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## Lithics in the West: Using Lithic Analysis to Solve Archeological Problems in Western North America

Douglas H. MacDonald

William Andrefsky Jr.

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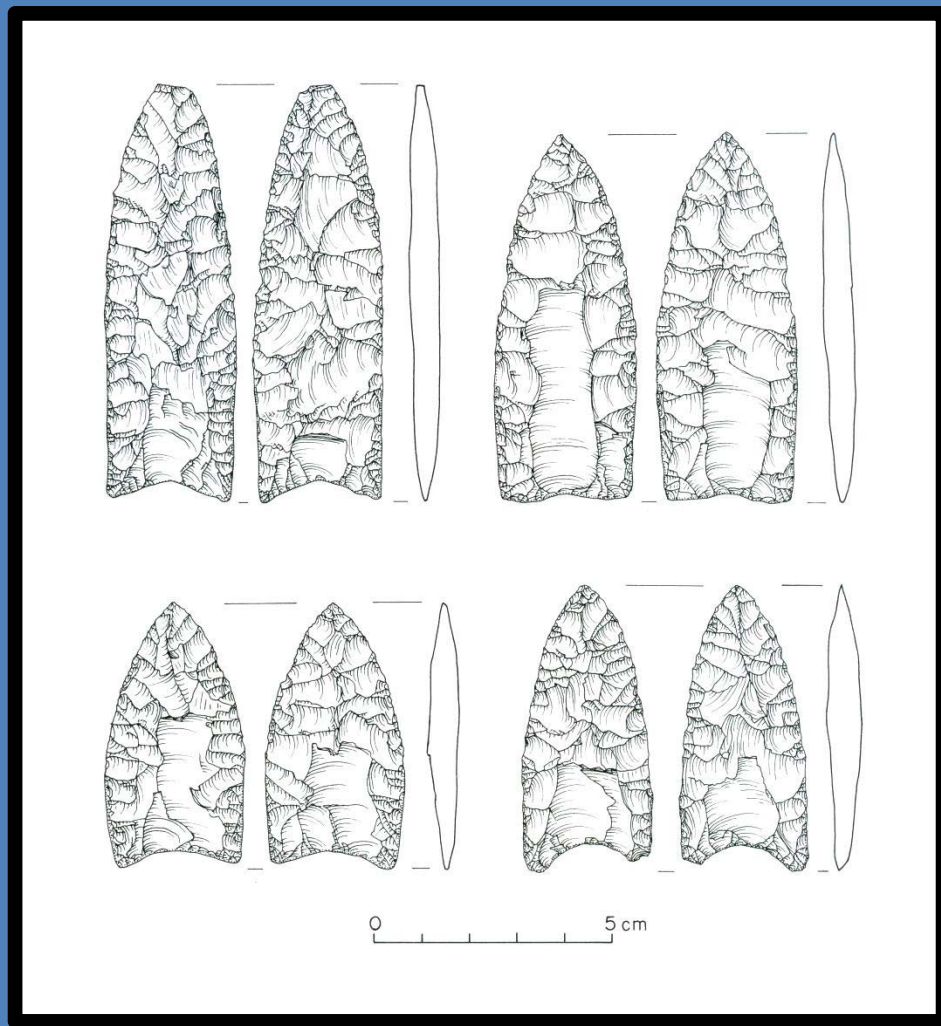
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# LITHICS IN THE WEST

Using Lithic Analysis to Solve Archaeological Problems in  
Western North America



Edited by  
Douglas H. MacDonald, William Andrefsky, Jr., and Pei-Lin  
Yu

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# LITHICS IN THE WEST

USING LITHIC ANALYSIS TO SOLVE ARCHAEOLOGICAL PROBLEMS IN WESTERN NORTH AMERICA

Edited by Douglas H. MacDonald, William Andrefsky, Jr., and Pei-Lin Yu

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## DEDICATION

We dedicate this volume to the memory of Sarah Moore, a wonderful person and lithic artifact illustrator whose time on this planet was cut unacceptably short. Her illustrations—such as those that grace the front and back covers of this book—are included in numerous volumes, articles, and reports. Sarah's elegant and scientifically accurate illustrations added greatly to lithic studies across western North America and beyond.



## PREFACE

**Douglas H. MacDonald, William Andrefsky, Jr, and Pei-Lin Yu, editors**

Stone tools and the by-products of their manufacture are the dominant type of artifact found at prehistoric archaeological sites in North America and much of the world. For that reason, the study of lithic artifacts facilitates our understanding of human use of landscapes, resources, and technology in the past. On an international scale, stone tool and debitage analysis has matured intellectually from its culture-historical origins, incorporating elements of human behavioral ecology, technological organization, land-use strategies, functional interpretations, and a variety of methodological advancements. A multitude of middle-range approaches — including experimental archaeology and ethnoarchaeology — are now utilized to understand human behavior in the past via the study of stone tools.

*Lithics in the West* seeks to link the rich archaeological lithic data base from the western United States with some of the contemporary theoretical and analytical approaches used in global settings in stone tool and debitage analysis today. The book highlights the role that lithic analysis (in all its forms) plays in solving research problems in the prehistory of western North America.

Although the papers in this volume represent a broad geographical spread over the western United States, most of the contributors have affiliations with one or more research institutions in the Intermountain West. This result speaks to the reach and network of scholarship in the western United States. We include 10 chapters in the volume, organized into two sections: Part 1, Methodological Approaches, Chapters 1-5; and Part 2, Lithic Raw Material and Settlement Pattern Studies, Chapters 6- 10.

All five of the chapters in Part One present unique methodological approaches to facilitate the solution of interesting problems in archaeological research. While the focus is on western North America, the methodological approaches will prove useful for any

archaeologist who works at sites with lithic artifacts. The first two chapters by William Andrefsky, Jr., Pei-Lin Yu and Jackie M. Cook, respectively, add behavioral and experimental contexts to the interpretation of stone tools and debitage found on archaeological sites. The papers are designed to broaden our view of how archaeologists can begin exploring behavioral meanings of lithics: viewing stone tools outside of traditional analytical approaches provides much-needed behavioral frames of reference for interpreting and generating hypotheses about the manufacture, use, repair, re-purposing, and discard of stone tools.

Andrefsky's Chapter 1 utilizes a set of controlled experiments to understand the functional effectiveness of unmodified flakes as cutting tools. This study makes us ask questions such as, "why do some sites have only unmodified flakes tools and other sites have heavily modified flake tools?" Experiments show that tool form found on sites relates not only to tool function, but also to human choices and to raw material availability.

Yu and Cook's Chapter 2 uses ethnoarchaeological data to generate expectations for morphological characteristics of fish butchering stone tools used by northwestern North American fishing peoples, with ramifications for expedient raw material acquisition, bulk processing, and gendered tool use, manufacture and re-use. The study of fishing has been problematic in the Intermountain West, in part due to our limited ability to identify fishing tools in archaeological sites.

Analysis of a lithic collection from an intensive fishing locality in the Columbia Basin allows for identification of baseline lithic tool characteristics that can be used to identify tools in archaeological assemblages of the Intermountain West where fishing was mostly supplemental to terrestrial hunting and gathering. The chapter concludes with implications for increased fishing as subsistence intensification in response to Euro-American immigration.

Chapters 3 and 5 by Waguespack and Surovell and Brunswig et al., respectively, focus on methodological approaches to the analysis of artifact and site distributions on local and regional scales. Waguespack and Surovell's study of lithic artifact distributions is truly



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unique, providing an ingenious method by which to identify otherwise invisible house structures within prehistoric archaeological sites. Their mapping of artifact distributions allows us to understand what types of living structures were used by Folsom peoples in Colorado 10,000 years ago. Brunswig et al.'s Chapter 6 also uses sophisticated mapping methods—in this case, geographic information systems (GIS)—to understand land use on a regional scale. The use of GIS is an important and up-and-coming method of study of prehistoric hunter-gatherer land-use.

In Chapter 4, Prasciunas uses minimum nodule analysis to evaluate Paleoindian stone tool manufacture and the organization of technology in the northwestern Great Plains 11,000 years ago. Her method of nodule analysis facilitates an understanding of Clovis organization of lithic technology and land-use which will facilitate our understanding of the peopling of the Americas.

Each of these initial five chapters introduces prescient methodological approaches to lithic analysis which will help solve interesting research questions about technological behaviors and their material correlates. While the focus is intermountain western North America, some of the papers use information about lithics from outside this region to offer applicable methods of analysis and behavioral frames of reference.

Through the use of lithic analysis, each of the five chapters in Part Two (Chapters 6-10) strives to understand lithic technological organization, land-use, mobility, and/or trade patterns of prehistoric Native Americans in the west over the last 11,000 years. Whereas the first five chapters sketched methods of lithic analysis that could vastly improve contemporary archaeological studies, the next five chapters are case studies in how western North American archaeologists have used lithic studies to advance our knowledge of prehistoric hunter-gatherers.

