BEHAVIORAL SNAPSHOTS: SINGLE-REDUCTION LOCI PATTERNING IN THE MOJAVE DESERT

MARC W. HINTZMAN
AECOM ENVIRONMENT, ONTARIO, CALIFORNIA

ALAN GARFINKEL
AECOM ENVIRONMENT, CAMARILLO, CALIFORNIA

The most abundant artifacts in the Mojave Desert are lithic debitage. To understand the behavioral patterns behind this material, it is necessary to determine the constraints of the raw materials, the technological patterning of the debitage, and the intended products that resulted. For the Mojave Desert, five technological patterns have been identified: material assay, bipolar reduction, Topaz Mountain reduction, single or multidirectional flake-core reduction, and bifacial reduction. This paper examines the patterns of the reduction identified during a recent survey in the western Mojave Desert. We use replicative lithic studies to examine these patterns of reduction. The results are a guide for interpreting these fascinating surface deposits.

In the last year, AECOM has been involved in several archeological projects in the California desert (Figure 1). Many of the prehistoric sites occur on cobble terraces or desert pavements. In such locations, high-quality toolstone is readily available and was often procured throughout prehistory (Figure 2). Similar sites have been reported since the early 1980s and were discussed by Wilke and Schroth (1989), who defined patterns of lithic reduction on such desert pavement surfaces. They interpreted these areas as locations where toolstone materials were “assayed” or “quarried.” One point we hope to make in this article is that the terms introduced by Wilke and Schroth may need to be reconsidered.

Flenniken and Spencer (2001) conducted a recent examination of the technology found on desert pavement surfaces. The authors examined cobble terrace sites and discuss the behaviors and technological patterns of reduction observed in these contexts so that we may better understand such sites. Byrd et al. (2009) noted that one benefit of the pavement deposits is that single-reduction loci (SRL) occur with great frequency. This paper specifically examines SRL contexts to shed light on the patterns of reduction.

DESERT PAVEMENT / COBBLE TERRACE DEPOSITS AND ASSOCIATED LITHIC MATERIALS

Desert pavements are defined as layer of pebbles or gravel which cover a stabilized surface (Waters 1992:204; Wells et al. 1987). Throughout the arid west, desert pavement surfaces are associated with artifact scatters (Ahlstrom and Roberts 2001:1). In the Colorado Desert, cobbles of toolstone material were deposited when the Colorado River meandered across the landscape during the Pleistocene and Holocene eras (Lerch et al. 2009:9). As the river flowed, it brought with it cobbles of various lithic materials such as chert, jasper, chalcedony, rhyolite, and fine-grained basalt, to name just a few. Over time, the river changed course and the cobbles remained behind. The cobble deposits eventually became the desert pavements and cobble terrace locations that are common in the Colorado River region today. Most studies of desert pavement focus on the formation processes or on the potential for dating desert-varnished surfaces; only a few have concentrated on the archaeology associated with these geological deposits (Alhstrom and Roberts 2001; Anderson 1999; Dorn 1988; McDonald et al. 1995; Wells and Ritter 1994; Wells at al. 1987).

In pavement contexts in the Mojave Desert, some researchers have argued that the reduction of cryptocrystalline silica (CCS) materials may be associated with a specific span of prehistory, from 5000 until 1800 cal B.P. (Byrd et al. 2009). Lithic reduction in these geological contexts raises several

Figure 1. Mojave Desert.

questions about the prehistoric behaviors associated with stone-tool procurement. If quality lithic materials are concentrated in these areas, should reduction patterns be the same in other areas rich with toolstone, or should reduction patterns differ from area to area? Should such site areas be conceptualized as "stone-rich" environments, or merely as places where people stopped briefly on their way to somewhere else? Several terms and concepts are frequently associated with such contexts; these are discussed below and help us to clarify these questions.

Often-Used Terms

The variety of terms used to characterize cobble terrace and desert pavement sites have led to some confusion about what these terms really mean. Some of the descriptions characterize these sites as

Figure 2. Site with high-quality toolstone.

areas where raw materials have been assayed (Wilke and Schroth 1989) and cobbles have been tested or quarried. The assaying and testing of lithic materials are two different ways of saying the same thing. Further, some have described the behaviors at these sites as quarrying (Wilke and Schroth 1989), while others disagree, contending that quarries are more appropriately defined as pits or shafts that have been dug to extract specific resources. At cobble terrace and desert pavement sites, the materials are surface deposits, which do not require pits or shafts to recover the materials.

