CHAPTER 13

Differential Selection of Lithic Raw Materials by Prehistoric Hunter-Gatherers in the Upper Yellowstone River Valley, Montana/Wyoming

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Procurement strategies of lithic raw materials are an integral part of the lithic technological organization of prehistoric hunter-gatherers. With the early beginnings of lithic technology studies**,** a debate emerged in the archaeological literature regarding the organizational and scheduling events of procuring lithic raw materials (Binford 1979; Gould and Saggers 1985). Differential patterns of raw material procurement were observed in middle range studies (Binford 1980; Schiffer 1972) and were utilized by archaeologists to estimate the organizational strategies of individuals in prehistory. However, these early debates occasionally neglected the most important part in the equation of lithic raw material procurement, the raw material source. As suggested by Andrefsky (1994a, 1994b) and Elston (1992), various extrinsic attributes are important to examine to understand lithic technological organization of hunter-gatherers, including lithic raw material morphology, quality, and availability. An examination of these attributes in the form of a quantitative gravity model (Wilson 2007), coupled with the ethnographic data, can provide a means of differentiating raw material procurement strategies.

In this paper**,** we attempt to evaluate the context in which prehistoric hunter-gatherers conducted lithic raw material procurement activities in the Gardiner Basin, Montana/Wyoming, in light of Binford's (1979) embeddedness concept. In so doing, we examine two raw material procurement areas in Yellowstone National Park, Wyoming: Obsidian Cliff obsidian and Crescent Hill chert. These two sources of stone were used most frequently by prehistoric hunter-gatherers that lived at two archaeological sites in the lowest, driest portion of Yellowstone National Park, Montana, the Yellowstone Bank Cache Site and the Airport Rings Site (Figure 13-1). At both of the archaeological sites, Obsidian Cliff obsidian represents the most common lithic raw material, with Crescent Hill chert representing the second most common material.

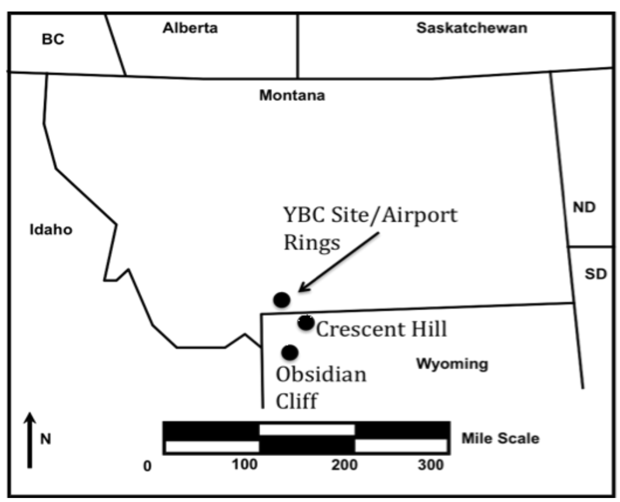

Figure 13-1. Location of areas discussed in text.

To evaluate the overall advantages of procuring material from one source over the other, various attributes were quantitatively examined in a gravity

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model. The remainder of this paper provides an overview of procurement strategies in the lithic technological organization literature. Subsequently, both raw material procurement areas in northwestern Wyoming will be discussed regarding basic attributes in the context of the two archaeological sites in the Gardiner Basin, Montana. Lastly, we review the arguments for why this provides a good case study for looking at differential procurement of raw materials.

Raw Material Procurement Strategies

With the genesis of lithic technological organization, the organizational and scheduling events of procuring lithic raw material has become a major topic of debate in the archaeological literature. During Binford's ethnoarchaeological work**,** he examined raw material procurement strategies among the Nunamiut and the Alyawara (Binford 1979, 1980; Binford and O'Connell 1984). He defined two types of procurement strategies, embedded and direct. Embedded strategies represent the procurement of raw materials when other tasks are being performed (e. g. subsistence tasks). Ethnographically, Binford (1979:259) provides an example of this among the Nunamiut:

> …a fishing party moves in to camp at Natvatrauk Lake. The days are very warm and fishing is slow, so some of the men may leave the others at the lake fishing while they visit a quarry in Nassaurak Mountain, 3. 75 miles to the southeast. They gather some material there and take it on top of the mountain to reduce it to transportable cores. While making the cores they watch over a vast area of the Anaktuvuk valley for game.

As seen from the example above there was no special trip for the procurement of raw material but instead it was "embedded" within a subsistence task, and even when the material was being reduced, it was accomplished at a location where hunting was the main site activity, not lithic reduction. The embeddedness concept represents the behavioral strategies of the Nunamiut and shows that procurement of raw materials was of secondary importance to hunting game. Direct strategies, on the other hand, assume that individuals travel for the specific task of obtaining raw material with no subsistence tasks in mind (Gould 1985) (see Figure 13-2).