The location of tool-stone sources is becoming increasingly more important for understanding how aboriginal tool makers and users occupied territory and moved around landscapes. Certainly, Chapter 6 by Reid recognizes this and provides a comprehensive and

exhaustive review of lithic resources available within western Idaho and eastern Oregon. Chapter 7 by Ostahowski and Kelly evaluates raw material in debitage form at a considerably smaller scale of analysis. They focus upon lithic debitage from Alm Rockshelter in Wyoming to evaluate population variability associated with climate change.

Continuing with the theme of lithic raw material source location and artifact distribution from those sources, the next three chapters provide other case studies from the west. Chapter 8 by MacDonald uses lithic sourcing to help decipher prehistoric land-use patterns of hunter-gatherers at North America's highest, largest lake, Yellowstone Lake in the Rocky Mountains of what is now Yellowstone National Park. In so doing, he illustrates that multiple distinct groups likely utilized Yellowstone Lake, deriving from the south, north, east and west. In addition, lithic analysis indicates that boats were not the main form of travel at Yellowstone Lake, nor was fishing crucial to subsistence patterns of Native Americans there.

Chapter 9 by Harris focuses on shifting human settlement patterns over the last 3,000 years in the Snake River region of north-central Idaho. The combination of obsidian source characterization and technological organization data from a variety of stone tools support the model that people in the Snake River Plain moved over a wide area of southeastern Idaho. Chapter 10 by Carpenter and Fisher provides an in-depth study of a Middle Archaic biface cache in the Paradise Valley of Montana. Through various creative methods, the authors provide a fascinating account of Native American land-use in the Greater Yellowstone Ecosystem ca. 3,700 years ago. Among other things, these final five chapters study human interaction at the landscape level through the analysis of lithic artifacts found at regional archaeological sites.

Few volumes on stone artifacts cover as wide a breadth of methodological and regional perspectives as the current one. We hope that the reader will garner useful information from the various papers that can lead to a better understanding of stone tool use in western North America and the world. At the very least, the

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volume introduces several methodological approaches which will be useful for future archaeological studies, both in North America and the world beyond. Students of archaeology will find numerous and diverse methods of lithic analysis by which to further their own research, while professionals in the field will find data by which to supplement their understanding of the prehistory of western North America.

## CHAPTER 1

### DEBRIS, DEBITAGE OR TOOLS: UNMODIFIED FLAKES AND CUTTING EFFICIENCY

BY WILLIAM ANDREFSKY, JR.

#### ABSTRACT

*In most North American archaeological assemblages unmodified flakes are regarded as debitage or debris from stone tool production efforts. However, there is a great deal of ethnographic information that suggests unmodified flakes are not only effective as cutting and scraping tools, but that they are preferred as tools by aboriginal tool makers and users. In many circumstances contemporary tool users prefer unmodified flakes over retouched flakes and more formalized stone tools. This study examines the results of cutting efficiency tests conducted on unmodified and modified flake tools. Results from wood working experiments show that unmodified flake tools are more efficient cutting tools than modified flake tools, and that different kinds of lithic raw material may also be more effective and efficient for cutting than other kinds of raw materials. One implication of this study is that archaeologists may be overlooking an important tool category if they emphasize tool use activities based solely upon analysis of modified stone objects and not unmodified flakes. These results are particularly relevant for archaeological assemblages located away from primary and secondary sources of chippable stone used for tool making.*

#### INTRODUCTION

This investigation of stone artifacts is focuses upon data generated from controlled experimental studies. No excavated artifacts or site assemblages are applied to the results of these investigations. However, all of the methods, techniques, and results were explicitly formulated and gathered with lithic analysis and interpretations from the western region of North America in mind. In fact, all of the lithic raw materials

and wood used in this investigation were from sources found in western North America.

This study describes a set of controlled experiments aimed at understanding the circumstances and variables related to functional efficiency of flake stone tools. I suggest wood whittling in the form of shaping, sharpening and notching sticks was a routine task for making tools such as arrow shafts, lances, snares, diggings sticks, pegs, poles and many other practical items used by foragers on a daily basis. How were such tools made and what do we know about the efficiency of the stone tools used to make wooden items that must have been ubiquitous at aboriginal living areas?

The research presented here takes a new look at flake tools and systematically explores several variables of flake tool morphology and relates those variables to flake tool cutting efficiency. All cutting and whittling experiments were conducted on wet wood in the shape of stems or pegs of uniform size. In this sense the results of this experiment are relatively narrow and related to a single material and a single action-whittling. However, I feel that holding this variable constant has provided important clues in understanding not only the parameters of cutting efficiency but it has also provided information about changes in efficiency over the use-life of flake tools. The results of this study are interpreted within the context of technological organization of stone tool production and use. Ultimately, results from these experiments can be applied to sites from throughout western North America.

#### BACKGROUND ON FLAKE TOOL USE

In the summer of 1975 I participated in an experimental archaeology project at Virginia Commonwealth University directed by Dr. Errett Callahan. That project involved a group of student archaeologists making and using primitive technology and foraging in the eastern woodlands along the banks of the Pamunky River for six weeks. As the trapper of the group I prepared snares by stripping hickory bark for cordage and cutting, sharpening and notching snare pegs from the same green hickory saplings-all with flaked

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stone tools. When I brought the first trapped groundhog (*Marmota marnax*) back to our camp, Dr. Callahan proceeded to remove a series of flakes from a large bifacial core. After removing a dozen or so, he selected one flake about an inch and a half long and proceeded to skin, clean, and disarticulate the marmot. After completing the task he held up the flake he used and proclaimed that, "...this was the most important tool for any hunter and gatherer." At the time I didn't think much of the event nor about what he had said. After all, it was clear to me that the biface he used to make the flakes was a more valuable tool and it certainly had more time invested in its manufacture.

If we look more closely at the ethnographic record of tool makers and users there are similar trends in tool production and use to that described above. Tom O. Miller (1979) describes his experiences with the Xeta' Indians in the jungle mountains of southern Brazil as they make stone tools for working wood. He notes, "*Nheengo piled up the flakes and fragments that he considered useful, pushing aside the rejects and waste...Rather than choose flakes on the basis of overall form, the informants tried out the stones empirically, one after another, to determine the tools best suited for any particular task*" (ibid.:402). There are several interesting and important observations made by Miller here. First, flake blanks were produced in quantity and then the tool maker selected from the group of flake blanks with an eye for particular tasks that were to be completed. This is similar to what Errett Callahan did when I brought the marmot into camp for dinner. Secondly, the tool maker was looking for suitable cutting edges to work wood on flake blanks. This suggests that sharp cutting edges were not produced from blank retouching, but instead selected from unretouched flake blanks.

Other descriptions of stone tool makers and users conform to this observation. Binford and O'Connell's (1984) description of stone tool production by Jacob, an Alyawara tool maker, at a stone quarry provides insight into the kinds of tools used for cutting tasks. "*Jacob explained that the tools most commonly employed at camp were small flakes used for cutting up things. He noted that these need not be any particular shape, only*

*fresh and sharp*" (1984:418). Sharp flake blanks were one of the tool types Alyawara tool makers transported from the quarry back to their camps. "*The men stressed the fact that they should be very careful in preparing flakes for transport and in transporting blanks from the quarry*" (Binford and O'Connell 1984:421). Again, the notion of selecting and keeping sharp unmodified or un-nicked edges is important for flake tool blanks.

Brian Hayden's (1977) experiences with stone tool makers and users in the Western Desert of Australia adds additional support to the notion that unmodified flakes were purposely selected for wood working activities over modified flake tools. He states, "*...the biggest surprise, and 'disappointment', was the unbelievable lack, or rarity, or fabrication of what the archaeologist calls 'tools'. At first, I saw Aboriginals using only unretouched primary flakes for shaving and scraping wood, and unmodified blocks of stone for chopping wood. ...Thus, only in special cases were flakes retouched. Instead of retouching primary flakes, the more common reaction of all informants was to look over other primary flakes for the work at hand, or to remove several more flakes from the core until a suitable one was knocked off*" (ibid.:179).

Richard Gould and colleagues (Gould et al. 1971) describe casual stone tool use for woodworking among Aborigines of the Western Desert of Australia. They note, "*...a man will pick up an untrimmed flake of chert and, gripping it between thumb and forefinger, use it as a kind of spokeshave for scraping wood from the shaft or point of a spear. This happens when, for one reason or another, he does not have a hafted adze with him. Generally, the flake is discarded when the task is finished. In all cases, the rocks used as tools were completely untrimmed*" (ibid.:163).

In each of these cases the stone tools selected for working wood are unmodified flakes. Recently, Chris Clarkson et al. (in press) conducted a series of experiments dealing with wood scraping. Surprisingly, his study shows that unmodified flakes were twice as efficient as modified flakes for scraping wood.