We suggest that the terms “assay” and “quarry” may be inappropriate since they originate from hard rock mining and imply the Euroamerican style of industrial exploitation of a resource. These terms are too burdened with meanings, and other terms appear to us to be more appropriate.

Methods and Findings

While conducting surveys in the Mojave Desert, more than 20 cobble terrace and desert pavement sites were recorded. The abundance of lithic artifacts at such sites requires careful thought prior to recording them. Dense concentrations of debitage, cores, and tools present a challenge. In a survey context, data need to be recorded efficiently and with enough detail that it is possible to interpret those data. On the other hand, how detailed should the recording be? Should every flake be recorded, or do we sample? Several methods were used to address these challenges.

For small sites, detailed information was recorded for all of the lithic artifacts. For medium and large sites, single-reduction loci and “formed artifacts” were recorded in detail, whereas individual flakes

Table 1. Eighty-two reduction loci at various sites in the Mojave Desert.

	Chalcedony	Other CCS*	Basalt	Total	Percentage
Bifacial Reduction	5	2	0	7	9
Flake-Core Reduction	0	22	0	22	27
Cobble Sections	0	6	37	43	52
Bipolar Reduction	0	3	7	10	12
Total				82	100

*CCS refers to cryptocrystalline silicates

were tallied according to material type and technology. The technological information recorded included the pattern of reduction (i.e., biface, flake core, or bipolar reduction), the methods used to produce the flakes (percussion or pressure), the stage of reduction (i.e., early, mid, or late stage), and the lithic material used.

Several desert pavement sites that we recorded literally spanned miles—to record such sites, additional methods were needed. For very large sites such as these, all the single-reduction loci and all the "formed artifacts" were recorded in detail; however, individual flakes were no longer tallied, and instead 10-x-10-m sample units were established across these sites and every artifact within them was recorded in detail. We pioneered the development of various methods to collect a set of data from which we could extract technological and behavioral information.

The methods applied at these sites allow us to identify:

- what the intended flaked stone end products are;
- how various toolstone material types affect the reduction strategy;
- patterns of reduction at the sites; and
- how the resources were conceptualized in the past.

For years, flintknappers have been saying that the configuration of the raw material affects the kinds of cores that could be produced. A discussion of how the technologies and their configuration affected the reduction strategies that were used follows (Table 1).

Bifacial cores are often made from tabular pieces of chalcedony or from thin oval cobbles of chert or jasper. Using tabular material or thin cobbles requires minimal effort to remove the cortex and shape these materials into early-stage bifaces. The pattern we describe is similar to the pattern described for pavement surfaces within Fort Irwin (Byrd et al. 2009). If the type of blank used to produce a biface changes, then the resulting debitage will change as well. For example, identified areas with tabular materials were used to produce bifaces, and other areas with large flakes were used to produce bifaces. Large flakes are frequently observed in flake-core reduction loci and are ideal blanks for biface production. When large flakes were used to produce bifaces, the associated debitage consists of a high frequency of debitage from early stages of biface reduction. This early-stage reduction does not typically manifest flakes with cortex on their dorsal surfaces. It is likely that many large flakes were the byproduct from flake core reduction. In contrast, the bifacial reduction of tabular materials results in debitage from the early stages of biface reduction. That debitage retains significant amounts of cortex on the dorsal surface.

Flake cores are a common occurrence on cobble terrace and desert pavement sites; we define a flake core as having one or more platforms from which linear flakes were removed in a systematic manner (Crabtree 1982). Such cores are made on thick, rounded cobbles. One end of a cobble is often detached using direct percussion or a bipolar method. Bipolar flaking is discussed below. Once a flake is detached, that scar can be used as a platform for further reduction. The debitage observed in these reduction loci often consists of one end of a cobble, associated with cortical or mostly cortical debitage, and often the core was discarded in the same area.

