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Raw material economies and mobility patterns in the Late Paleolithic at Shuidonggou locality 2, north China

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ABSTRACT

This paper addresses variation in lithic raw material economy within the Late Paleolithic sequence at Shuidonggou locality 2, north China. The stratigraphic sequence documents nearly 14,000 years of the Late Paleolithic, with evidence for changes in raw material procurement and exploitation, mobility pattern and territory use. Although raw materials are generally similar throughout the sequence, the ways local materials were exploited changed over time. There is also evidence for increased exploitation of more distant sources in some cultural layer. Shifts in raw material economy at Shuidonggou locality 2 are argued to represent responses to changes in residential mobility and the scale/duration of occupations at the site itself: data on cultural features and foraging strategies provide independent evidence for shifts in site use. Results have implications on more appropriate approaches to investigate the adaptive dimensions of simple core-flake technologies in north China from a cost/benefit perspective.
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1. Introduction

Studies of lithic raw material economies have become integral to analyses of lithic assemblages, assuming an increasingly prominent role in the understanding of technological decision-making among extant and prehistoric hunter-gatherers (for resent summaries and references, see, for example, Adams and Blades, 2009; Braun et al., 2008; Hovers, 2009). As a basic source of information about Paleolithic technology, analyses of chipped stone raw materials have provided much interesting evidence for understanding technological organization and mobility (e.g., Andrefsky, 1994; Ambrose and Lorenz, 1990; Ambrose, 2002, 2006; Blades, 1999; Kuhn, 1995, 2004; Minichillo, 2006), exchange and social networks (Bourque, 1994; Féblot-Augustins, 1993, 2009; MacDonald, 1999), cognitive capacities (e.g., Wynn and McGrew, 1989) and other features of ancient foragers and foraging adaptations.

There is a broad agreement about the dynamic links between lithic technologies and mobility patterns, based on principles of raw material economics which are often combined ecological models (e.g., Ambrose, 2006; Ambrose and Lorenz, 1990; Bamforth, 1986, 1990, 1991; Binford, 1979, 1980; Johnson and Morrow, 1987; Kelly, 1988, 1992; Kuhn, 1991, 1995, 2004; McCall, 2007; Nelson, 1988; Odell, 2004; Surovell, 2009). The main points of debate revolve around the relative importance of lithic raw material availability versus strategic factors in determining the organization of technology (e.g., Andrefsky, 1994). Holding the disposition of raw materials constant, however, researchers concur that variables such as mobility and site use have a strong influence of the economics of raw material exploitation.

This paper presents a case study in changing raw material economy among prehistoric foragers using a single site. It describes hypothetical changes of mobility patterns demonstrated by raw material procurement and exploitation. Such topics were of little concern in Chinese Paleolithic research until recently (but see Brantingham, 1999; Brantingham et al., 2000; Gao, 1999, 2001). The Paleolithic sequence at Shuidonggou locality 2, north China, documents changes occurring over a period of more than 14,000 years. The same range of local and semi-local raw materials were used throughout the sequence and these materials were used to make similar assemblages of artifacts, mainly using simple core and flake technology. Meanwhile, there are detectable changes in procurement of more distant raw materials and in how various types of stone were exploited. Evidence from cultural features

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and faunal records support the notion that shifts in raw material use were in turn related to mobility and land use.

2. Time, technology, raw material and mobility

Discussions of patterns in tool use and their archaeological consequences have increasingly emphasized the systematic consideration of cost and benefit, although few of these studies make substantive use of formal ecological models (Bird and O'Connell, 2006). However, studies have established some dynamic linkages between raw material economy, technology, and mobility within an ecological framework. In terms of optimality models, the goal of foraging is to gain food calories (or other currencies) in the most efficient way possible, either by maximizing the energy gained in some fixed time or minimizing the time required to meet a fixed energy requirement (Ugan et al., 2003). Time budgeting is a primary adaptive constraint and in many case it is likely to be a more critical factor for human survival (Bousman, 1993; Collard et al., 2005, 2011; Torrence, 1983). Given this assumption, technological choices in foraging can be expected to vary according to the time allocation (Torrence, 1983; Ugan et al., 2003). Although time was certainly not the only constrain in prehistory subsistence, it does play a potentially important role and provides a ready theoretical tool which connects human behavior (such as technology and mobility) and environment (such as food and raw material sources) to help model evaluate human decision-making. Considering costs and benefits under the guidance of generalized optimality models can help reveal relations between technology and mobility in prehistory communities.

On one hand, if the total amount of time available for conducting an activity is limited, there will be benefits to employing tools that increase the time efficiency of that activity. In other cases there may be no actual time stress for carrying out a particular activity but it may be necessary to schedule certain types of behavior in order to minimize opportunity costs for various competing activities (Torrence, 1983). The time available to gather resource is influenced by a range of constraints such as resource availability (food and raw material), foraging scheduling (like mobility), or the use-life of the technology (Ugan et al., 2003).

