PART ONE

INTRODUCTION, BACKGROUND, AND REVIEW

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AN INTRODUCTION TO STONE TOOL LIFE HISTORY AND TECHNOLOGICAL ORGANIZATION

It is relatively easy for most people to understand differences in life histories with organisms such as dragonflies and mollusks, because these organisms undergo dramatic morphological transformations during their life histories. However, if we did not know that *glochidia* living in the gills of fish were the larval phase of mussels, we might classify them as totally different organisms because of their different appearance and different habitat. However, biologists have followed the life histories of these and countless other organisms and have demonstrated the metamorphoses that have taken place. Archaeologists working as taxonomists do not have the benefit of observing the life histories of stone tools. We find and record artifacts in a static state. However, as a result of replication experiments, renewed ethnographic observations, and detailed lithic analytical strategies, it has become apparent to researchers that lithic tools often undergo a series of transformations from the time they are produced or drafted into service until the time they are ultimately discarded. Such transformations relate to all manner of social and economic situations of the tool users. Tools are sharpened when they become dull. They are reconfigured or discarded when they are broken. They are modified to suit a certain task in a certain context. Their uses are often anticipated and they are produced in anticipation of those uses. These and countless other examples of tool transformations can be characterized as part of the life histories of lithic tools.

Lithic tools are dynamic in their morphological configurations because of these life history transformations.

A flake blank originally used as a meat-slicing knife with an acute edge angle may be transformed due to dulling and edge resharpening into a tool that contains a serrated edge used for sawing. This tool can be intentionally chipped and shaped into a projectile point and mounted into a shaft for use as a dart. A single specimen can undergo one or more such transformations during its life history. Such life history transformations not only change the tool form but may also change the tool function, and both formal and functional changes are often associated with forager land-use practices. In this manner, the life histories of stone tools are intimately linked to the organization of stone tool technology.

Lithic technological organization has been defined in a number of different and yet similar ways (Andrefsky 2006; Binford 1973, 1977; Kelly 1988; Koldehoff 1987; Nelson 1991; Shott 1986; Torrence 1983). In all cases, it refers to the manner in which humans organize themselves with regard to lithic technology. Because foraging societies are most often associated with lithic technology, most studies of lithic technological organization deal with forager adaptive strategies. In this context, the manner in which lithic tools and debitage are designed, produced, recycled, and discarded is intimately linked to forager land-use practices, which in turn are often associated with environmental and resource exploitation strategies. I consider lithic technological organization a strategy that deals with the way lithic technology (the acquisition, production, maintenance, reconfiguration, and discard of stone tools) is embedded within the daily lives and adaptive choices and decisions of tool makers and users.

An important component of lithic technological organization concerns the life histories of stone tools. Below I review some of the ways that technological characteristics of lithic artifacts relate to their life histories. I then provide a brief review of the assembled papers in this volume, which address many of the reviewed concepts, such as measuring retouch, recognizing curation, using lithic raw material variability, and understanding tool transformations.

REDUCTION AND REDUCTION SEQUENCES

The life histories of stone tools are often associated with the reduction of stone tools. Because stone tools are produced by reduction or the removal of stone from a nucleus or objective piece, it is easy to equate stone tool life histories to the unidirectional reduction of stone – the farther an objective piece is reduced, the farther the specimen is in its life history. Some of the early thinking in this area can be attributed to William Henry Holmes (1894), who coined the term *lithic reduction sequences*. Stone tool reduction sequences have traditionally been associated with stone tool production phases, stages, or continua. This is particularly true of North American bifacial technology, where the trajectory of reduction begins with raw material acquisition and ends with notching, fluting, or final sharpening of the tip and edges (Callahan 1979; Shott 1993: 94–6; Whittaker 1994: 153–61). Investigators not only examine lithic tools for evidence of reduction sequences but also focus on detached pieces (debitage and debris) in an effort to gain insight into tool production activities (Ahler 1989; Amick and Mauldin 1989; Andrefsky 2001; Bradbury and Carr 1999; Carr and Bradbury 2001; Kalin 1981; Odell 1989; Pecora 2001; Rasic and Andrefsky 2001). Other studies of lithic debitage have examined the source of variation in debitage characteristics in an effort to link those characteristics to broader issues of technological practices. For instance, a series of studies have examined the relationship of debitage striking platform angles to original flake size and production technology (Cochrane 2003; Davis and Shea 1998; Dibble 1997; Dibble and Pelcin 1995; Pelcin 1997; Shott et al. 2000).