Cobble sectioning is a method that detaches flakes in a sequential order along the long axis of a cobble (Figure 3). The goal is to produce flakes of a consistent size and character. The technique has been

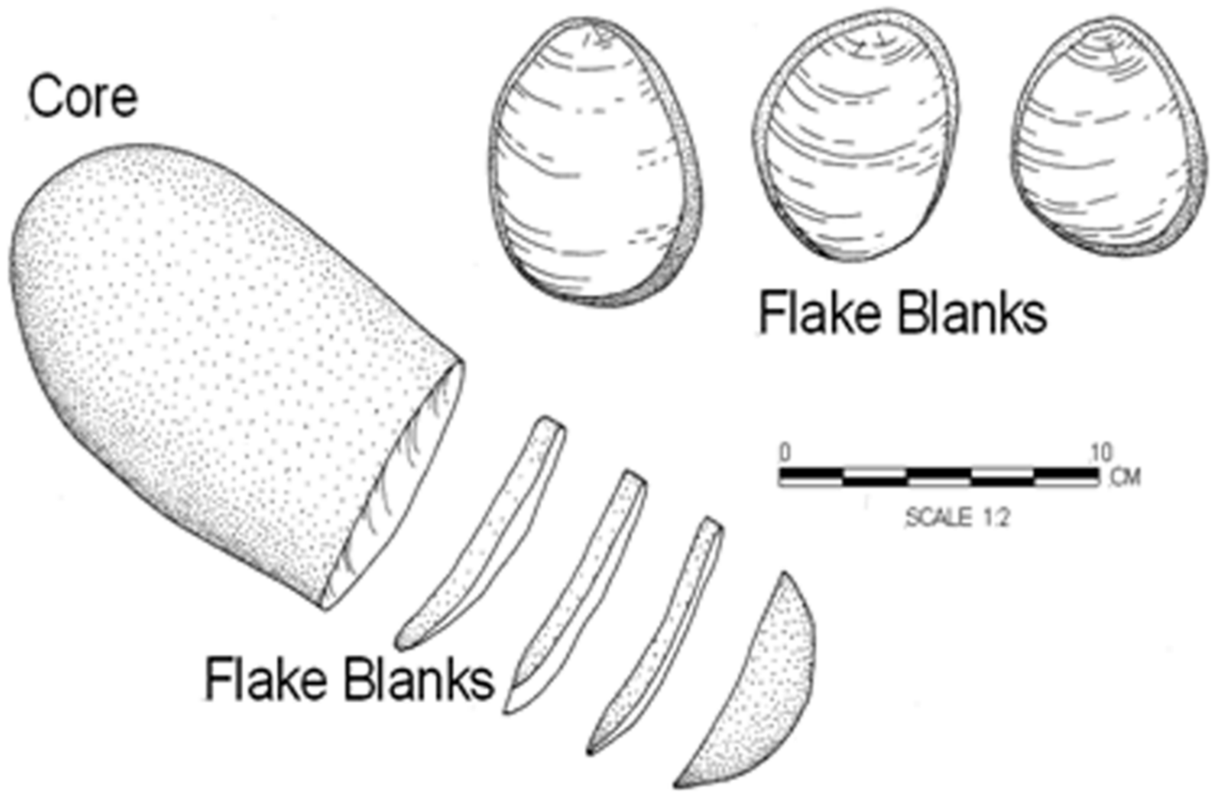

Figure 3. Cobble sectioning. (Illustration courtesy of Dr. Jeffery Flenniken; see Flenniken and Spencer 2001.)

described as the "sausage slice" method (Tixier and Newcomer 1974) and as Topaz Mountain reduction (Flenniken and Spencer 2001). Cobble sectioning occurs with regularity on some cobble-terrace sites. The debitage from cobble sectioning often consists of the proximal and distal ends of a core as well as several broken cobble sections. Often, hammer stones are also associated with these deposits.

Bipolar reduction was frequently used to reduce small pebbles of high-quality materials that could not be reduced by any other method (Figure 4). The bipolar method places the pebble that is intended for reduction on an anvil. The pebble is then struck with a hammer stone; the force of the percussion emanating from the hammer stone and the anvil causes a pebble to split and produce debitage (Crabtree 1982; Kooyman 2000:56). Bipolar-reduction debitage includes split pebbles and flakes or "shatter" often demonstrating concentrated and pronounced rings of force. Additionally, flakes and shatter are also a common result, and these typically are devoid of rings of force. Other diagnostic attributes include debitage that has crushing on its proximal and distal ends and that often exhibits cortex that remains along all margins of the debitage. Hayden cautions that none of these attributes appear consistently. Some or only one attribute might appear in this type of reduction sequence. As a result, bipolar reduction can be difficult to identify in the field.

In the Mojave Desert, the reduction of fine-grained basalts is often correlated with percussion biface reduction that has been identified as characteristic of early and middle Holocene adaptations (Basgall 1996; Basgall and Hall 1994). The reduction patterns noted by Basgall and Hall did not include bipolar reduction. It is unlikely that the bipolar reduction of basalt would be associated with early or middle Holocene deposits.