With the two strategies of raw material procurement posited, a debate in the archaeological literature emerged between Lewis Binford (Binford 1979, 1985, 1989; Binford and Stone 1985) and Richard Gould (Gould 1985; Gould and Saggers 1985) regarding the soundness of these terms. Binford (1979:259, emphasis in original) states that, "*very rarely, and then only when things have gone wrong, does one go out into the environment for the express and exclusive purpose of obtaining raw material for tools.* " However, Gould et al. (1971) propose that direct procurement of raw materials occurred commonly among aborigines in the central desert of Australia.

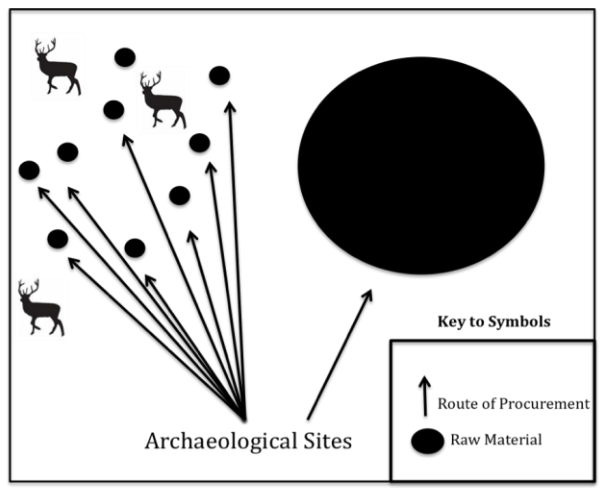

Figure 13-2. Embedded compared to Direct Procurement.

Gould and Saggers (1985) argued this point by examining the procurement strategies of aborigines of the central desert of Australia and the amount of variability in material types observed at archaeological sites. They posit objections to Binford's view that procurement is only associated with subsistence activities and suggest that the procurement of raw materials may be tied to social factors that may reflect the technological needs of individuals, for instance, establishing kinship networks to accommodate for the risk of living in the harsh desert environment. From their standpoint there were specific trips for the sole purpose of obtaining lithic raw material, deemed the "righteous-rock" argument. Gould and Saggers (1985:120) state that:

> In contrast to the Nunamiut, there is ample evidence that Western Desert Aborigines made special efforts to visit lithic sources. Usually as part of a visit to an adjacent site, but sometimes, too, in order to obtain raw material that was known to have superior technical properties.

That said, both Binford and Gould agree that embedded raw material procurement is the most common of the strategies. This makes the most sense from a standpoint of overall task management and efficiency when moving on the landscape. However, Seeman (1994) looked at early Paleoindian lithic use at the Nobles Pond site in Ohio and concluded that procurement of raw materials was a "disembedded" task. He states that, "the acquisition of lithic raw material was not embedded in subsistence behavior, but rather, was a specialized activity required by the particular demands of band aggregation in a location far removed from sources of acceptable lithic materials" (Seeman 1994:273).

Attributes of Raw Material Procurement

Since the Binford-Gould debate, as well as important studies by Schiffer (1972) and Andrefsky (1994a, 1994b), the study of technological organization and lithic raw material procurement has emerged as a major research focus for archaeologists in North America (Andrefsky 2008; MacDonald 2009; Nelson 1991). Comparing lithic raw material sources is often difficult and can be subjective in nature. However, there are certain attributes that can be examined to determine the overall quality of a source and the economic value of exploiting the source. Elston (1992) postulates several "extrinsic cost factors" that remove some of the subjectivity of the examination of quality of a raw material source. These extrinsic cost factors include quality, abundance, distribution, and mode of occurrence of lithic raw material on the landscape. In a similar thread, Andrefsky (1994a, 1994b) has viewed the roles raw material size, shape, quality, and availability play in hunter-gatherer decision-making strategies. There are also human "factors" in the decision-making involved with the procurement of raw materials such as difficulty of terrain (Raven 1992; Wilson 2007). These factors deal with social organization, mobility patterns, provisioning strategies, and territorial limits (Wilson 2007). Both "extrinsic cost factors" and human factors will now be examined in regard to Obsidian Cliff and Crescent Hill.

Obsidian Cliff vs. Crescent Hill

Obsidian Cliff is an obsidian source in northwestern Wyoming that was continuously visited throughout prehistory for the purpose of obtaining high quality lithic raw material. Regional studies of lithic raw material use indicate the importance of obsidian from Obsidian Cliff as a toolstone source in prehistory (Davis et al. 1995; MacDonald and Hale 2011; Scheiber and Finley 2011). That said, the material was not just localized to the Greater Yellowstone Ecosystem, but has been found across North America. For instance, 300 kg of Obsidian Cliff obsidian was found cached at a Hopewell site 680 km away in the midwestern United States (Davis et al. 1995:57).

