1

A brief introduction to lithic analysis

On a global scale an argument can be made and easily defended that chipped stone tools and debitage represent the most abundant form of artifacts found on prehistoric sites. In many areas of the world they represent the only form of remains that have withstood the inroads of environmental and human perturbation, such as erosion, decay, and landscape development. Because of this, lithic artifacts represent one of the most important clues to understanding prehistoric lifeways. Yet many archaeologists and most laymen do not understand how stone tools can be analyzed to obtain information about prehistoric lifeways and behavior. Recently I was asked by a graduate student in anthropology what I had found at a site on which I had been working for the past several years. I briefly described a whole array of flake tools, production debitage, bifaces, and raw-material variability. The student was apparently from the school of thought that associates archaeology with the science of discovering buried cities and hidden treasures, because she responded, "how about the good stuff – did you find any good artifacts?" Believing these to be the good artifacts I described how various artifacts and their characteristics relate to time depth, prehistoric exchange, relative sedentism, function, and prehistoric economy. This exchange led me to think about the things lithics can bring to the broader field of archaeology and how the epistemology of lithic artifacts has changed over the past century since lithic studies were first given serious consideration in the archaeological literature. This chapter reviews some of the significant developments in the field of lithic analysis. Most of this review emphasizes topics that will not be covered in detail within this book.

THE ORGANIZATION OF THE BOOK

The goal of this book is to describe and explain how to conduct various kinds of macroscopic analysis of lithic artifacts, and to show how various types of analysis relate to prehistoric human behavior. There are three major sections. The first section comprises the first four chapters and provides the basic background information needed to begin lithic analysis. Chapters 5, 6, and 7, the second section, introduce the analysis of lithic debitage and tools and present technical material to show the reader how to measure, record, and verify. The last section of the book is composed of lithic analysis case studies. Chapters 8 and 9 contain examples of lithic analytical techniques from various parts of the world and draw upon chapters in the first two sections as examples are discussed and explored. Concluding remarks are presented in Chapter 10.

After a brief review of lithic studies in Chapter 1, Chapter 2 explains the principles of the mechanical production of stone tools. Within this context a basic terminology is introduced to the reader and this is gradually expanded and developed throughout the book. The basic concept developed in Chapter 2 is that lithic artifacts are dynamic entities that changed shape and size as they were used in prehistoric cultural systems. This concept sets the foundation for many of the analytical techniques described and explained in later chapters.

To understand variability in lithic artifacts it is important to understand the nature of variability in lithic raw materials. Chapter 3 describes how lithic raw materials are classified. Rocks used for the production of chipped stone tools are given special emphasis. A primary focus of the discussion is upon rock genesis and how that genesis is closely linked to rock classification.

Chapter 4 discusses the identification and classification of lithic artifacts. It is not a review of numerical classification techniques, but instead covers the basic concepts of classification, and then introduces a generalized classification scheme useful for all chipped stone artifacts. Concepts such as attributes, attribute states, types, and typologies are reviewed. These are applied to various approaches to classification, such as monothetic and polythetic approaches, and divisive and agglomerative strategies. The generalized classification scheme introduced in this chapter is used as the framework for organizing different shapes of lithic artifacts and can also be used as a guide for a common vocabulary that is implemented in the subsequent chapters. Debitage characteristics and the techniques used to identify and measure them are discussed in Chapter 5. This chapter reviews some debitage studies and provides a basic guide to debitage measurement. Standardized techniques for measuring debitage size, cortex amount, striking platform types, dorsal flake removals, and curvature are illustrated and discussed.

Various approaches to debitage analysis are included in Chapter 6, which is divided into two primary sections: debitage typological analysis and debitage aggregate analysis. Although both kinds of analysis overlap in the methods of their application, typological approaches emphasize single artifact characteristics and aggregate approaches emphasize artifact populations.

Chapter 7 focuses upon various approaches to lithic tool analysis. Cores, flake tools, and bifaces are considered separately and different analyses are described for each. This chapter reviews some of the basic kinds of lithic tool attributes typically emphasized in the literature and demonstrates how to perform lithic tool analysis. Approaches to analysis such as measuring retouch and assessing reduction trajectories are reviewed and explained. A short review of artifact functional analysis is also included in this chapter. The functional analysis section covers microscopic techniques of analysis as well as approaches to residue analysis.