Figure 4. Bipolar reduction: A) bipolar core; B) bipolar flake; C) the proximal end of the core with crushing.

RESULTS

In more than one instance, cobble reduction began using the bipolar method (often to detach a platform). Next, the cobble was reduced as a flake core; then a large flake from the reduction was used as a blank for a biface. The various strategies were identified according to the distinct debitage types that each produces. Further, in these loci, debitage could often be retrofit (or refit), and the stages of reduction were immediately apparent and very distinctive. The analysis of the various reduction loci at a number of different sites identified that these patterns of lithic toolstone reduction are not linear. The reduction sequence does not begin with one technique and continue using the same strategy. Instead, reduction patterns are fluid, often starting with one technology and shifting to another as needed. Changes in reduction strategy likely occurred when a different approach would garner the best results.

Such fluid patterns of reduction make it difficult to quantify the frequency of one method of reduction vs. another. Careful examination of the debitage ensures that the textured nature of the reduction sequence is retained. With these challenges in mind, we discuss the patterns observed to explain the various reduction patterns that occur at these sites.

During our surveys, bipolar reduction was consistently associated with pebbles of fine-grained basalt. It is worth noting that some attributes of bipolar reduction are more pronounced on CCS materials than on fine-grained basalts. For example, with CCS, crushed proximal and distal ends, cortical margins, and pronounced compression rings occur regularly. However, bipolar reduction of fine-grained basalts often results in crushed proximal and distal ends and cortical margins, while not demonstrating the pronounced compression rings noted in other materials.

It is not surprising that flake-core reduction and bifacial-core reduction occurred with the greatest frequency. It is clear that the configuration of the raw materials affected the methods of reduction applied.

Cobble sectioning occurs consistently on many sites, most often applied to quartzite cobbles; lesser amounts of chert were also used. The frequency with which this technique was observed suggests that the flake blanks may have served a specific function.

From these findings, several patterns are clear. Chalcedony was almost exclusively used for the production of bifaces. Most often, chalcedony occurs as flat, tabular materials, which are well suited for biface production. Further, flake cores were more commonly produced from other CCS materials like chert or jasper. One reason for this is that chert and jasper occur as large, rounded river cobbles. The materials are configured in ways that lend themselves to being reduced as flake cores. Finally, only one material was constantly reduced using the bipolar method: basalt. Basalt occurs as small pebbles, which cannot be reduced as a biface or a flake core. Unlike the chert cobbles, the pebbles of basalt are high-quality material and often occur as small, ovate pebbles, which are particularly well-suited for bipolar reduction. On the other hand, the quality of smaller CCS materials is unpredictable.

In the Tiefort Basin, the reduction of fine-grained basalts is associated with the Pinto Period and earlier deposits (Hall 1993). As previously mentioned, bipolar debitage is commonly associated with debitage from other reduction strategies. This situation makes it difficult to quantify the frequency of this technique across a site. It is unclear whether bipolar reduction was a means to establish a platform, split a biface, or produce flakes from a cobble prior to reduction by another means. In many of the reduction loci examined, the majority of the debitage produced and the core itself from which the flakes were taken remained in association. The artifacts could all be refit, and only one or two flakes would be missing from the reduction sequence.

CONCLUSIONS

This paper identifies that there is yet much to be learned about cobble terrace and desert pavement reduction areas. The assumption that assay and quarrying are all the behavioral information that could be collected should be questioned. Further, there is a need to reconceptualize these geological and cultural contexts, as the patterns of reduction at such sites differ from most other kinds of sites in the California desert. The patterns could be described as “wasteful,” or perhaps better as only typical for areas where stone is plentiful. The apparent contradiction of shaping a cobble into a core and then leaving the core behind is evidence of this mindset. Further, patterns of reduction that have been identified have clearly been shaped by the configuration of the cobbles that were reduced.

The suggestion has been made that basalt reduction occurred prior to the Gypsum period, while CCS was preferred throughout the Gypsum period (ca. 1200 B.C. to A.D. 600). We agree that the desert pavement sites examined for this research might likely adhere to that chronological pattern. However, we caution that bipolar reduction of basalt clasts was noted with regularity; we do not suggest that the bipolar reduction of basalt implies a pre-Gypsum pattern of reduction. Rather, the small size of the clasts and the quality of the material would have made it more desirable during the Pinto period (ca. 5000 to 1200 B.C.).