The literature on lithic reduction sequences as it relates to technological organization is sometimes complicated by confusing terminology. When talking about the manufacture of "tools" using pressure or percussion flaking methods, I use the term "production." I use the term "reduction" when talking about the removal of detached pieces from cores. In this sense, "reduction" refers to the process of flake removal for the acquisition of detached pieces and "production" refers to the process of flake removal for the purpose of making, shaping, or resharpening a tool. So cores are "reduced" and tools are "produced." I use the term "retouch" as a generic descriptor for removing detached pieces from an objective piece. Essentially, retouch is the process by which flintknappers produce tools and reduce cores.

The recent literature dealing with lithic reduction sequences is not far removed from the concept of chaîne opératoire. Some researchers claim the chaîne opératoire concept "comprises a much wider range of processes than do the English terms reduction sequences or even lithic tool production" (Simek, 1994:119; see also Audouze 1999; Eren and Prendergast, this volume). Inizan and colleagues suggest that chaîne opératoire includes the processes from the procurement of raw materials, through the stages of manufacture and use, and including discard (Inizan et al. 1992; Sellet 1993). Other archaeologists challenge the notion that chaîne opératoire is more encompassing than the concept of "reduction sequences" (Shott 2003). This chapter is not the appropriate venue to explore this discussion. My general opinion is that both concepts are substantially the same thing, and that both are inclusive of the larger issues of procurement, manufacture, use, maintenance, and discard. Furthermore, both concepts are embedded within the larger issues of human land use related to environmental, social, and historical contexts (Andrefsky, this volume; Bleed 1986; Clarkson 2002; Eren et al. 2005; Hiscock and Attenbrow 2003; Hiscock and Clarkson, this volume; Nowell et al. 2003; Pecora 2001; Wilson and Andrefsky, this volume). It is for these reasons that regardless of the terms used, the production of tools and the reduction of cores are central to an understanding of lithic technological organization. Lithic retouch, whether it relates to tool production or maintenance, or the acquisition of blades and flakes, has much to do with the contexts of human land use, and for this reason, understanding reduction sequences and chaîne opératoire allow us to better understand lithic technological organization and the life histories of stone tools.

As lithic analysts begin thinking about the place of stone tools within the framework of life histories, we envision tools in multiple contexts. Stone tools are produced, used, maintained, reconfigured, discarded, reused, discarded, and ultimately discovered by archaeologists and others. These multiple contexts expand our understanding of stone tool reduction from simply the production contexts of tools to a more inclusive understanding of maintenance contexts. Retouch of stone tools not only includes the production stages of tool manufacture, but also includes the chipping of tool edges after use to resharpen or reconfigure the specimen (Brantingham and Kuhn 2001; Flenniken and Raymond 1986; Hiscock and Attenbrow 2003; Morrow 1997; Nowell et al. 2003; Tomka 2001). Recent investigations have shown that some stone tool types such as flake knives have no separate production and use phases. Such tools are retouched as needed, resulting in morphological transformation during the process of use and resharpening (Clarkson 2002; Dibble 1987; Rolland and Dibble 1990). Other stone tool types such as projectile points have very discrete production and maintenance phases; they are not used or maintained until after they have gone through a formal production process (Andrefsky 2006; Hoffman 1985; Shott and Ballenger 2007). Even though stone tools such as projectile points undergo morphological transformation in both the production and use phases as a result of retouch, the production phase is not a good measure of tool use. Such differences in tool types have important implications for measuring reduction as a proxy for curation.