In regard to quality, Obsidian Cliff represents an extremely homogenous, isotropic source of raw material (Figure 13-3). As seen from the example shown here, hunter-gatherers went to great lengths to obtain the material in prehistory. When a stone is highly siliceous, homogeneous, and isotropic in character, it can be considered a valuable commodity for peoples manufacturing stone tools (Cotterell and Kamminga 1987). Andrefsky (2005:24) states that, "stones most suitable for flintknapping are those that are brittle and do not have direction-dependent properties such as bedding planes, fissures, cracks, or inclusions…natural glass or obsidian is probably the best example of this kind of material. "

Figure 13-3. Obsidian Cliff obsidian.

Not only is the quality of obsidian at Obsidian Cliff very high, availability of the stone was also great, with the material found in abundance across approximately a square kilometer area in northwest Wyoming (Davis et al. 1995). Across this area, obsidian is available in large nodules that have eroded out of the cliff face, material in the cliff face, as well as access to bedrock at the top of the outcrop area. The overall distribution of the material is also ideal, with the outcrop area representing a densely concentrated source on the landscape. For the human factor of the equation, distance plays a major role in how far people were willing to go to obtain materials. In the case of Obsidian Cliff, it was likely only accessed during snow-free times, due to the substantial accumulation of snow on the Yellowstone Plateau in winter.

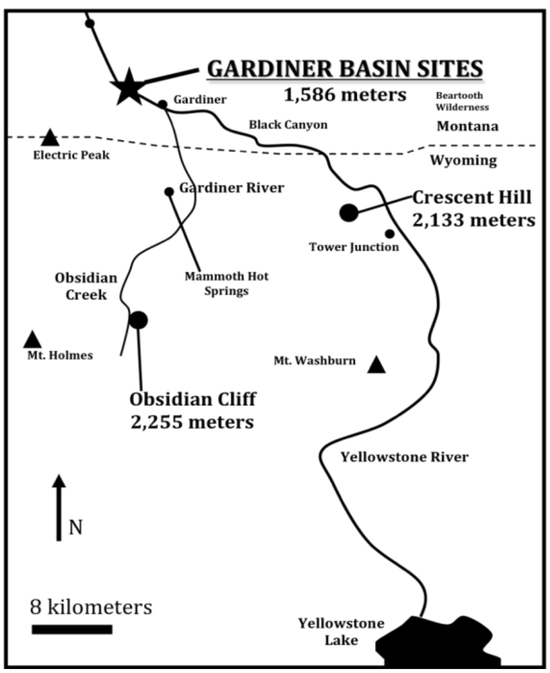

Figure 13-4. Location of procurement areas in regard to sites.

In relation to the two sites in our study, Obsidian Cliff is located approximately 41 kilometers south of the Yellowstone Bank Cache Site and Airport Rings Site (discussed below) and would have been accessed following the Yellowstone River upstream, then heading south following the Gardiner River (Figure 13-4). To gain access to Obsidian Cliff from the Gardiner Basin there is an approximate elevation gain of 669 meters, with the most elevated part of the journey being from the Gardiner Basin to the Swan Lake Flat area. From that point on, a fairly constant elevation prevails along Obsidian Creek to the cliff itself (see Figure 13-4).

There are two contexts in which Crescent Hill chert occurs within its source area of northwestern Wyoming: 1) eroding from hill tops or knobs; and 2) as chert lenses within the Crescent Hill columnar basalt formation (Adams 2011) (see Figure 13-5). Geodes are found ubiquitously across the landscape, displaying a high quality fibrous chalcedony precipitate. Chert found within the Crescent Hill basalt formation and eroding from hilltops presents itself in a variety of colors and textures. The chert ranges in colors of purples, reds, greens, and browns. Overall, the quality of the material is extremely variable, with very high quality milky white chalcedonies surrounding a macrocrystalline structure, to homogenous red jaspers, to coarse-grained poor quality green cherts.

Figure 13-5. Crescent Hill chert.

In regard to quality, Crescent Hill chert is extremely heterogeneous with a continuum ranging from fine-grained to almost unworkable coarse-grained materials. Even though these materials are not as isotropic in character as obsidian, they still provide options for individuals procuring raw materials.

Looking at the abundance of Crescent Hill, it is fairly limited compared to Obsidian Cliff; it is not a dense source but rather patchy across the landscape (see Figure 13-6) and occurs in nine distinct locations. On average, distance between the nine procurement areas is approximately 1. 6 kilometers, which emphasizes the sporadic nature of the chert on the landscape, and highlights the search costs for the raw material. The material is available within outcrop areas, eroding from outcrop areas as well as in the morphological form of tabular and rounded amorphous nodules on hilltops, varying in size and quality. Crescent Hill chert does not occur in a dense concentration as Obsidian Cliff does, but is dispersed across the landscape in different geological contexts.