Finally, it has been demonstrated that reduction patterns are not linear, even in a stone-rich environment. Instead, they are fluid and adaptive to the various challenges that the stone presents to the flintknappers. These findings indicate that there is yet much to learn about how cobble terrace sites were used, what changes in toolstone material preference occurred over time, and the role that patterns of reduction played in these contexts.

REFERENCES CITED

Ahlstrom, Richard V. N., and Heidi Roberts

2001 Desert Pavements and Buried Archaeological Features in the Arid West: A Case Study from Southern Arizona. *Journal of California and Great Basin Anthropology* 23:1-26.

Anderson, Kirk G.

1999 Processes of Vesicular Horizon Development and Desert Pavement Formation on Basalt Flows of the Cima Volcanic Field and Alluvial Fans of the Avawatz Mountains Piedmont, Mojave Desert, California. Unpublished Ph.D. dissertation, Department of Earth Sciences, University of California, Riverside.

Basgall, Mark E.

1996 *A Brief Cultural History of the National Training Center, Fort Irwin, San Bernardino County, California.* On file, San Bernardino Archaeological Information Center, San Bernardino County Museum, Redlands, California.

Basgall, Mark E., and Mathew C. Hall

1994 *Status Report on Cultural Resources Management at the National Training Center, Fort Irwin, 1993-1994.* Addendum to the Fort Irwin Historic Preservation Plan. On file, San Bernardino Archaeological Information Center, San Bernardino County Museum, Redlands, California.

Byrd, Brian F, D. Craig Young, and Kelly R. McGuire

2009 Pavement Quarries, Gypsum Period Residential Stability, and Trans-Holocene Settlement Systems of the Mojave Desert: A Case Study at Fort Irwin. *Journal of California and Great Basin Anthropology* 29:121-143.

Crabtree, Don E.

1982 *An Introduction to Flintworking*. Idaho State Museum, Pocatello.

Dorn, Ronald I.

1988 A Rock Varnish Interpretation of Alluvial-Fan Development in Death Valley, California. *National Geographic Research* 4(1):56-73.

Flenniken, Jeffery J, and A. C. Spencer

2001 *In Field On-Site Analysis of Lihtic Debitage Dominated Sites (LDDS) Associated with the McCoy Wash Watershed Project, Riverside County, California*. U.S. Department of Agriculture, Natural Resources Conservation Service.

Hall, Mathew C. (editor)

1993 *Archaeology of Seven Prehistoric Sites in the Tiefort Basin, Fort Irwin, San Bernardino County, California*. Far Western Anthropological Research Group, Davis, California.

Kooyman, Brian P.

2000 *Understanding Stone Tools and Archaeological Sites*. University of Calgary Press, Calgary, Canada.

Lerch, Michael K., Robert M. Yohe II, and Mark Q. Sutton

2009 *Quarries along the Sidewinder Trail II: Further Investigations in the Sidewinder Quarry Archaeological District, Barstow, San Bernardino County, California*. Report on file, San Bernardino Archaeological Information Center, San Bernardino County Museum, Redlands, California.

McDonald, Eric V., Leslie D. McFadden, and Stephen G. Wells

1995 The Relative Influences of Climate Change, Desert Dust, and Lithologic Control on Soil-Geomorphic Processes on Alluvial Fans, Mojave Desert, California: Summary of Results. *San Bernardino County Museum Association Quarterly* 42(3):35-42.

Tixier, Jacques, and M. H. Newcomer

1974 *Glossary for the Description of Stone Tools, with Special Reference to the Epipalaeolithic of the Maghreb*. Newsletter of Lithic Technology Special Publication No. 1. Washington State University, Pullman.

Waters, Michael R.

1992 *Principles of Geoarchaeology: A North American Perspective*. University of Arizona Press, Tucson.

Wells, Stephen G., Leslie D. McFadden, and John G. Dohrenwend

1987 Influence of Late Quaternary Climatic Changes on Geomorphic and Pedogenic Processes on a Desert Piedmont, Eastern Mojave Desert, California. *Quaternary Research* 27:130-146.

Wells, Stephen G. and J. B. Ritter

1994 Surficial Geology. In *Archaeological Overview and Sample Survey of the Silurian Valley Study Area*, edited by Bryan Byrd and Drew Pallette, pp. 25-84. On file, San Bernardino Archaeological Information Center, San Bernardino County Museum, Redlands, California.

Wilke, Philip P., and Adella B. Schroth

1989 Lithic Raw Material Prospects in the Mojave Desert, California. *Journal of California and Great Basin Anthropology* 11:146-174.