There have been many archaeological studies that suggest unmodified flakes as choice tools given specific circumstances. For instance, Parry and Kelly (1987)

demonstrate that “expediently made” flake tools are generally preferred over formalized stone tools in contexts where people are more sedentary. Other archaeological investigations have added to this scenario and indicate that availability of lithic raw material is an important factor in the selection of expedient technology over more formal technology (Andrefsky 1994; Bamforth 1986; Bamforth and Becker 2000; Holdaway et al. 1996). Other researchers have shown that transport of unmodified flake blanks are an optimal solution for available cutting edge versus carrying weight (Kuhn 1994; Surovell 2009). In other words, not only are unmodified flakes preferred as cutting tools as noted above, these kinds of artifacts are shown to be a more efficient choice of tool to carry when considering overall weight of transported materials and amount of reliable cutting edge.

Ethnographic accounts of flake tools used for wood working suggest that unmodified flakes are more efficient than modified flakes in some circumstances. The archaeological evidence suggests that unmodified flakes provide more efficient and reliable sources of cutting edges compared to heavier cores when raw materials need to be transported. However, what do we really know about the efficiency of flake stone tool cutting edges? Archaeological models are simple simulations of transport costs (weight) against amount of usable cutting edges. The few ethnographic examples we have available to us are simply isolated occurrences of tool makers using flakes for cutting wood. Such examples say nothing of tool efficiency-only that such and such tools were used. To address this issue I have designed a set of wood whittling experiments that compare a number of flake stone tool characteristics over the use-life of those stone tools used for whittling wood.

#### EXPERIMENTAL DESIGN

We know from the archaeological record that wooden sticks are used for a variety of tools from arrow and dart shafts, to digging sticks, to stakes for stretching hides, to snare pin switches and potentially hundreds of

other tools and tool components (Aikens 1970; Heizer and Napton 1970; Jennings 1957, 1980; Strong 1969). All of these wooden implements had to be cut, shaped, sharpened and or notched-presumably by stone tools. Ethnographic accounts (noted above) indicate that unmodified flake tools were often used for wood working tasks. Because I know very little about the efficiency of working wood with flake stone tools I thought one effective strategy to learn something from a set of experiments would be to standardize the task and vary the flake stone tool characteristics, then explore those characteristics with regard to task efficiency.

In this experiment wooden sticks cut from a stand of Ocean Spray (*Holodiscus discolor*) were sharpened with many different flake stone tools. Ocean Spray is commonly used by indigenous peoples in the Pacific northwest to make arrow shafts and digging sticks because it grows relatively quickly and into straight stems with few branches (Daubenmire 1970). After drying, it also becomes very hard. Each stem or peg of Ocean Spray was cut into lengths of consistent diameter between 11.4 and 12.4 mm. One end of the peg was sawed into a 45 degree angle (see Figure 1.1A). The experiment consisted of sharpening the peg by whittling with flake tools in a uniform direction, slicing away from the hand with the hopes of maintaining the 45 degree angle or point of the peg (Figure 1.1B). Each peg was weighed before whittling began and the peg was weighed after every 20 strokes or slices. This provided consistent information on the amount of wood removed from the peg after each sequence of 20 strokes. Wood removed could then be used as a proxy for whittling efficiency. Each flake tool was used in this manner for a total of 500 strokes. A total of 49 flake tools were used in this manner over the period of several days.

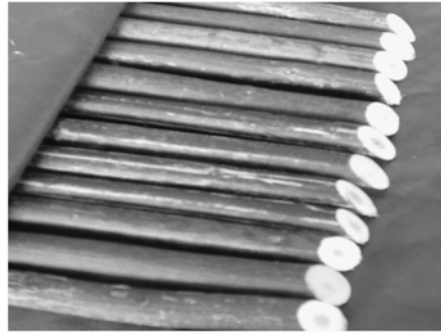
The wooden pegs were air dried for 30 days after being harvested. This produced very dry and hard wood that was difficult to whittle. As such, each peg was soaked for 24 hours before whittling. This not only softened the wood for more effective whittling, but the uniform soaking time tended to standardize the wood density among the different pegs. Each peg was towel dried prior to whittling. During the whittling process the

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pegs actually lost weight from water evaporation. However, this did not negatively impact the collected data on wood removal as evaporation of water occurred at a rate of approximately 0.01 gm per hour with slight variance depending upon how quickly each peg was whittled. No peg was whittled for more than two hours.

Of the 49 flake tools used 25 were made of Edwards Plateau chert and 24 were made of Glass Buttes obsidian. Approximately half of the chert and obsidian flake tools began with pressure flaked retouched cutting edges and the other half had unmodified edges.

Other characteristics recorded for the flake tools were maximum flake length, width and thickness, flake weight, length of flake cutting edge, and average cutting edge angle. The average cutting edge angle was based upon three measurements taken at the mid-point and at the approximate quarter-points of the cutting edge using a Number 17, General Tools MFG. CO. goniometer. To this day, I still feel there is quite a bit of error in measuring edge angles accurately on stone tools with any currently available instrument, but I do feel my average edge angles were at least accurate when compared ordinally when edge angles were grossly different. In other words, an average value of 33 degrees was consistently less than 50 degrees and that was consistently less than 73 degrees, and so forth. However, if two flake tools with very similar edge angles were independently measured multiple times I don't believe one flake tool would consistently be measured with a greater or lesser average edge angle than the other flake tool. Table 1.1 shows the summary information for the experiment.



A



B

**Figure 1.1. A: Cut pegs of Ocean Spray sawed at 45 degree angles. B: Whittling position of flake tool used to maintain sharpened pegs.**

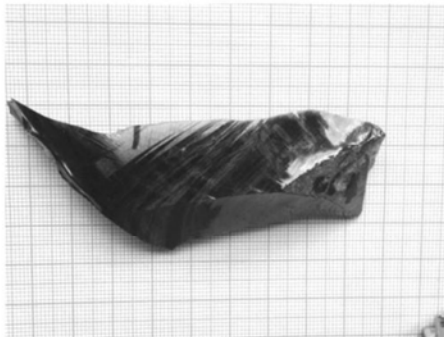
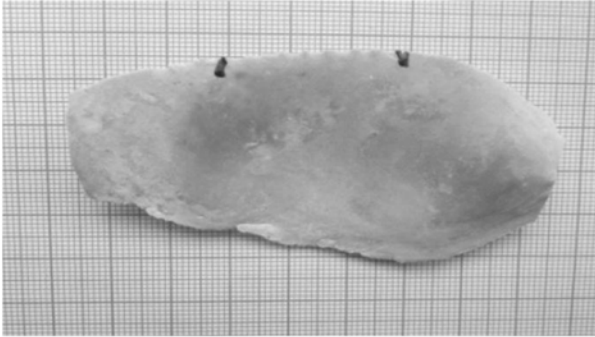
**Table 1.1. Summary of Flake Data for All Flake Tools Used in the Experiment.**

Measurement	Minimum	Maximum	Mean
Maximum Flake Length (mm)	31.76	104.62	65.986
Maximum Flake Width (mm)	16.46	69.81	34.981
Maximum Flake Thickness (mm)	3.51	15.74	8.604
Flake Weight (gm)	2.5	48.2	18.12
Flake Use Length (mm)	11.24	40.87	23.047
Average Flake Edge Angle	29	54	40.653
Peg Diameter at Cut (mm)	11.4	12.38	12.022
Wood Removed (gm)	0.413	2.971	1.25

Number Chert = 25; Number Obsidian = 24; Number Modified = 22; Number Unmodified = 27

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The length of the cutting edge for each tool was marked on every flake used in the experiment. It is important to understand that the maximum length of the flake is different than the length of the cutting edge. I consistently used only the marked area for whittling wood. The marked cutting edge was also the location where the cutting edge angle measurements were taken. Figure 1.2 shows pictures of some the flake tools used before whittling began (note the marked areas for length of cutting edge).



**Figure 1.2. Examples of flake tools used in the whittling experiments. Background graph paper is partitioned into cm and mm blocks. Note the blade cutting edge locations marked in black.**

### RESULTS

During the course of conducting the experiment I felt confident that there were several characteristics of the flake tools contributing to cutting efficiency including length of the cutting edge, average edge angle, and size of the tool. These were characteristics that I informally inferred as important while whittling day after day. Surprisingly, none of these characteristics were significantly important for flake tool efficiency of whittling wood.

For instance, when length of cutting edge was compared against the amount of wood removed for each flake tool there was no correlation. In fact, the longest cutting edge of 4.1 cm produced about the lowest cutting efficiency ratings of 0.8 gm of wood removed on average per a twenty stroke segment. Figure 1.3 shows a scatter plot of flake cutting edge length against tool efficiency using this average measure. The  $R^2$  linear regression value is 0.0009 showing no correlation. Average flake edge angle on the cutting edge of each flake tool was also charted against the average amount of wood removed. Figure 1.4 shows no correlation between efficiency of wood removal and average flake edge angle ( $R^2 = 0.0058$ ).