Several different lithic analytical studies are presented in Chapters 8 and 9 in order to illustrate how lithic analysis relates to interpretation. All of the examples presented use various kinds of lithic artifacts and all revolve around a central theme. Chapter 8 emphasizes the relationship between artifact diversity and site function, and provides a review of artifact function as it relates to artifact form. Chapter 9 continues with additional case studies that use lithic artifacts as the medium for analysis. The central theme for this chapter concerns the manner in which lithic analysis can inform archaeologists about prehistoric sedentism. Within this context, lithic raw-material analysis is introduced to illustrate how complicated lithic patterning can be and what potential problems researchers may encounter when making behavioral interpretations.

Chapter 10 concludes with a discussion on how I would organize a lithic analysis of a complex assemblage. This chapter refers to techniques and examples identified in the earlier chapters. There is also a discussion of the relationship between research questions and the design of lithic analytical strategies.

EARLY HISTORICAL DEVELOPMENT

It can be said that the discovery of stone tools was instrumental in establishing the antiquity of humans. For example, in 1797 John Frere found stone tools in a brick-earth quarry near the English town of Hoxne. Those artifacts were located stratigraphically below the bones of extinct animals (Feder 1996:20). Most of the scientific community at the time believed that humans had been on Earth no longer than 6000 years, the age of the universe created by God. Yet stone tools continued to be found in contexts which suggested that people had inhabited the Earth earlier than 6000 years before the eighteenth century.

William Henry Holmes (1894) was one of the first archaeologists to attempt a systematic analysis of lithic artifacts. In his work Holmes described the goals and contributions of lithic analysis; these included using stone tools as chronological markers, understanding the evolution in form and function of stone tools, and understanding the processes of stone tool production and use. These are still goals for archaeologists interested in stone tool analysis today. From before the twentieth century through to the present, stone tool analysis has followed the lead of Holmes. Chronologies have been constructed using lithic tool styles as diagnostic traits in most parts of the world (Childe 1925; Clark 1932; Frison 1991; Griffin 1943; Kidder 1924; McKern 1939; Oakley 1949; Ritchie 1944). Archaeologists have also characterized the function of prehistoric sites based upon the inferred function of stone tools (Bordes 1961; Burkitt 1925; Clark 1958; Goodyear 1974; Harold 1993; Sieveking 1958).

One of the most significant developments in archaeology that had a major impact on lithic analysis was the replication of stone tool forms by craftsmen such as François Bordes and Don Crabtree in the 1950s and 1960s. Such replication studies stimulated interest in the investigation of lithic tool production techniques. Bordes and Crabtree were not the only archaeologists conducting replication experiments at this time (see Leakey 1954), and they were not pioneers (see Evans 1872); however, they were instrumental in training a significant segment of the archaeological community to value such techniques. The controlled replication of stone tool forms helped develop the related techniques of reduction sequence analysis and tool refitting analysis.

At about the same time that replication studies were being explored in archaeology the microscopic analysis of used stone tool edges was also being carried out. This work was first given serious scientific consideration in the 1930s by Russian scientist Sergei Semenov (Levitt 1979). Semenov's 1957 work was not introduced to western researchers until 1964 when *Prehistoric Technology* was translated into English (Semenov 1964). Significantly, his work suggested that overall stone tool morphology might not always coincide with stone tool function, and that it was possible to conduct direct functional analysis of stone tools by magnification of worked edges.