Based on its availability as described above, locating the highest quality Crescent Hill materials would have been a difficult task at best. The overall density of the material should be considered low, as it is scattered across an 8. 6-km^2 area.

Figure 13-6. Extent of Crescent Hill chert procurement area.

As with Obsidian Cliff, Crescent Hill is also located upon the Yellowstone Plateau, limiting its access to warm weather months. To gain access to Crescent Hill from the sites in our study near Gardiner, Montana, people would have followed the Yellowstone River eastward through the Black Canyon of the Yellowstone approximately 32 kilometers until feeder streams allowed for upland access to the source. To access the source, an overall elevation gain of between 395-750 m would have occurred (MacDonald et al. 2010). Of the two sources, Crescent Hill would have been the easiest to access from the Gardiner Basin, but the lithic material was less abundant and more difficult to find on the landscape. In terms of material quality, Crescent Hill chert is also characterized as an inferior stone to Obsidian Cliff obsidian. Both sources provide raw materials, but hunter-gatherers would have had to weigh the economics of procuring them (see Table 13-1).

While the above discussion provides a subjective evaluation of the two lithic materials attributes, we use a gravity model to quantitatively

Table 13-1. Attributes of Raw Material Procurement Areas.

Factors	**Obsidian Cliff**	**Crescent Hill**
Quality	High quality, isotropic, homogeneous material	Low-High quality, heterogonous material
Abundance	High	Low-Medium
Distribution	Consolidated to one area	Patchy

assess the two raw material procurement locations. Gravity models are often used in economic contexts to evaluate the attractiveness of one region over another for marketing purposes. For instance, an entrepreneur will evaluate the costs and benefits of numerous factors prior to establishing a new business in one location or another. The type of people living in the area, the other businesses around the area, and the type of neighborhood are all important factors in the business decision. Wilson (2007) applied a similar model she refers to as the attractiveness equation, to evaluate the benefits of procuring one lithic raw material source over another. It allows a quantitative, economic, cost-benefit analysis to be applied to a source area (Figure 13-7). This model has had very few, if any, uses in the archaeological literature, but is highly pertinent to examining raw material procurement strategies in quantitative terms.

$$A(s)=\frac{(\text{quality})(\text{extent of source})(100)}{(\text{difficulty of terrain})(\text{cost of extraction})}\times\frac{\text{size}}{\text{scarcity}}$$

Figure 13-7. Wilson's (2007) Attractiveness Equation.

The equation determines the overall attractiveness of one raw material source over another by looking at variables such as quality of material and difficulty of terrain to obtain the material. These variables are summarized below in Table 13-2 for prehistoric hunter-gatherers living in the Gardiner Basin of Montana. Quality is ranked numerically on a scale from very poor to excellent (see Wilson 2007 for further discussion). Extent of source is characterized in regard to size in meters, ranging from small to very extensive. Size looks at the morphological dimensions of the largest pieces of raw material available at the outcrop. Scarcity looks at the amount of raw material at a procurement location and ranges from very abundant to scarce. Difficulty of terrain looks at the

Table 13-2. Quantitative Evaluation of Major Lithic Raw Material Sources for Occupants of Gardiner Basin Sites after Wilson 2007.

Source	Quality Rank (0-16)	Extent of source (1-4)	Size (max dimension in cm)	Scarcity (1-4)	Difficulty of Terrain (calories)	Cost of Extraction (1)	Attractiveness Score
Obsidian Cliff	16	4	100 cm	1	2080 cal	1	307. 7
Crescent Hill	8	2	25 cm	3	1600 cal	1	8. 3

number of calories per kilometer necessary for an individual to walk to a source location. Lastly, cost of extraction takes into account the cost of extracting material from the actual source area (Wilson 2007). In the end, an overall attractiveness score is calculated for the lithic raw material source based on the source's location compared to the sites in question (in this case, the Gardiner Basin).

As reflected in Table 13-2, we quantified the six extrinsic cost factors of the two lithic raw material procurement sources used most frequently by inhabitants of the Gardiner Basin, Montana, in prehistory (results discussed below). Based on this assessment, Obsidian Cliff yielded an attractiveness score of 307. 7, while Crescent Hill achieved a score of 8. 3. In every case, except for difficulty of terrain, Obsidian Cliff was deemed superior to Crescent Hill chert, dominating in all categories, including material quality, extent of source, material size/morphology, scarcity, and cost of extraction. The very high overall attractiveness score may explain that the high extrinsic values of Obsidian Cliff obsidian likely encouraged hunter-gatherers to differentially prefer it during prehistory, despite the closer proximity and increased ease of access of Crescent Hill chert (see Figure 13-8).