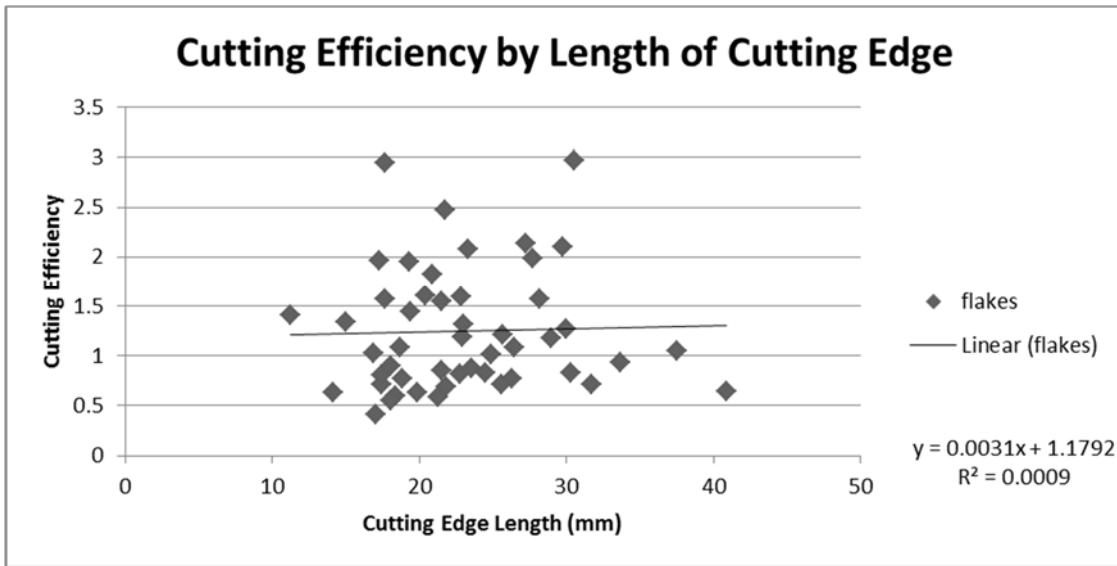


Figure 1.3. Cutting efficiency measured by weight of wood removed (gm) compared against cutting edge length for all 49 flake tools. No correlation.

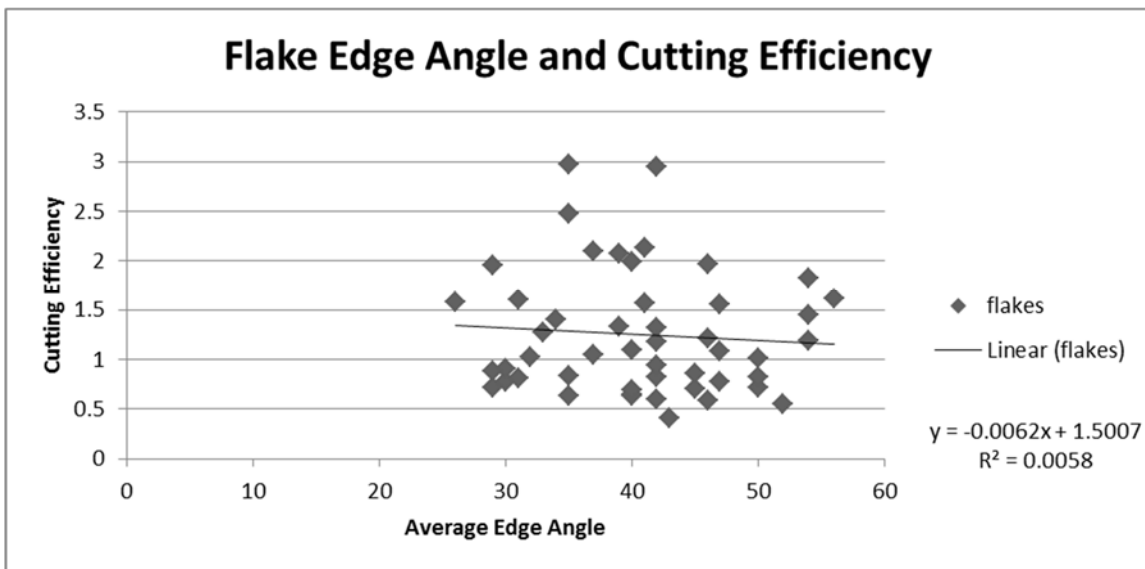


Figure 1.4. Cutting efficiency measured by weight of wood removed (gm) compared against average edge angle for all 49 flake tools. No correlation.



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While whittling wooden pegs I felt that larger flakes were more efficient at wood removal, mostly because they were easier to hold in the hand and could be used with more force when slicing wood away. I had difficulty holding the very small flakes and as a result I imagined that larger flakes were more efficient for whittling. Flake size and the ability to hold and use the flake is a function of mass and shape. A rounded "nodule shaped" flake may have more mass and may be considered larger than a thin and elongated flake but its shape may preclude it from being an effective cutting tool. As such, I explored flake size by correlating different linear measures of shape against flake weight to determine a useful proxy for flake size. Figure 1.5 shows a couple of linear measures (length x width and width x thickness) graphed against flake weight. The linear measurements multiplied against each other provide a proxy for shape. When shape is compared to weight of flakes, in all cases flake weight correlates significantly against the linear measurement proxy for flake shape. This suggests that flake weight (at least with this data set) is a reliable estimator for flake size. Shott (1994) has also shown this to be the case using archaeological data on flake size.

Since flake weight correlates with flake shape to give a proxy value for flake size, I graphed flake size (and shape) against cutting efficiency as measured by the average amount of wood removed and again I was surprised to find that flake size had very little to do with efficiency of wood whittling (Figure 1.6). This figure shows that flake size and potentially shape are not correlated to wood whittling efficiency—at least when sharpening sticks that are approximately 11.5 mm in diameter. Flake size may be important for more heavy duty wood whittling but this experiment focused on sharpening wooden pegs and flake size was not an important factor in whittling efficiency.

Since the metric variables recorded for flake tools were not effectively characterizing wood whittling efficiency I classified the flake tools by raw material type and the presence or absence of retouch on the cutting edge. This resulted in four flake tool types; unmodified chert, modified chert, unmodified obsidian, and modified obsidian. Figure 1.7 shows a proportional graph of the

average amount of wood removed in 0.5 gram increments for the four flake tool types. Almost all of the modified obsidian flake tools produced less than 1.0 gm of wood removed. The unmodified obsidian flake tools and the modified chert flake tools had about equal amount of wood removed (20%) in the small size increment of less than 1.0 gm. The most striking element of this graph is that unmodified chert flakes had their highest representation in the greater than 2 gm increment. All other tool types had no or very few specimens in the largest increment category. These trends show that unmodified chert flakes are more efficient than modified chert flakes and any obsidian flakes for whittling wood, based upon amount of wood removed.

When these results are graphed to show the average amount of wood removed for each of the four tool types (Figure 1.8), unmodified chert flakes are almost twice as efficient at removing wood than modified chert flakes and unmodified obsidian flakes. And they are almost three times as efficient as modified obsidian flakes at whittling wood.

The whittling experiment also gathered information on the use-life efficiency of each flake tool type. Efficiency data were collected for every flake tool after every twenty strokes during the 500 stroke use-life of each tool. When the aggregate data for all flake tools are charted for stroke count and amount of wood removed (Figure 1.9), there is a significant trend associating more efficiency with early use of the tool. That is, the longer a tool is used the less efficient it becomes. The most efficient tools are those that were just made and had not been previously used. Those tools become less efficient as the number of strokes increases. Tools used during their first 20 strokes were the most efficient and tools used during their last 20 strokes (480-500 strokes) were the least efficient.