Another important discovery that affected the manner in which lithic tools are analyzed and perceived today centers upon the realization that stone tool shapes actually change throughout their limited uselife. Although many researchers probably realized this characteristic of stone tools, George Frison (1968) was among the first to make it explicit. If artifact morphology changed during uselife, then tool typologies must reflect such changes in order to be useful functional, temporal, or spatial indicators. The understanding that tools changed shape not only affected the utility of stone tool typologies as diagnostic indicators, it also inspired archaeologists to view stone tools as dynamic, ever changing elements of human material culture directly related to human organizational parameters such as mobility, scheduling, economy, and exchange. Revelations about the character of lithic artifacts brought about by new methodological techniques and perceptual insights have not been easy for all archaeologists to accept. That a lithic typology may not reflect a prehistoric cultural assemblage or that a particular artifact shape may not be ascribed to a single function reaches deeply into the heritage of archaeology. For the reader who wishes to maintain the sanctity of that heritage, there is a great deal of evidence that suggests that lithic types and typologies are firmly linked to function and cultural chronology in many regions of the world. The important thing to realize is that types and typologies can be interpreted differently in different places and in different contexts. More and more, lithic analysts are realizing that there are very few universals in stone tool analysis and that it is important to interpret lithic artifact assemblages within their unique individual contexts.

Much of the support or justification for various techniques of analysis introduced in this book comes from the experimental data generated from replication and microwear studies; however, the techniques of replication and microwear are not within the scope of this volume. Before introducing the formal treatment of macroscopic lithic analytical techniques it is worthwhile to summarize the historical development and contemporary status of lithic experimental studies.

A PERSPECTIVE ON MICROWEAR

Microwear analysis attempts to determine the functions of stone tools by examining direct evidence in the form of usewear on the tool surfaces, particularly near the edges. Both high and low magnification microscopy are used in microwear analysis. As previously stated, microwear analysis in archaeology was stimulated by Semenov's (1964) microwear research in the 1930s. It is important to realize that before 1964 other researchers had attempted to determine lithic tool functions directly from tool surfaces without, but occasionally with, microscopy techniques. Observations on worn or battered stone tool edges had been noted as early as the second half of the nineteenth century (Evans 1872; Rau 1869; Spurrell 1892); researchers in the early twentieth century studied wear patterns in the form of sickle gloss or polish (Crawford 1935; Curwin 1930, 1935; Vayson de Pradenne 1920); and Witthoft (1955, 1967) and Sonnenfeld (1962) used microscopy to determine the function of lithic tools before Semenov was translated. In the late 1960s and early 1970s a number of people experimented with microwear analysis and many articles appeared on the proper technique(s) and contributions of microwear analysis (Ahler 1971; Gould *et al.* 1971; Hayden and Kamminga 1973; Keeley 1974; MacDonald and Sanger 1968; Odell 1975; Tringham *et al.* 1974). In 1977 and 1978 three doctoral dissertations on microwear analysis appeared from different parts of the world. Lawrence Keeley's (1977) research on a British assemblage supported the position that microwear analysis was most effective when very high magnification (up to 500 ×) was used. Keeley also noted that microwear polishes were diagnostic for determining the type of material that lithic tools were used upon. In other words, different worked materials produced variation in polish morphology and texture. According to Keeley's research, such polish variability could only be determined at high magnification levels. George Odell's (1977) research on a Dutch lithic assemblage was based on what has been referred to as low-powered magnification (under 100 ×). Odell's analysis is reported to determine the action of use (such as slicing, boring, and sawing) and the relative density of material being worked (soft or hard). In 1978 Johan Kamminga produced a third dissertation on microwear analysis in Australia. Unlike the Keeley and Odell studies that used experiments to verify microwear patterns on prehistoric lithic artifacts, Kamminga's study used microwear analysis to recognize functional differences on aboriginal stone tools with ethnographically verifiable functions.

Since 1978 the field of microwear analysis has grown steadily in one form or another. One of the most significant contributions to the field was the publication of papers from the first Conference on Lithic Use-Wear (Hayden 1979c). This edited volume covered a variety of topics that microwear analysis has come to address frequently in the archaeological literature, such as polish and abrasion of lithic tools, tool function, variability in raw materials, fracture of tools, and methodological and theoretical applications. Some of the recent studies of lithic microwear analysis have focused upon: (1) use of scanning electron microscopy (SEM) (Anderson 1980; Bienenfeld 1995; Knutsson 1988; Mansur-Franchomme 1983; Meeks *et al.* 1982); (2) tool hafting and prehension (Beyries 1988; Keeley 1982; Moss and Newcomer 1982; Odell 1980, 1994; Shea 1988); (3) prehistoric subsistence (Anderson-Gerfaud 1988; Juel Jensen 1989; Shea 1993; Sussman 1988; Unger-Hamilton 1985); and (4) specialization and ceremonial functions (Odell 1994; Pope 1994; Sievert 1992; Yerkes 1983).

