Hummer, and Jay F. Custer

1986 Late Woodland Cultures in the Middle and Lower Delaware River Valley and the Upper Delmarva Peninsula. In *Late Woodland Cultures of the Middle Atlantic Region*, edited by Jay F. Custer, pp. 58-89. University of Delaware Press: Newark.

Struever, Stuart

1968 Flotation Techniques for the Recovery of Small-Scale Archaeological Remains. *American Antiquity* 33(3): 353-362.

Summerfield, M.A.

1981 *The Nature and Occurrence of Silcrete, Southern Cape Province, South Africa.* Research Papers, No. 28, School of Geography, University of Oxford.

———

1983 Silcrete as a Paleoclimatic Indicator—Evidence from Southern Africa. *Palaeogeography, Palaeoclimatology, Palaeoecology* 41:65-79.

Taçon, Paul S.C.

1999 All Things Bright and Beautiful: The Role and Meaning of Colour in Human Development. *Cambridge Archaeological Review* 9(1):120-123.

Thomas, Ronald A., and Nancy H. Warren.

1970 Salvage Excavations at the Mispillion Site. *The Archeolog* 22(2):1-23. n.p.: Sussex Society of Archaeology and History.

Thornbury, William D.

1954 *Principles of Geomorphology*. John Wiley and Sons: New York.

Trigger, Bruce

1989 *A History of Archaeological Thought.* Cambridge University Press: Cambridge.

Truncer, James, J.

1990 Perkiomen Points: A Study in Variability. In *Experiments and Observations of the Terminal Archaic of the Middle Atlantic Region,* edited by Roger W. Moeller, pp. 1-62. Archaeological Services: Bethlehem, Connecticut.

Turner, Victor

1967 *The Forest of Symbols: Aspects of Ndembu Ritual.* Cornell University: Ithaca and London.

Twain, Mark [Samuel L. Clemens]

1893 The Diary of Adam and Eve. In The Complete Short Stories of Mark Twain, edited by Charles Neider, pp. 273-295. 1990 reprint of 1957 edition. Bantam Books: New York.

van der Leeuw, Sander

1993 Giving the Potter a Choice. In *Technological Choices: Transformation in Material Cultures since the Neolithic*, edited by Pierre Lemonnier, pp. 238-288. Routledge, London.

Wallace, A.F.C.

1947 Woman, Land, and Society: Three Aspects of Aboriginal Delaware Life. *Pennsylvania Archaeologist* 17(1-4):1-35.

Wenban-Smith, Francis

2000 *Bringing Behaviour into Focus: Archaic Landscapes and Lithic Technology.* Electronic document, http://www.soton.ac.uk/~ffws/New_ffws/ publications/ ithic5.pdf. Accessed September 14, 2005.

White, Randy

1989 Production Complexity and Standardisation in Early Aurignacian Bead and Pendant Manufacture: Evolutionary Implications. In *The Human Revolution: Behavioral and Biological Perspectives on the Origins of Modern Humans*, edited by C. Stringer and P. Mellars, pp. 366-390. Edinburgh University Press: Edinburgh, Scotland.

———

1997 Substantial Acts: From Materials to Meaning in Upper Paleolithic Representation. In *Beyond Art: Upper Paleolithic Symbolism*, edited by Margaret Conkey, Olga Soffer, Deborah Stratmann, and Nina Jablonski, pp. 93–121. California Academy of Sciences, San Francisco.

Widmer, Kemble.

1964 *The Geology and Geography of New Jersey.* D. Van Nostrand Company: Princeton, New Jersey.

Wiessner, Polly

1990 Is There a Unity to Style? In *The Uses of Style in Archaeology*, edited by Margaret Conkey and Christine Hastorf. Cambridge University Press: Cambridge.

Williams, Lorraine, and Ronald A. Thomas

1982 The Early/Middle Woodland Period in New Jersey. In *New Jersey's Archeological Resources from the Paleo-Indian Period to the Present: A Review of Research Problems and Survey Priorities,* edited by Olga Chesler. Trenton: New Jersey Office of Cultural and Environmental Services. pp. 103-138.

Wilmsen, Edwin N.

1970 *Lithic Analysis and Cultural Inference: A Paleo-Indian Case.* University of Arizona: Tucson.

Witthoft, John

1953 Broadspears and the Transitional Period Cultures. *Pennsylvania Archaeologist* 23(1): 4-31.

———

1963 General Interpretations. In "The Townsend Site near Lewes, Delaware," edited by H. Geiger Omwake and T. D. Stewart. *The Archeolog* 15(1):59-69. Seaford, Delaware: Sussex Society of Archaeology and History.

Wobst, H. Martin

2000 Agency in (Spite of) Material Culture. . In *Archaeology in Agency,* edited by Marcia-Anne Dobres and John Robb, pp. 40-50. London: Routledge.

Wolfe, Peter E.

1977. *The Geology and Landscapes of New Jersey.* Crane Russak: New York.

Wyckoff, John S., and Wayne L. Newell

1988 Silcrete near Woodstown, New Jersey. In *Proceedings of the 1988 U.S. Geological Survey Workshop on the Geology and Geohydrology of the Atlantic Coastal Plain,* edited by Gregory S. Gohn. U.S. Geological Survey Circular 1059: Washington, D.C.

Young, David E., and Robson Bonnichsen

1984 *Understanding Stone Tools: A Cognitive Approach.* Center for the Study of Early Man, University of Maine: Orono.

———

1985 Cognition, Behavior, and Material Culture. In Stone Tool Analysis: Essays in Honor of Don E. Crabtree, edited by Mark G. Plew, James C. Woods, and Max G. Pavesic, pp. 91-131. University of New Mexico Press: Albuquerque.