Although stone was not the only material for making tools, it is the best preserved and most plentiful material in Pleistocene archaeological records globally, making it an essential document of ancient hominin behavior. The availability of raw material had an important influence on lithic technologies and technological behavior. As essential challenge is keeping people provisioned with usable material when requirements arise, for there are few places where people can always count on finding the raw material and time they need to make tools on the spot (Kuhn, 1995, 2004). Scarcity of raw materials in the vicinity of locations where tools are most frequently used will result in comparatively intensive exploitation and reuse (Andrefsky, 1994; Kuhn, 1991, 1995), and/or the transport of raw materials from distant locations (Binford, 1979; Kuhn, 1995, 2004), partly because getting new material in these context costs much more time than reusing and reshaping transported artifacts. On the other hand, when tool use occurs in locations with rich raw materials, there are no obvious economic advantages to reusing and reshaping artifacts, unless the artifacts themselves are comparatively costly or unless activities are time-stressed. This is not usually the case with simple stone tools, so archaeologists frequently observe "wasteful", or at least non-economizing behavior where raw materials are plentiful.

Patterns of landuse and mobility affect both raw material availability and time allocation, and further influence lithic technology. Generally, people engaging in frequent residential moves cannot be assured of finding raw material or time to make tools as needs arise (Kuhn, 1991; Goodyear, 1989). In order to ensure that tools are available when needed, at least a basic inventory of implements must be carried from place to place (Kuhn, 1991, 1992). This kind of transport of toolkits favors extensive maintenance and reduction of implements which are important parts of so-called "curated" technology generally (Binford, 1979; Bleed, 1986; Kuhn, 1994; Kelly, 1988; Shott, 1996). In the case of particular activities such as hunting large game, which entail high levels of time stress, pre-made artifacts should always be used (Torrence, 1983, 1989). Groups that spend more time in a particular place experience more predictable access to raw materials, fewer transport costs, and (sometimes) reduced time stress, and, all other things being equal, we can expect much less extensive raw material and artifact reuse and reshaping, or more "expedient" tool production strategies a pattern which has been demonstrated repeatedly in North American assemblages (e.g., Parry and Kelly, 1987).

The duration of individual occupation can also affect the allocation of time. Short-term occupations provide few opportunities to collect new raw material to make tools, so assemblages of artifacts generated by very brief occupations might be expected to contain a large component of worn-out or broken transported fear (Kuhn, 1991; Surovell, 2009). But if raw materials are locally plentiful, more intensive use of local material should be expected due to constraints of time. As lengths of occupation periods expand, people have more opportunity to procure materials from the surrounding countryside (Kuhn, 1991; Surovell, 2009) and experience less time stress in their use of the local material, if available. Considering a continuum of occupation durations, a wider range of raw material types, and/or less intensive exploitation of local raw material could be expected as occupation durations increase.

3. A case study: Shuidonggou locality 2

The Shuidonggou Basin is located in north China, 18 km east of the Yellow River on the margins of the Ordos Desert (Fig. 1). During the first studies of the Shuidonggou in 1923, Emile Licent and Pierre Teilhard de Chardin (Licent and Teilhard de Chardin, 1925) identified and investigated five distinct localities including Shuidonggou locality 2. This site is located at the left side of Biangou River opposite to the better-known Shuidonggou locality 1. Locality 2 was excavated in 2003, 2004, 2005, and 2007 as part of a multi-disciplinary program of research on several of the Shuidonggou localities (Gao et al., 2013; Li et al., 2013a; Pei et al., 2012).

Two trenches of up to 100 m^2 in area were excavated at locality 2. The exposed strata reach a total thickness of 12.5 m. The sedimentary sequence from unit 2, the more complete of the two trenches, is described by Liu et al. (2009). Sediments at the base are fine sand and gravel; these give way successively to a greyish black peat deposit, then light greyish green silt, and finally light greyish yellow silt. A total of 18 substrata are described, seven of which contain debris from Palaeolithic occupations. The cultural layers are numbered 7–1 from bottom to top (CL7-CL1) (Fig. 2). The strata preserving Paleolithic remains are mainly shallow lake and lakeshore deposits, which generally have small planar, wavy or cross bedding (Liu et al., 2009, 2012). At a macroscopic scale occupation of the locality was episodic, with more-or-less dense cultural layers interspersed with accumulations of archaeologically sterile sediment (Fig. 3).

Comparison of debitage size profiles with the experimental assemblage reported by Schick (1986) indicates that the majority of assemblages are intact, with little evidence of winnowing by water (Fig. 4). However, assemblages from CL7, CL6 and CL5b do not fit well with experimental size profiles. The bias towards larger

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