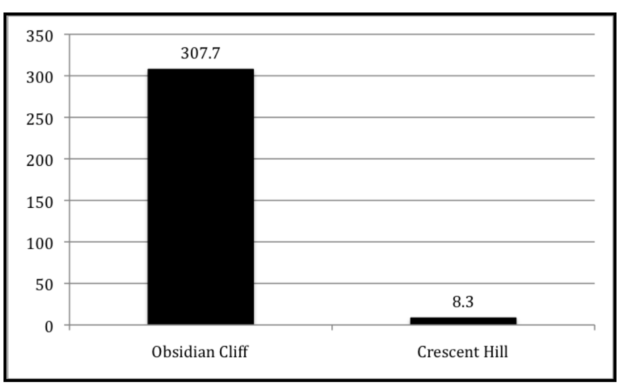

Figure 13-8. Bar graph showing attractiveness scores.

As discussed below, these two lithic raw material types—Obsidian Cliff obsidian and Crescent Hill chert—dominate the archaeological assemblages in the Gardiner Basin. To determine the source provenance of artifacts from collections, it was necessary to implement characterization studies (Hughes 2008a, 2008b, 2008c). The volcanic Obsidian Cliff obsidian was geochemically-identified through energy-dispersive x-ray fluorescence (edxrf). This technique penetrates the surface of a rock specimen and allows for the characterization of trace elements for specific volcanic sources of rock. Archaeological specimens can then be directly linked to their geologic sources via edxrf. For this study, Hughes (2008a, 2008b, 2008c) examined a total of 60 obsidian and dacite specimens from the study area, including 27 Late Archaic artifacts (MacDonald and Maas 2011:67) and 33 Late Prehistoric artifacts (Livers 2011:83).

In regard to Crescent Hill chert, 139 hand samples from the procurement area were collected and matched to artifacts in the assemblages using macroscopic visual traits. Macroscopic traits outlined by Luedtke (1992) were taken into account, including translucency, luster, texture, structure, as well as the morphological appearance of the specimen. A detailed look at the structure or fabric of the hand samples was also recorded noting inclusions, stringers, striations, streakers, and mottles (Adams 2011). This allowed for a reliable method of associating artifacts at the archaeological sites back to their original provenance.

The Archaeological Sites

Given the extrinsic cost factors discussed above, we can predict that hunter-gatherers of the Gardiner Basin of Montana/Wyoming would have differentially preferred to use Obsidian Cliff obsidian compared to Crescent Hill chert. At prehistoric sites in the Gardiner Basin, we should expect to see increased use of the obsidian versus chert. As such, we now look at the differential use of lithic raw material and two sites located in the Gardiner Basin of Yellowstone National Park in Montana (Adams et al. 2011). Each site has well dated hearth features that allow for a comparison of lithic raw material use between the Late Archaic (3,000-1,500 B. P.) and Late Prehistoric (1,500-300 B. P.) time periods. For a complete overview of these sites, see MacDonald (2007), MacDonald et al. (2010), MacDonald and Maas (2011) and Livers (2011).

The Yellowstone Bank Cache Site is located along the upper banks of the Yellowstone River in the Gardiner Basin portion of Yellowstone National Park, Montana. The site is representative of "…an intensive series of Late Archaic occupations, suggesting patterned subsistence and land-use in the Upper Yellowstone River Valley during the Late Archaic period" (MacDonald et al. 2010). With a correlation between four radiocarbon dates, as well as three Pelican Lake projectile points, there are solid data to support Late Archaic occupations. A total of 18 prehistoric features were identified during survey and excavation. Four of the roasting pit features were excavated, yielding a total of 1,490 lithic artifacts and 1,391 faunal remains.

Overall, the substantial amount of lithic artifacts and faunal remains that were recovered at the sites indicate that this was an area associated with intensive lithic reduction and subsistence activities (MacDonald et al. 2010). From the lithic assemblage at this site, the Late Archaic features indicate variable use of both Crescent Hill chert and Obsidian Cliff obsidian (Figure 13-9). One outlier was the high presence of more than 400 Crescent Hill chert flakes, side by side, with a similar amount of obsidian flakes in Feature 36 at YBC. The overall trend for these lithic data from the Late Archaic features at YBC is approximately 25 percent Crescent Hill, nearly 65 percent Obsidian Cliff, and a remainder of other material types.