# LITHICS IN THE WEST

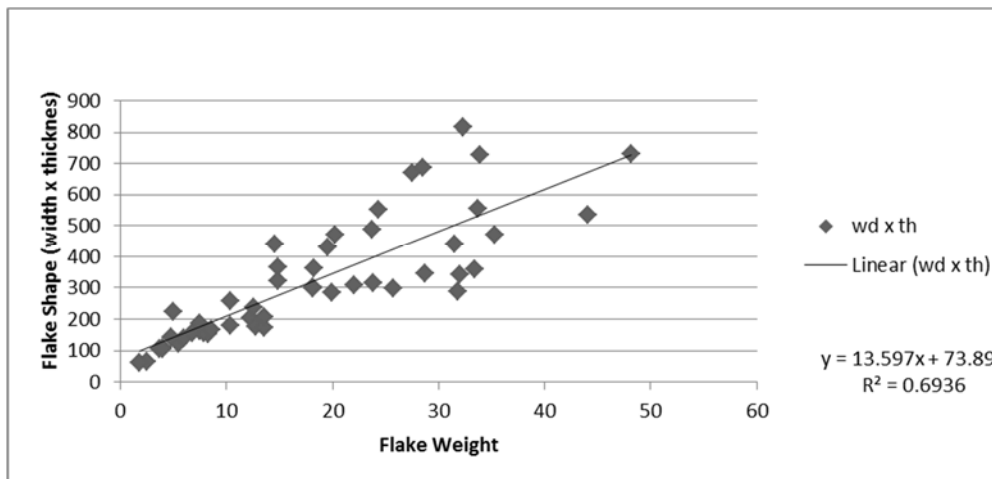
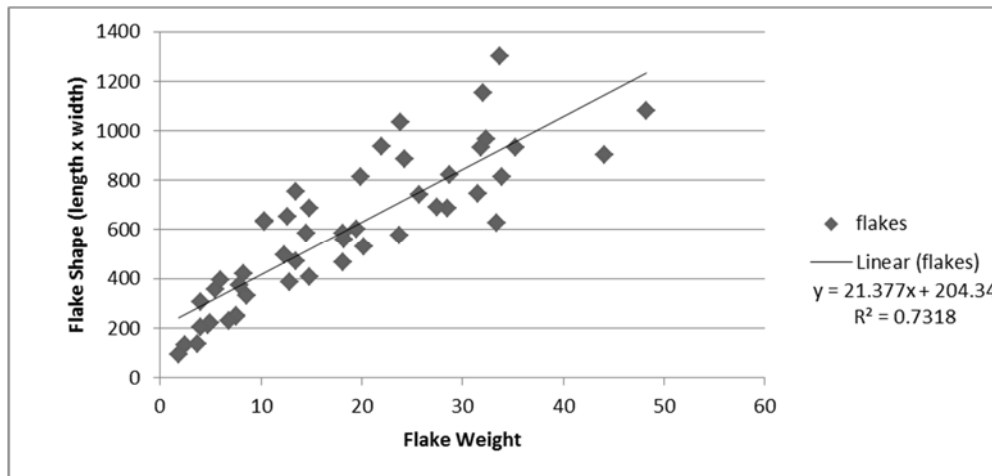


Figure 1.5. Flake shape characterized by width multiplied by thickness of flake tools and characterized by length multiplied by thickness (all in mm<sup>2</sup>). Both shape characterizations are positively correlated to flake mass (weight in gm).

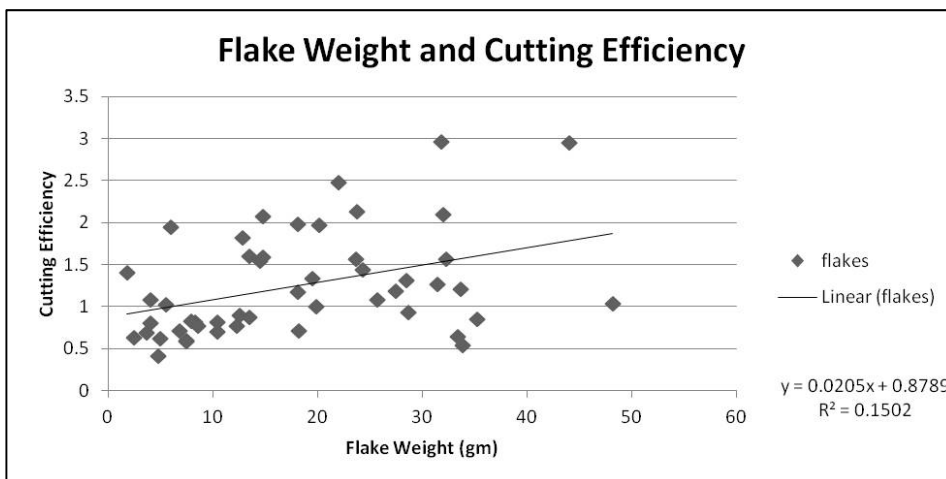


Figure 1.6. Cutting efficiency measured by weight of wood removed (gm) compared against flake size using weight as a proxy for both size and shape. Very weak relationship.

LITHICS IN THE WEST

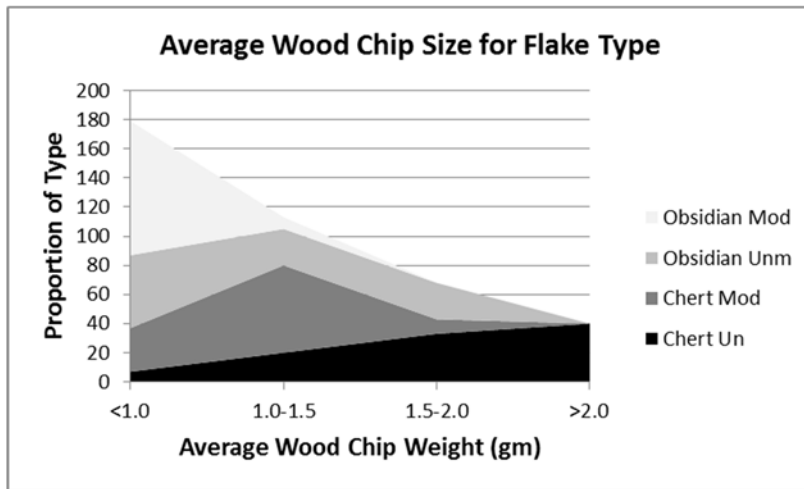


Figure 1.7. Proportion wood chip weight in 0.5 gm increments for each flake tool type. Note the high relative proportion of unmodified chert flakes in the >2.0 gm increment.

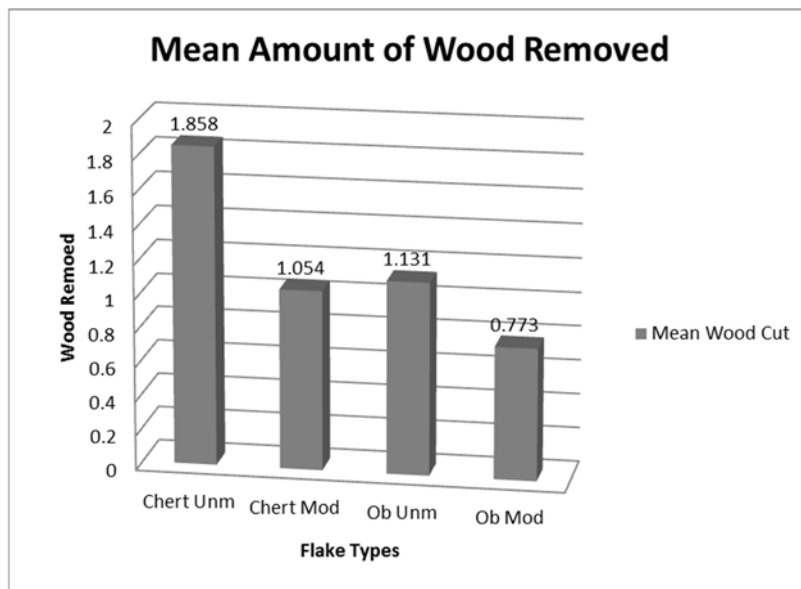


Figure 1.8. Average amount of wood removed per 20 stroke increment for each flake tool type.

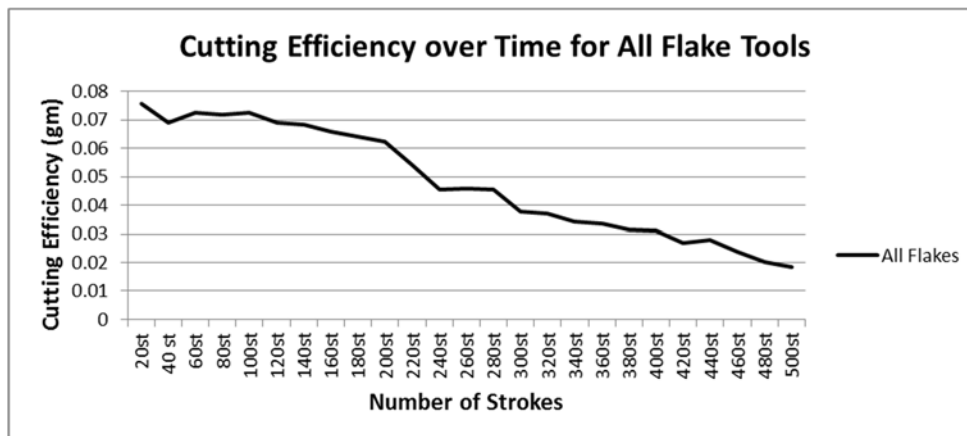


Figure 1.9. All flake tools combined; showing a decreasing amount of cutting efficiency as the tool are progressively used based upon number of strokes.

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Flake Tool Type	Linear Regression Equation	Correlation
Unmodified Chert	$y = -0.0016x + 0.0633$	$R^2 = 0.8902$
Modified Chert	$y = -0.0039x + 0.1245$	$R^2 = 0.9608$
Unmodified Obsidian	$y = -0.0024x + 0.076$	$R^2 = 0.925$
Modified Obsidian	$y = -0.0025x + 0.628$	$R^2 = 0.8852$

Table 1.2. Linear Regression Values for Each Flake Tool Type by Cutting Efficiency Loss During Use-Life.