ARTIFACT RETOUCH AND CURATION

In the 1970s Binford (1973, 1979) introduced the curation concept to hunter–gatherer archaeology. Shortly afterward archaeologists began exploring, discussing, and dissecting this concept in some detail (Bamforth 1986; Bleed 1986; Chatters 1987; Close 1996; Gramly 1980; Nash 1996; Odell 1996). One reason the curation concept generated so much discussion was Binford's complicated way of using the term. In my opinion, it was complicated because he did not provide a strict definition and instead used the term in association with a number of interesting ideas. For instance, Binford discussed curation in the context of artifacts being transported from one location to another in anticipation of tasks to be completed at the new location (1973). As a result, some archaeologists associated curation with transported tools (Bettinger 1987; Gramly 1980; Nelson 1991). Binford also linked curation to efficiency of tool use. Bamforth's (1986) paper on technological efficiency and tool curation expanded this concept to include five aspects of tool curation: (1) production in advance of use, (2) implement design for multiple uses, (3) transport of tools to multiple locations, (4) maintenance of tools, and (5) recycling of tools. The notion of tool production effort was added to the definition in the form of complex tools, or tools with haft elements or complex flaking patterns (Andrefsky 1994a; Hayden 1975; Parry and Kelly 1987). Nash's review of the curation concept concludes that the term is ill-defined but already embedded in the literature. He says (Nash 1996:96), "In the absence of such standardization, we should drop the term from the archaeological literature all together." Odell (1996: 75) concludes that for the term "curation" to be useful, "the most parsimonious usage would retain those elements associated with mobility and settlement, and discard the ones associated with tool conservation."

Some of the early lithic analytical practitioners of the curation concept contrasted "curated tools" with "expedient tools" (Andrefsky 1991; Bamforth 1986; Kelly 1988; Parry and Kelly 1987). "Curated" tools were often recognized as having extensive retouch and "expedient" tools were recognized as having very little retouch. This simple way of viewing retouch on tools was sometimes superposed on Binford's model of hunter–gatherer land use, with foragers being residentially mobile and collectors being residentially sedentary or semisedentary. "Curated" tools were often associated with foragers and "expedient" tools were often associated with collectors. This kind of stone tool classification is still popular in the literature. However, most lithic researchers now realize that this one-to-one relationship is not realistic and stone tool configuration is influenced by many other factors, such as raw material availability, shape, and functional considerations (Andrefsky 1994a; 1994b; Bamforth 1991; Bradbury and Franklin 2000; Kuhn 1991; Tomka 2001; Wallace and Shea 2006).

Many early studies of stone tool curation viewed curation as a type of tool. I find the curation concept workable in the context of technological organization if it is recognized as a process associated with tool use rather than a tool type. I refer to it as a process reflecting a tool's actual use relative to its maximum potential use (Andrefsky 2006, this volume; Shott 1996; Shott and Sillitoe 2005). Importantly, then, curation is a process related to tool use. Curation is not a tool type. There are no curated tools, but only tools in various phases of being curated from very low use relative to maximum potential use to very high use relative to maximum potential use. In this way, curation can be measured from low to high, allowing investigators to plug curation into models of human organizational strategies and into the life histories of tools.

For these reasons, it is important to understand that some tools have a production phase discrete from the maintenance phase. Because retouch occurs in both production and maintenance phases, retouch in and of itself may not be a good proxy for curation. Tool curation deals with tool use. Some forms of tools are retouched extensively and never used. As such, they have not undergone curation, even though they are extensively retouched (Andrefsky 2006; Hoffman 1985). This suggests that measures of retouch and reduction must be intimately associated with characteristics such as artifact type and potential artifact function, and even with extramural agencies such as lithic raw material abundance and quality. The collection of papers in this volume demonstrate the importance of these various contextual influences on retouch measures and show how retouch relates to processes such as curation, human land use patterns, and lithic tool functional differences.

HUMAN ORGANIZATION AND LITHIC RAW MATERIAL SELECTION

Another factor that influences lithic technological organization and the life histories of stone tools is lithic raw material availability, abundance, form, and quality. These aspects of lithic raw materials play an important role in the length of time and detail with which a tool is prepared, used, and maintained. Anthropologists studying tool makers and users long understood the importance of lithic raw material availability and abundance to those tool makers and users (Gould 1980, 1985; Gould and Saggers 1985; O'Connell 1977; Weedman 2006). The distribution and availability of lithic raw materials are undeniably important in stipulating how humans manufactured, used, and reconfigured stone tools. Because lithic raw materials can often be provenanced, they provide robust information about the circulation of stone, and by inference, the circulation of people across the landscape. This fact alone makes lithic raw material an important resource for gaining insight into human land use and mobility patterns and relating those to lithic technology. Recent archaeological research has directly linked lithic raw materials to tool production and core reduction technologies (Brantingham and Kuhn 2001; Roth and Dibble 1998) to artifact functional effectiveness (Brantingham et al. 2000; Hofman 1985; Sievert and Wise 2001), to retouch intensity on tools (Andrefsky, this volume; Bradbury et al., this volume; Kuhn 1991, 1992; MacDonald, this volume), and to aspects of risk management (Baales 2001; Braun 2005).