The Airport Rings Site is a Late Prehistoric site with 11 stone circles situated on a terrace above the Yellowstone River in the Gardiner Basin of Yellowstone National Park (Livers 2011). In 2008, the University of Montana excavated three stone circles identifying three subsurface hearth features, two of which exhibited Late Prehistoric

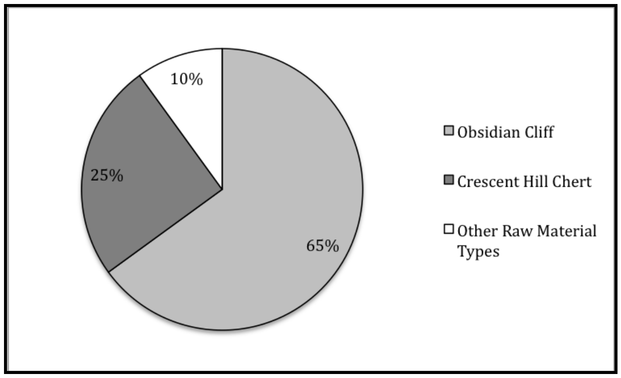

Figure 13-9. Use of Crescent Hill chert and Obsidian Cliff obsidian at Yellowstone Bank Cache site during the Late Archaic.

radiocarbon dates. Livers and MacDonald (2010) point out that the site is a "multi-component, stratified, tipi ring site consisting of two occupation levels, with both Late Prehistoric dates (300-400 B. P.) and a Middle Archaic date (5300 B. P.). " As with the YBC Site, Obsidian Cliff obsidian and Crescent Hill chert were the most prevalent raw material types in the archaeological assemblage from the Airport Rings Site (Figure 13-10). However, during this period there is an even stronger trend toward the use of obsidian. Overall, obsidian accounts for 80 percent of the assemblage with Crescent Hill chert representing only 13 percent, with a remainder of other raw material types.

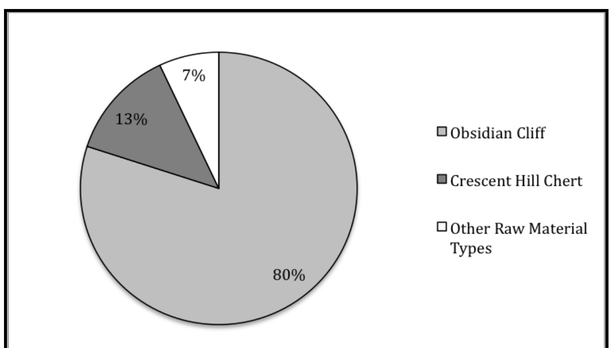

Figure 13-10. Use of Crescent Hill chert and Obsidian Cliff obsidian at the Airport Rings site during the Late Prehistoric.

Summary and Conclusions

Hunter-gatherers from the Gardiner Basin used the Yellowstone Plateau—including Obsidian Cliff and Crescent Hill chert—seasonally, incorporating trips to Yellowstone Lake to the south during warmer months (Nabakov and Loendorf 2002:67-68; see Figure 13-3). The most convenient route to the lake was via the Yellowstone River Valley which took hunter-gatherers past the Crescent Hill chert source directly south to the lake. However, it is clear that many hunter-gatherers chose to use the Gardiner River to Obsidian Creek route to get to the lake, with the main reason likely being the attraction of Obsidian Cliff along the way. The high percentages of Obsidian Cliff obsidian at archaeological sites along the northern shore of Yellowstone Lake—80 percent on average (MacDonald et al. 2012)—support this likely travel route. While this activity can be interpreted as a form of embedded procurement within a seasonal round, hunter-gatherers clearly diverged from the expected and easier travel route to the lake in order to have access to Obsidian Cliff obsidian. Thus, while Crescent Hill chert was clearly an embedded (casual collection) phenomenon on a logically-advantageous travel route to Yellowstone Lake, the choice of collecting Obsidian Cliff obsidian was intentional and more akin to direct procurement.

When evaluating Obsidian Cliff obsidian and Crescent Hill chert, in regard to raw material attributes, it is clear that Obsidian Cliff represents the logical choice for hunter-gatherers in prehistory. It is of the highest quality raw material found, high in abundance and densely consolidated, making it easy to find. Crescent Hill, while comparatively easy to access on travel routes along the Yellowstone River, is extremely variable in quality, low-medium in abundance, and scattered across the landscape. For travel to and from the raw material procurement locations, they both would have been very similar, with the trip to Crescent Hill probably a bit less strenuous and conveniently on the way to the popular Yellowstone Lake. This makes the examination of the variables influencing the procurement of raw material an important factor in hunter-gatherer decision making.