The current field of microwear recognizes three levels of magnification based upon the kind of laboratory equipment used: scanning electron microscope (SEM), metallurgical microscope, and the stereomicroscope. The SEM does not use reflected light to illuminate a specimen, but instead captures an image with a controlled electronic field. Objects can be magnified at over 10 000 × with the SEM. The metallurgical microscope has an effective range of magnification to approximately 500 ×. Metallurgical microscopes use incident lighting that illuminates objects from above at a 90° angle. Stereomicroscopes use external lighting and are effective in the range of 6 × to 150 × magnification. There are advantages, disadvantages, and limitations to each kind of microscope (e.g., Knutsson 1988; Kooyman 2000). The investigator should match his or her research needs with the appropriate instrument.

Although the number and composition of microwear studies have increased rapidly, not all researchers believe that microwear analysis is as effective or as accurate as has been portrayed in the literature. Tests of low-powered microscopy have shown this to be an accurate technique of analysis (Odell and Odell-Vereecken 1980). However, this technique has never been precise enough to determine the kinds of materials on which stone tools were used. The approach has emphasized the action of the tool and the relative density of the material being worked. High-powered microscopy that examines the variability in polishes, among other things, is reported to be successful in determining the kind of material being worked by stone tools. However, even some of the original "blind tests" have shown high-powered microscopy to be problematic, particularly when the tool was used to cut or scrape more than one kind of material (Keeley 1980; Keeley and Newcomer 1977). Post-depositional alteration of the tool (Lévi-Sala 1986), raw-material color (Bamforth 1988), and replicability of polish signatures (Hurcombe 1988; Moss 1987) have been suggested as other factors that reduce effectiveness of functional identifications of tools undergoing microwear analysis. Some researchers strongly disagree that high-powered microscopy can discriminate tool function (Grace 1989; Grace *et al.* 1988; Newcomer *et al.* 1986; Unrath *et al.* 1986). Although criticisms of microwear analysis continue, most of the practitioners continue to use microwear analysis to determine lithic artifact functions (Odell 2004; Yerkes and Kardulias 1993:104).

THE TRUTH ABOUT REPLICATION

Lithic replication studies encompass a broad field of experimental approaches to stone tool analysis and attempt to understand the mechanisms of stone fracture and how these mechanisms produce lithic artifact assemblages. In replication analysis the debitage or by-products of stone tool production experiments are as important to understanding stone tool technology as the finished tools. Modern replication analysis emerged from the craft of flintknapping – the use of primitive technology to make replicas of stone tools. Flintknapping or flintworking techniques used by primitive stone tool makers and users produced the lithic artifact assemblages excavated by archaeologists. To understand the place of replication analysis within the larger field of lithic analysis it is worthwhile to review briefly the history of flintknapping and the replication of stone tools.

Until recently there have been few modern-day flintknappers, and most were making gunflints and not replicas of aboriginal stone tools (Skertchly 1879). However, many of the same principles apply to both gunflint and primitive stone tool production. One of the first individuals to make replicas of primitive stone tools was the English craftsman Edward Simpson (Blacking 1953). During the 1850s he made replicas and sold them to antiquities collectors. By the late nineteenth and early twentieth centuries some researchers began to recognize the value of flintworking techniques in interpretations of the archaeological record and attempted controlled experiments to determine the mechanical principles of stone fracturing (Cushing 1895; Holmes 1891; Nelson 1916; Warren 1914). With the exception of a few studies in the early twentieth century (Ellis 1939; Pond 1930), flintknapping techniques were neither used nor accepted as viable research techniques by archaeologists interested in lithic analysis.