When these data are partitioned by the four tool types we have conformational data on efficiency of tool type against tool use-life. Figure 1.10 plots average efficiency of flake tool types by stroke increment for each of the four types. This graph shows that unmodified chert flake tools are more efficient at whittling wood than any of the other flake tool types. Unmodified chert flake tools can be used for approximately 280 strokes before their efficiency drops to the level of an unmodified obsidian flake tool that has never been used. The unmodified chert flake tools can be used for approximately 340 strokes before their efficiency drops

to the level of modified chert or obsidian flake tools. Table 1.2 lists the linear regression values for each of the flake tool types graphed. All flake tool types show a significant and strong linear trend of efficiency loss over use life time. However, unmodified chert flake tools show a much stronger efficiency value than the other flake tool forms throughout total use-life.

DISCUSSION AND CONCLUSIONS

This study indicates some interesting efficiency trends about flake tool use at least with regard to whittling wet or green wood. Unmodified flake tools are

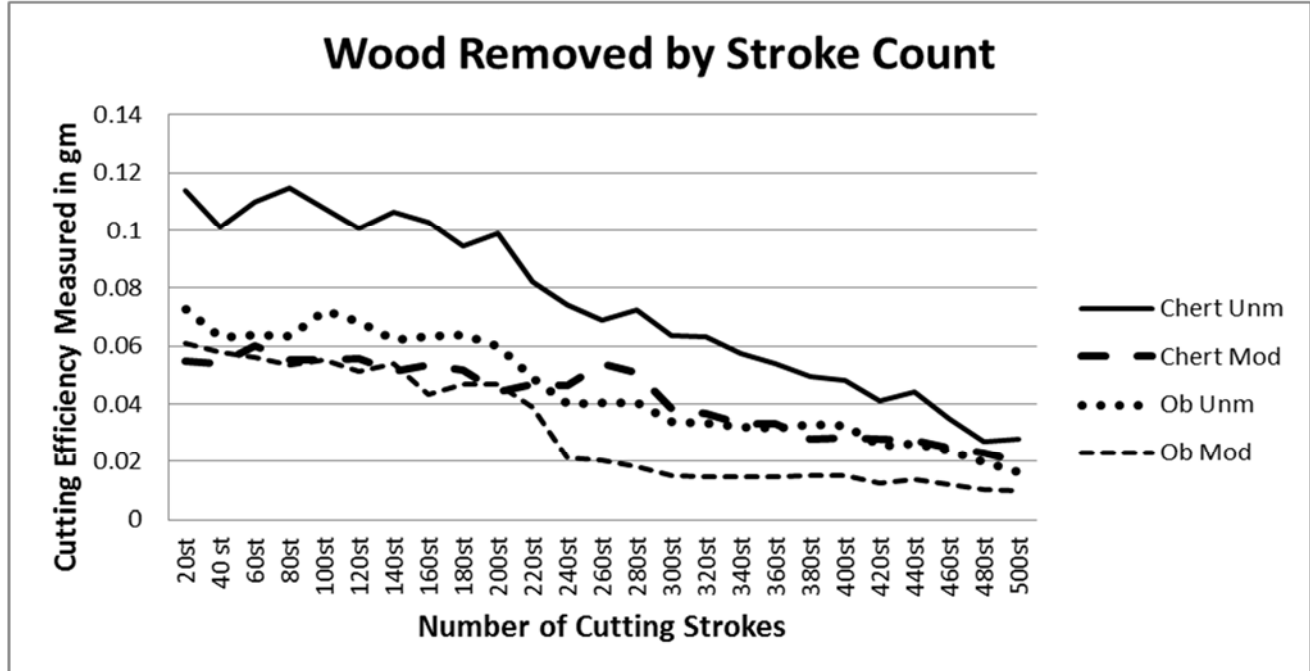


Figure 1.10. Cutting efficiency compared against tool use-life based on numbers of strokes for each flake tool type.

## LITHICS IN THE WEST

more efficient than modified flake tools. Unmodified chert flake tools are more efficient than unmodified obsidian flake tools. These patterns probably hold equally well for whittling and slicing materials softer than green wood such as leafy plant materials, animal hide and flesh. Harder materials such as dried wood, bone, antler and shell will probably reveal different patterns of efficiency than those produced here. I can envision cases in which retouched flake tools that have serrated edges would work effectively as saws for bone and hard wood. But sawing and whittling require two different kinds of cutting edges. Clearly, from this study retouched cutting edges that may be similar to serrated edges are not effective for whittling wood. Similarly, I can envision steep edged retouched flake tools such as end scrapers being useful for scraping soft materials such as cleaning sinew or hides without fear of inadvertently cutting through the materials. However, I'm confident that steep edged scraping tools are ineffective for use on wood or bone. Given the results of this experiment I would not expect retouched flake tools that have a serrated or steep edge to be used for whittling or slicing—they are just not as efficient as unmodified flake tools.

Previous archaeological studies of stone tool production and use models that link expedient flake tool use to sedentism and availability of raw materials (see Bamforth 1986; Kelly 1988; Parry and Kelly 1987) may be correct given what has been shown in ethnographic studies and this experimental study. That is, unmodified flake tools (or expediently made tools) may have been selected over modified flake tools and more formalized tools in general when available tool stone was present. If a good supply of lithic raw material were available for retooling there would be no reason for tool makers and users to even resharpen their flake tools when efficiency dropped. They could easily discard the inefficient flake tool and pick-up or strike-off a new sharp edged flake for use.

Many of the models that characterize flake tool use and transport (Beck et al. 2002; Kuhn 1994; Surovell 2009) suggest that unmodified flake tools were selected for use because of optimal cutting edge relative to carry weight. Again, this may be correct, however, the

information from this experiment suggests that there may also be a functional reason for selection of unmodified flakes for specific tasks. Unmodified chert flake tools are significantly more efficient than modified chert flake tools and any form of obsidian flake tool. These experiments suggest that aboriginal tool makers and users would probably have been aware of the relative efficiency of various tool types and raw materials and could easily have selected specific tool types for the task at hand in much the same way that the Alyawara and Xeta' selected specific flakes for their tasks (Binford and O'Connell 1984; Miller 1979). Retouched flake tools were probably a secondary choice for tool users when raw materials were abundant enough for easy replacement.

How about those situations when lithic raw materials for flake tools were not readily available or stockpiled for needed consumption? Those are the situations in which I would expect to see flake tools being retouched for longer use-life. In such situations tool makers and users cannot afford to discard flake tools simply because they are losing efficiency. Those tools would be used until their efficiency drops low enough so that resharpening is an effective means of increasing tool usefulness. Based upon these experiments, that drop would be at approximately 340 strokes on unmodified chert flakes. But even in those instances where lithic raw materials are abundant, archaeologists should not be surprised to find special function tools that are retouched such as steep edged scrapers for working soft materials. However, these need to be recognized as special function tools where the working edges are specifically crafted for a unique task. Such tools should not be calculated into optimality equations associated with tool use-life and retouch amounts.

In this study I suggest that wood working was an important component of forager life-ways and that the most efficient tool to whittle wooden implements was an unmodified flake of a durable raw material such as chert. Unmodified obsidian flakes could also be used but because obsidian is more brittle than chert it was not as efficient for whittling wood, but could have been used effectively for softer materials such as animal flesh.

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Archaeologists working on sites or site assemblages that have readily available and chippable stone need to consider the possibility that “unmodified flakes” were not simply discarded debitage, but instead are flake tools that were used to perform a needed task and discarded as efficiency of task performance began dropping. Furthermore, a higher frequency of recognizable retouched flake stone tools on some sites may simply be a reflection of low raw material abundance and not some functional or task specific difference of the site. Because the lithic and wood raw materials were specifically gathered from the western region of North America this study was envisioned with this region in mind. However, I believe the results of these controlled experiments have much broader impact and can be applicable to investigations related to foraging societies from many places around the globe.

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## CHAPTER 2

### UPPER COLUMBIA RIVER LITHIC TECHNOLOGY AND PREHISTORIC FISHING IN THE INTERMOUNTAIN WEST

BY PEI-LIN YU AND JACKIE M. COOK

#### ABSTRACT

*Prehistoric North American fishing is usually inferred from fish remains. Identifying durable lithic tools would increase our sample size of fishing sites but the diversity of fish processing lithic tool forms makes them difficult to identify archaeologically. The apparent lack of fishing tools in sites compared to abundant ethnographic references has been attributed to intensification of Native fishing activity resulting from Euro-American colonization. This study uses ethnographic data and known fishing tools from Kettle Falls on the Upper Columbia River to identify regular, archaeologically observable characteristics germane to all fish processing tools. We conclude that certain characteristics of fishing tools can be predicted, but multifunctionality blurs diagnostic characteristics. Investigating Native American fishing intensification in response to resource pressure from Euro-American immigration will require evidence for terrestrial hunting and gathering as well as aquatic resources.*

#### DISCERNING FISHING ACTIVITY IN THE ARCHAEOLOGICAL RECORD

Prehistoric fishing activity is usually inferred from anatomical remains of fish (bones and other anatomical structures such as otoliths [Belcher 2009; Butler and O'Connor 2004; Cressman et al. 1960; Graesch 2007; Prentiss et al. 2012]) and, if the depositional environment allows, remains of fish procurement technology (e.g., hook-and-line, nets and sinkers, weirs,

and dams [Lindström 1996; Lyons, in press; Lubinski 2000]).