In the archaeological contexts it is apparent that obsidian was the preferred raw material type. As indicated by the hearth features, this trend increases significantly from the Late Archaic to the Late Prehistoric. At the YBC Site, during the Late Archaic, the overall mean average of Crescent Hill chert was 25 percent; at the Airport Rings Site during the Late Prehistoric the average tapered down to 13 percent. Obsidian, on the other hand, at the YBC Site during the Late Archaic had an overall mean of 65 percent and increased at the Airport Rings Site to 80 percent during the Late Prehistoric. Another line of evidence in regard to the cultural use of Crescent Hill chert and Obsidian Cliff obsidian is from the projectile points found in the Gardiner Basin; with 93 points being recovered, obsidian accounts for 67 percent with Crescent Hill chert accounting for 20 percent of the total collected points.

Not only was Obsidian Cliff obsidian the preferred material, its heightened quality, availability and other extrinsic cost factors likely pushed it into the realm of direct procurement. The attractiveness of the material forced people to reconsider traveling southward into the Yellowstone Plateau along the major waterway—the Yellowstone River—and instead using the more difficult and less intuitively advantageous route along the Gardiner River and Obsidian Creek. While Crescent Hill chert procurement was likely an embedded phenomenon during the occasional use of the Yellowstone River Valley corridor, obsidian from Obsidian Cliff clearly was directly targeted during prehistory, as witnessed by the significantly greater use of it at the Late Archaic and Late Prehistoric sites discussed above in the Gardiner Basin.

With the overall geographic distribution of the material, Obsidian Cliff obsidian was not just sought after by local hunter-gatherers, but also by other people from other regions as well. In this sense, Obsidian Cliff obsidian became a trade commodity, not just a material to be used in stone tool manufacture.

Crescent Hill may be the second most abundant material type in the archaeological contexts in the Gardiner Basin, but it is a far second from Obsidian Cliff. It is extremely variable in quality, scattered, and patchy across the landscape, which would make it a non-destination area to procure raw materials. For these reasons, Obsidian Cliff obsidian was preferred by residents of the Gardiner Valley in Montana despite it being more distant and more challenging in terms of travel routes compared to Crescent Hill chert. The results of the gravity model applied above confirm that Late Archaic and Late Prehistoric hunter-gatherers of the Gardiner Basin weighed the extrinsic cost factors of lithic raw material procurement and preferred to collect and use Obsidian Cliff obsidian, going out of their way to procure it during their travels within the Yellowstone Plateau.

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References Cited

Adams, J. S.
2011 Crescent Hill Chert: A Geological and Cultural Study of a Raw Material Procurement Area in Yellowstone National Park, Wyoming. Unpublished Master's thesis. Department of Anthropology, University of Montana, Missoula.

Adams, J. S., D. H. MacDonald, and R. E. Hughes
2011 Prehistoric Lithic Raw Material Use in the Gardiner Basin, Montana. In *Yellowstone Archaeology: Northern Yellowstone*, edited by D. MacDonald and E. Hale. University of Montana Contributions to Anthropology 13(2):72-97.

Andrefsky, W., Jr.
1994a Raw Material Availability and the Organization of Technology. *American Antiquity* 59:21-34.
1994b The Geologic Occurrence of Lithic Material and Stone Tool Production Strategies. *Geoarchaeology: An International Journal* 9:345-362.
2005 *Lithics: Macroscopic Approaches to Analysis*. Cambridge University Press, Cambridge.

Andrefsky, W., Jr. (editor)
2008 *Lithic Technology: Measures of Production, Use, and Discard*. Cambridge University Press, New York.

Binford, L. R.
1979 Organization and Formation Processes: Looking at Curated Technologies. *Journal of Anthropological Research* 35:255-273.
1980 Willow Smoke and Dogs' Tails: Hunter Gatherer Settlement Systems and Archaeological Site Formation. *American Antiquity* 45(1):4-20.
1985 'Brand X' Versus the Recommended Product. *American Antiquity* 50:580-590.
1989 Richard Gould Revisited, or Bringing Back the "Bacon". In *Debating Archaeology,* edited by L. R. Binford, pp. 106-121. Academic Press Inc., San Diego

Binford, L. R. and J. F. O'Connell
1984 An Alyawara Day: The Stone Quarry. *Journal of Anthropological Research* 40:406-432.

Binford, L. R. and N. M. Stone
1985 "Righteous Rocks" and Richard Gould: Some Observations on Misguided "Debate". *American Antiquity* 50:151-153.

Cotterell, B. and J. Kamminga
1987 The Formation of Flakes. *American Antiquity* 52:675-708.

Davis, L. B. , S. A. Aaberg, J. G. Schmitt and A. M. Johnson
1995 *The Obsidian Cliff Plateau Prehistoric Lithic Source, Yellowstone National Park, Wyoming.* National Park Service, Rocky Mountain Region, Selections from the Division of Cultural Resources, No. 6, Denver, Colorado.