Information gained from lithic raw materials regarding source location, shape, size, durability, and abundance has increased our understanding of stone tool technological organization. Important in this growing knowledge is the fact that lithic raw materials do not play a deterministic role in human organizational decisions, but rather act as one of many factors in how tool makers and users decide to produce, maintain, and discard stone tools.

DISCUSSION

Shott and Nelson (this volume) provide a detailed review of the collection of papers in this volume. I will not repeat their insights here, but instead discuss the multiple linkages among the different papers that bring this volume together into a new synthesis of artifact life histories and lithic technological organization. However, first I must emphasize that the collection of papers covers a broad geographic and temporal span of aboriginal tool maker data. Three papers cover examples from French data sets spanning the Paleolithic. Two papers deal with Near Eastern data during the Neolithic. North American examples are derived from Paleoindian times to historic period aboriginal populations, and from the east coast to the central plains to the west coast, and from Canada to the arid southwest. Other papers touch upon data from Mongolia, Australia, and Italy. The collection of papers as a group illustrate the importance of artifact life history analysis in understanding technology and human organizational strategies.

In the past several decades, lithic artifact production and use experiments have been beneficial in helping researchers understand tool production debris (Amick et al. 1988; Andrefsky 1986; Carr and Bradbury 2004; Kuijt et al. 1995; Titmus 1985), reduction sequences (Ahler 1989; Bradbury and Carr 1999; Magne 1989), and artifact function (Bradley and Sampson 1986; Geneste and Maury 1997; Odell and Cowan 1986; Shea 1993). Several papers in this volume continue the trend of using experiments to generate empirical data for comparison and interpretation of excavated assemblages. Eren and Prendergast (this volume) use a series of retouch experiments to assess various reduction indices. They show that different indices actually measure different aspects of tool retouch. Wilson and Andrefsky (this volume) conduct experiments to show that biface production is analytically separable from biface maintenance after use, and that bifacial retouch related to production is part of the tool's life history but has nothing to do with the curation of the biface. Quinn et al. (this volume) use a suit of experiments to assess retouch on awls and drilling tools. Their results suggest that retouch measures should be designed for specific tool types and assemblage contexts to be most effective for inferring aboriginal behaviors. Bradbury et al. (this volume) use extensive experimental data to isolate raw material influences and hammer type influence in the reduction process. They suggest that lithic raw materials can be partitioned into three broad categories relative to retouch intensity. That is, lithic raw material fracture properties can effectively be segregated into three gross kinds of raw material as opposed to the hundreds and thousands of varieties that exist in chipped stone technology.

Technological organization has been intimately linked to studies of lithic raw material abundance and availability (Ammerman and Andrefsky 1982; Andrefsky 1994b; Daniel 2001; Knell 2004; Larson and Kornfeld 1997) and of suitability for various tool tasks (Amick and Mauldin 1997; Bradbury and Franklin 2000; Ellis 1997; Knecht 1997). Several of the volume contributions focus specifically upon the influence of lithic raw material variability on retouch mechanics or retouch measures. The Bradbury et al. paper (this volume) directly explores the role of raw material type in the flake removal process. MacDonald's paper (this volume) explores raw material abundance and quality as it relates to tool design strategies. His results suggest that aboriginal tool makers and users selected raw material types for their functional qualities. Andrefsky's paper (this volume) uses XRF analysis to locate raw material sources and relates source distances to aspects of tool retouch, resharpening, and discard within the circulation ranges of the tool makers. Harper and Andrefsky (this volume) use lithic raw material analysis to help tease out the life histories of dart points to show how they are recycled in later period occupations in the American southwest. Similarly to Andrefsky's study, Clarkson's paper (this volume) uses raw material diversity to address issues of artifact provisioning and tool stone transport.

Artifact function has always been an important factor in understanding stone tool morphology. Archaeological evidence (Dixon et al. 2005; Elston 1986; Kay 1996; Truncer 1990) and ethnographic analogy