Relative frequencies of these largely organic items are often used to infer changes in the proportion of fish in the diet. However, depositional environments of western rivers are characterized by acidic soil, erosion, wave action, currents, and dynamic stream and terrace structural morphology. These influence the attrition rate of organic materials and can result in under-representation in the archaeological record (Cannon 1996; Chance *et al.* 1977; Graesch 2007). In larger rivers, deterioration of archaeological organics has been accelerated by dam construction and reservoir operations.

Relying primarily on organic fish remains to infer past human behavior, cultural systems, and cultural evolution can lead to conflicting or ambiguous conclusions. For example, salmonid remains at Snake River archaeological sites have been used to argue a strong focus on salmon at odds with ethnographic reports (Plew and Guinn, in press). On the other hand, in Northern California the scarcity of archaeological salmonid remains is cited as evidence that ethnographic record *overstates* the importance of salmon (Gobaleta *et al.* 2004). On the Upper Columbia River Plateau, gaps in deposition of fish bone have been used to propose cycles of abandonment and re-population by ethnically distinct peoples (Chance and Chance 1985; Pouley 2008).

Regarding fishing in mountain settings, Lubinski (2000) says the paucity of archaeological evidence for fishing on the Green River in Wyoming is representative of the Rocky Mountains region as a whole. He concludes that the disjuncture between frequent reports of fishing in the ethnographic record of the Intermountain West and the lack of archaeological fish remains is real, not just a preservation issue (p. 163).

This may be an historical pattern associated with post-Contact disruptions to subsistence and mobility that necessitated increased focus on aquatic resources although sampling, preservation, and cultural change are still contributing factors to the lack of archaeological evidence for fishing (p. 164, also see Bogstie 2012). This conundrum is also present in the archaeological and



ethnographic record of the Upper Truckee River in the Sierras (Lindström 1996). But does this problem arise because archaeologists aren't recognizing most fishing tools in the archaeological record?

The technology of fish procurement (e.g. hooks, netting or line, fish spear points, weirs, baskets, dams, and traps) does tend to be underrepresented archaeologically. Most fishing tools are organic, therefore much of what we know about their form and the functional requirements comes directly from ethnographic reports. Stone net sinkers do preserve well, but indicate little more than the fact that nets were used. Stone tools used to butcher fish and prepare them for storage are likely to preserve in the archaeological record, but the diversity of forms of the North American West (discussed in detail below), presents archaeologists with a real diagnostic challenge.

In addition, ethnographic reports of fish processing tools being used for hide processing and other tasks makes clearcut connections between morphology and function even more elusive (Chen, personal communication; Gould and Plew 1996; Plew and Guinn, in press; Graesch 2007). This supports Odell's argument that functional requirements of stone tools may play out in morphologically variable, but equally valid ways in different settings (1981).

Techniques for identifying use wear and trace residues of lipids and proteins on tools (cf. Butler and O'Connor 2004; Hardy and Moncel 2011) offer some hope for identifying fishing archaeologically. However, the information obtained with these techniques has its limits. Post-depositional processes, washing, and other laboratory processing can obliterate microwear and residue, shrinking and randomizing the sample. If a tool was used to butcher fish for most of its functional life and then overprinted with woodworking and hide scraping in its final months, then microwear and residue may not reflect most of its use history.

Finally, time and cost usually constrains laboratory analysis to a few tools. As O'Shea notes, "if ... three-fourths of the (lithic artifacts) in ... a nonprobabilistic sample bore either organic residues or microwear traces referable to butchery, one could not legitimately infer

that the preponderance of (lithic artifacts) *in the larger population of such tools from that site* were used for butchery" (2007:217, emphasis mine).

Clearly, improving our ability to recognize fishing tools requires us to identify the factors that regularly influence the morphology of tools, including manufacture, use, repair and discard. We now turn to Kettle Falls on the Upper Columbia River, where fishing was carried out for thousands of years and associated lithic tools were regularly deposited. In this 'bottleneck', major salmon migrations allowed for periods of intensive fish procurement and processing.

### THE KETTLE FALLS COLLECTIONS

The Upper Columbia River salmon fishery was eradicated in the 1940s by the construction of the Grand Coulee Dam. Detailed oral histories of Elders from the Spokane Tribe of Indians, and the constituent tribes of the Confederated Tribes of the Colville Reservation (the Wenatchee, the Moses-Columbia, the Nez Perce, the Okanagans, the Lakes, the Sanpoils, the Nespelems, the Methow, the Palus, the Colville, the Entiat, and the Chelan) provide details about important characteristics of traditional fishing (Butler and O'Connor 2004, Pouley 2008).

Salmon, lamprey, and steelhead were harvested in large quantities and processed for storage and trade (Figure 2.1; Ray 1933; Teit 1930; Thompson 1968). Plateau fishermen and women coped with variability in timing and abundance of migrating fish that was affected by random, often remote, events (Davis 2007; Gould and Plew 1996; Grabowski, in press). These factors include sea level changes, deglaciation, rockslides, stream bed morphology, precipitation, global temperatures, migration routes, local runoff, and altered sediment load and vegetative cover from wildfire (Cannon 1996; Davis 2007; Plew and Guinn, in press; Schalk 1977).



Figure 2.1. The traditional fishery at Celilo Falls c. 1950.

When fish migrations were strong, a successful harvest required long-range planning, excellent communication, and rapid deployment of a sizeable labor force that was skilled and well-equipped. The archaeological record shows that, with minor exceptions, salmon fishing along the Columbia increased in intensity over a ten-thousand year span, particularly in the last 1,500 years (Galm 1994; Meengs and Lackey 2005; Schalk 1977, 1986).

For more than 70 years, excavations conducted at archaeological sites inundated and eroded by Lake FDR on the Columbia River have collected, analyzed, and curated millions of artifacts from Kettle Falls and nearby fishing locations (Chance 1986; Chance and Chance 1985; Chance et al. 1977; Collier et al. 1942; Galm 1994; Larrabee and Kardas 1966; McKay and Renk 2002; Pouley 2008).

These artifacts are now curated by the Confederated Tribes of the Colville Reservation and the Spokane Tribe of Indians on behalf of the federal government. Stone tools associated with fish processing, defined here as all tasks from butchering and drying to packaging for storage, have received little attention in the peer-reviewed literature (Yu and Cook, in press), but thousands of lithic tools from the legendary fishing site

of Kettle Falls offer an opportunity for large-scale analysis.

This paper has three goals: first, to describe the relationship between salmon life history and functional properties of fish butchering tools. Second, to formulate a model describing the expected range of variation in tool morphology relative to a sample of archaeological tools from the Kettle Falls collection. And third, to apply performance requirements for mass-processing tools as a frame of reference for fishing tools used at smaller scales expected in most of the Intermountain West.

#### RELEVANT CHARACTERISTICS OF ANADROMOUS FISH

Harvest and processing of migratory salmon was conditioned by life history, habitat, and distribution. Characteristics include

- large seasonal upriver migrations of thousands of fish,
- uneven distribution with periodic concentrations at specific locations,
- de-coupling from local environmental productivity (reproducing individuals rely on

marine productivity and stop feeding once upstream migration has begun), and

- inter-annual variability driven by a variety of geologic and hydrologic factors.

Longer migrational distances 'stacked' the chances that some random external factor would alter the timing of the run (Davis 2007; Schalk 1977; Gould and Plew 1996). Inland communities needed to monitor and communicate about salmon movements, assemble at constricted locations, organize the labor force, establish living and working spaces quickly, and create or refurbish infrastructure and tools. These 'gearing up' events are well documented in ethnographic sources (Graesch 2007; Ray 1933; Teit 1930; Thompson 1967).

With anadromous species the access window is narrow and likelihood of spoilage is high (Ibid), so the incentive to procure and process as many salmon as possible was extreme (Ames and Maschner 1999:115-116; Graesch 2007:581; Schalk 1977:226). Salmon can be cached temporarily in the river, but butchering and drying were generally done as quickly as possible (Graesch 2007:581).

This required many skilled hands. Binford's (2001) database, which uses known characteristics of foragers to project organizational characteristics in environments where they no longer reside, predicts very large task groups in regions with access to salmon (p. 261). Task group sizes should have co-varied with the bulk of resources processed per unit time and the degree of dependence on stored resources (Ibid).

Periodic, random collapses of local salmon fisheries—sometimes for decades—required logistical tactics to maximize returns when the fish were running. These included a sophisticated system of communication, rapid deployment of the labor force, regulation of access to fishing locations, mass processing, regulation of fish distribution, long-term storage (e.g., delayed return), and, if the run failed to materialize, re-directing efforts to alternative bulk resources such as camas (Ray 1933; Thoms 1989).