Elston, R. G.
1992 Modeling the Economics and Organization of Lithic Procurement. In *Archaeological Investigations at Tosawihi, A Great Basin Quarry, Part 1: The Periphery, Volume 1*, edited by R. G. Elston and C. Raven, pp. 31-47. Inter-mountain Research and Bureau of Land Management, Silver City, Nevada.

Gould, R. A.
1985 The Empiricist Strikes Back: Reply to Binford. *American Antiquity* 50:638-644.

Gould, R. A. , D. A. Koster, and A. H. Sontz
1971 The Lithic Assemblage of the Western Desert Aborigines of Australia. *American Antiquity* 36:149-169.

Gould, R. A. and S. Saggers
1985 Lithic Procurement in Central Australia: A Closer Look at Binford's Idea of Embeddedness in Archaeology. *American Antiquity* 50:117-136.

Hughes, Richard E.
2008a Geochemical Research Laboratory Letter Report 2008-2. Geochemical Research Laboratory, Portola Valley, California
2008b Geochemical Research Laboratory Letter Report 2008-104. Geochemical Research Laboratory, Portola Valley, California
2008c Geochemical Research Laboratory Letter Report 2008-112. Geochemical Research Laboratory, Portola Valley, California

Livers, M. C.
2011 Airport Rings: Stone Circle Archaeology in Yellowstone National Park. In *Yellowstone Archaeology: Northern Yellowstone*, edited by D. MacDonald and E. Hale. University of Montana Contributions to Anthropology 13(2):72-97.

Livers, M. C. and D. H. MacDonald
2010 Airport Rings: Stone Circle Archaeology in Yellowstone National Park. Unpublished Professional Project, University of Montana, Missoula.

Luedtke, B. E.
1992 *An Archaeologists Guide to Chert and Flint: Archaeological Research Tools 7*. Institute of Archaeology, University of California, Los Angeles.

MacDonald, D. H.
2007 *Final Inventory and Evaluation Report, Yellowstone National Park, Boundary Lands Archaeological Survey, Gardiner, Montana*. Report Submitted to Yellowstone National Park by the University of Montana Department of Anthropology, Missoula.
2009 Understanding Decision-Making among Prehistoric Hunter-Gatherers via the Study of Lithic Technological Organization. *Lithic Technology* 34(2):71-92.

MacDonald, D. H. , J. Gish, and R. Hughes
2012 Late Paleoindian versus Early Archaic Occupation of Yellowstone Lake, Wyoming. *Current Research in the Pleistocene* 28: in press.

MacDonald, D. H. and E. S. Hale (editors)
2011 *Yellowstone Archaeology: NorthernYellowstone*. University of Montana Contributions to Anthropology 13(2). University of Montana Department of Anthropology, Missoula.

MacDonald, D. H. , L. Maas, and J. Hardes
2010 The Yellowstone Bank Cache Site (24YE355): A Late Archaic Pelican Lake Occupation on the Upper Yellowstone River, Montana. *Archaeology in Montana* 51(2):1-23.

MacDonald, D. H. and L. E. Maas
2011 Late Archaic Lithic Technology and Land Use within the Gardiner Basin, Upper Yellowstone River, Montana/Wyoming. In *Yellowstone Archaeology: Northern Yellowstone*, edited by D. MacDonald and E. Hale. University of Montana Contributions to Anthropology 13(2):56-71.

Nabokov, P. and L. Loendorf
2002 *American Indians and Yellowstone National Park: A Documentary Overview*. National Park Service, Yellowstone Center for Resources, Yellowstone National Park, Wyoming.

Nelson, M. C.
1991 The Study of Technological Organization. *Archaeological Method and Theory* 3:57-100.

Raven, C.
1992 The Natural and Cultural Landscape. In *Archaeological Investigations at Tosawihi, A Great Basin Quarry, Part 1: The Periphery, Volume 1*, eds. R. G. Elston and C. Raven, pp. 7-30. Inter-mountain Research and Bureau of Land Management. Silver City, Nevada.

Scheiber, L. L. and J. B. Finley
2011 Obsidian Source Use in the Greater Yellowstone Area, Wyoming Basin, and Central Rocky Mountains. *American Antiquity* 76(2):372-394.

Schiffer, M. C.
1972 Archaeological Context and Systemic Context. *American Antiquity* 37(2):156-165.

Seeman, M. F.
1994 Intercluster Lithic Patterning at Nobles Pond: A Case for “Disembedded” Procurement Among Early Paleo-Indian Societies. *American Antiquity* 59:273-288.

Wilson, L. W.
2007 Understanding Prehistoric Lithic Raw Material Selection: Application of a Gravity Model. *Journal of Archaeological Method and Theory* 14:388-411.