During the 1960s François Bordes and Don Crabtree brought flintknapping to the attention of lithic artifact researchers. Both were exceptional stone tool craftsmen who understood and could explain many of the principles of stone fracture that related to the craft of stone tool production. These two men were united with other professional and amateur archaeologists at the lithic technology conference in France that was instrumental in convincing the profession at large of the value of flintknapping in lithic analysis (Jelinek 1965). In the years following that conference several publications appeared that used results of flintknapping experiments to interpret lithic artifactual data (Bordes and Crabtree 1969; Crabtree 1966, 1967, 1968, 1970, 1972; Crabtree and Swanson 1968). In the 1960s and early 1970s the field of flintknapping was polarized between those interested in the benefits of flintknapping knowledge for lithic analysis and those interested in making high-quality replicas of primitive technology. Many flintknappers with ties to academic programs became interested in lithic analysis as a result of replicating stone tools as a craft. In addition to Bordes and Crabtree some of the other prominent flintknappers of the time were Errett Callahan, Jacques Tixier, J. B. Sollberger, and Bruce Bradley.

Throughout the 1970s and early 1980s replication studies relied more heavily upon the craft of flintknapping and less upon the science of stone tool production technology. Many archaeologists became flintknappers and a great deal of the literature on lithic tool replication focused upon the how-to or craft side of replication (Bradley 1974, 1978; Callahan 1974, 1976, 1979; Clark 1982, 1984; Flenniken 1978, 1981). However, this was a necessary step in the development of replication analysis because it was important to understand the range of production variability. Unfortunately, because much of that production variability was not systematically controlled in experiments, replication studies were criticized as nonscientific (Thomas 1986, 1989). However, the field of lithic replication studies was growing and moving in many directions. While some replication studies were criticized as nonscientific, others were criticized by flintknapping craftsmen as too scientific or laboratory sterile to be relevant for interpretations of prehistoric stone tools. The more controlled experiments shifted the emphasis of analysis away from the finished products of lithic tool production to the by-products of production (Andrefsky 1986a; Cotterell and Kamminga 1979, 1987, 1990; Speth 1972, 1974, 1975, 1981). As a result of this shift, lithic replication experiments gained new acceptance in the archaeological community as controlled scientific experiments that could provide important behavioral information to lithic analysis (Ahler 1989; Ammerman and Andrefsky 1982; Ammerman and Feldman 1978; Andrefsky 1983; Henry *et al.* 1976; Patterson 1979; Raab *et al.* 1979; Stahle and Dunn 1982). The use of more controlled experiments in replication analysis has grown to include not only debitage studies, but also the analysis of finished lithic tools (Flenniken and Raymond 1986; Frison 1989; Frison and Bradley 1980, 1981; Titmus 1985; Titmus and Woods 1986).

Critics of replication studies persist in charging that such studies demonstrate only how stone tools might have been made and used, but not how they actually were made or used. This is true. Yet such criticisms ignore the fact that controlled replication experiments produce a range of lithic artifact variability within differing parameters that can be controlled and understood. Such variability can also be compared with archaeological assemblages to gain insight into the parameters associated with the archaeological assemblage. Additionally, refitting or conjoining studies of excavated lithic assemblages have supported the findings of replication analysis associated with lithic tool reduction sequences (Cahen *et al.* 1979; Hofman 1981; Singer 1984; Villa 1982). Most of the powerful criticisms against lithic replication studies focus upon those that either lack precision on experimental controls or jump to interpretations about the archaeological record from experiments that are not well linked to archaeological assemblages. Since flintknapping is a part of lithic replication analysis and because most flintknappers are not scientifically trained archaeologists (Whittaker 1994:61), it is important to remember that interpretations derived from replication experiments do have varying scientific merit. *Flintknapping*, a book by John Whittaker (1994), emphasizes the relationship between debitage characteristics and tool production procedures, and takes flintknapping out of the arena solely of arts and crafts and shows its value in lithic replication analysis. The edited volume *Experiments in Lithic Technology* (Amick and Mauldin 1989a) contains numerous examples of how replication experiments could be used to interpret archaeological stone tool data. Studies of this kind have gone a long way towards solidifying the role of replication studies in the larger field of scientific archaeology (cf. Austin 1999; Bradbury and Carr 1999; Carr and Bradbury 2001; Dag and Goren-Inbar 2001; Ferguson 2003; Knecht 1997; Rasic and Andrefsky 2001; Shen and Wang 2000; Will 2000).