Spiritual measures to minimize risk and uncertainty included an array of prohibited activities, substances, and

at times, persons (Thompson 1967) as well as tight social controls at fishing locations to ensure that spiritual errors did not offend or frighten the fish (Ray 1933:28, 70-71). If all went well and the run was strong, facilities and personnel for fish processing needed to be primed for action. Preparation began weeks beforehand (travel, establishing camp, gathering of raw materials, constructing/refurbishing facilities, etc. [Ibid]).

### THE TASK OF BUTCHERING

On the Upper Columbia River and many other locations ethnographic sources state it was the men's job to procure and deliver salmon to the women. Fishermen stood on natural features and platforms and used an array of net forms (including J-shaped basket nets or dip nets (see Figure 2.1; Ray 1933; Graesch 2007; Thompson 1968), or traps at major confluences (Ray 1933). Fishermen gaffed and clubbed the salmon and handed them to others who transported them to processing locations. The women had already constructed drying shelters and prepared large staging areas of sunflower leaves, a plant connected spiritually to salmon (Ray 1933:28). The women had also manufactured, refurbished, or otherwise obtained their butchering toolkits.

In North America, salmon butchery methods appear somewhat standardized across cultural and geographic boundaries. On the Upper Fraser River of British Columbia, women cut open the fish along the backbone, removed the head, drained the blood, and removed the vertebral column and attached ribs (Graesch 2007:580-581). The head was split and set aside to dry separately, then the body was laid open and the remaining fillets, still connected by a section of ventral skin, were scored perpendicular to the length of the fish. Fillets were typically no more than one cm. thick and were backed by the skin—backing was essential to the integrity of the fillet for drying and transport. The thickness of each row of scored flesh was determined by anticipated weather conditions.

In Central Alaska, Cu'pik women cut off the head just below the gills, split the belly, and removed the fish's



**Figure 2.2. Colville fish rack with drying salmon. Howard Ball Collection, Northwest Museum of Arts and Culture (Negative #L97-14.5).**

internal organs (Frink et al. 2003:119). The body was then split along both sides of the vertebrae, which were removed and either dried or discarded. The head was also split. Filleting entailed leaving two flanks of meat attached at the tail, and the alternative method of stripping separated the fillets from the tail and cut them into strips. Scoring of the fillets, a step to facilitate drying, is not mentioned in the Central Alaskan experiment, perhaps due to the lower risk of spoilage in a cooler climate. Similar fish butchery techniques have been observed among the Tutchone of the Southwest

Yukon (O’Leary 1992) and the *St’át’imc* Nation bands of the Fraser River region (Prentiss et al. 2012).

On the Upper Columbia River, women of the Lakes, Sanpoil, and Nespelem divided the task into two main phases. First, women removed the intestines immediately and placed the fish on drying racks for about one hour (Figure 2.2; Ray 1933:75). After several fish had accumulated, women cut off each head and opened up the body: “One flank was partially severed from the body by cutting along one side of the backbone, between the bones and the flesh. The fish was then turned over and a second cut was made from the ventral side extending almost to the backbone. Each flank, thus separated, was slashed transversely about every half inch. Long slender splints of cedar were used to hold the sides of the salmon apart” (Ibid). Heads were also split and placed on drying racks.

Salmon were hung from racks by piercing the tail and inserting a forked stick. Ten to 14 days were required to dry filets, and twice as long for heads and roe (Ibid). During the drying period, fish were vulnerable to pilfering by wild animals, dogs, and kids (Marchand 1999; Ray 1933) and had to be guarded.

Modern fishermen and women would be surprised by the scale of traditional Native salmon processing. The closest analogy is 19<sup>th</sup> century salmon canneries prior to mechanization, in which hundreds of Asian and Native laborers worked around the clock for several weeks (O’Bannon 1987:559-60; Newell 1988:630; Price 1990:48). There are clear implications for the prehistoric labor force: women (Frink et al. 2003, Graesch 2007, Ray 1933, Rousseau 2004). In Alaska, Oswalt (1963:44) observed that even a small increase in salmon meant a significant spike in workload for women.

On the Upper Columbia and other camas-rich regions, the spring salmon season arrived with women having already spent significant energy on the camas harvest, processing, and storage (Ray 1933:27), entailing *two* closely-linked workload surges in the spring months. Romanoff (1992:235) estimates that each woman worked for about 12 hours continuously to process 60-100 fish, and Graesch citing Frink et al. (2003) and Schalk

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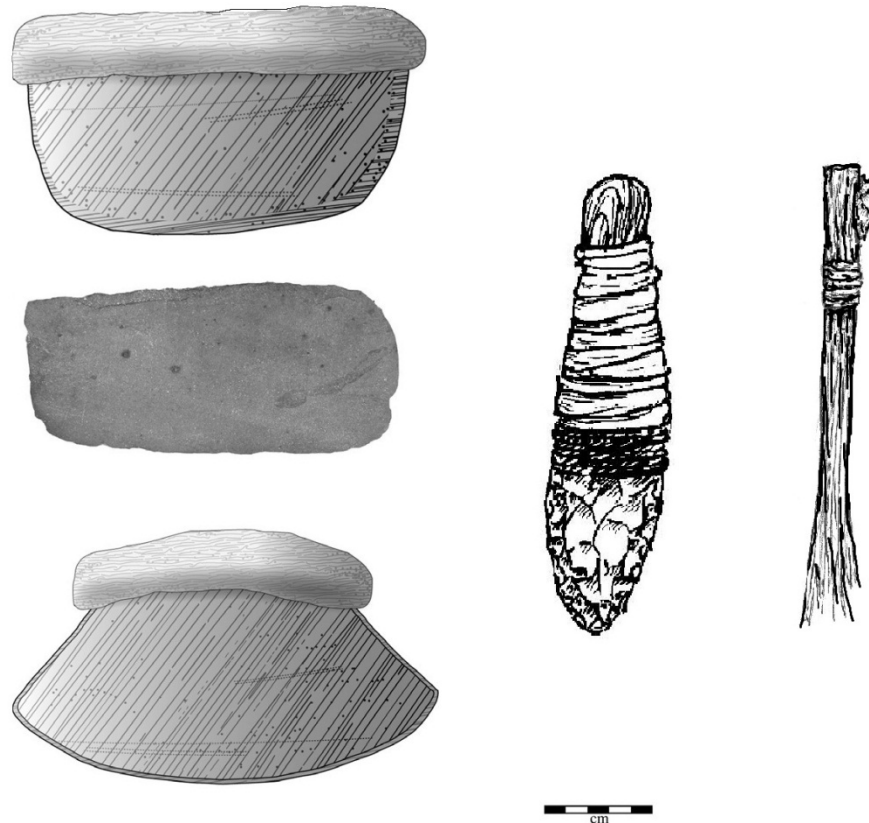
1977 estimate between 67 and 100 salmon processed per woman per day.

In western Alaska the average household took in about only 150-300 salmon per annum (Frink et al. 2003). In a maritime household the estimate is 54 woman-days of labor needed per year to supply enough salmon for the family; if ritual/giveaway salmon are added, the workload could double to 110 woman-days (Graesch 2007:581-582). A modern estimate of 'continuous effort' probably does not include time for refurbishing tools, family-related interruptions, resting, eating and drinking, dealing with work-related injuries, and so forth. In our opinion, it is appropriate to add 10-20% more time to a woman's annual salmon-processing budget to arrive at a

maximum estimate of 132 days—or about one-third of her year.

We can now summarize elements affecting technological needs that were common to large-scale salmon processing.

1. Tasks were carried out by labor groups near key procurement locations.
2. Due to the messy nature of fish butchering and the need to monitor drying salmon, the processing area was separate from, but near to, residential areas.
3. Labor was skilled, and organized by gender (men procuring and transporting; women butchering,



**Figure 2.3. Some fish butchering knife forms: Slate knife (Graesch 2006:579); chert fish butchering knife (drawing after Kroeber and Barrett 1960, plate 20, p. 196); and hafted microlithic tool (Hoko River Digital Image Archive). Scale is approximate.**

drying, and packaging for storage).

4. Incentive to process salmon quickly during a strong run was high, imposing physical and logistical demands on the labor force and their gear.

From these data we argue that physical traces of these organizational characteristics should be visible archaeologically (Cannon 1996:25). *Salmon processing tools, features, and by-products should be functionally and spatially distinct from, although associated with, procurement and residential areas. Discarded tools should accumulate at or near processing areas, covarying with frequency, intensity, and duration of site use.* We now turn to characteristics of the tools themselves.

#### **CHARACTERIZING VARIABILITY OF FISH BUTCHERING TOOLS**

The relationship between morphology and function is not straightforward (Figure 2.3). In sub-Arctic North America, fish butchering tools come in a wide variety of hafted and handheld forms. Knives of tabular slate are well-documented on the Fraser River (Hayden 1997; Graesch 2007; Prentiss et al. 2007), and in late 19<sup>th</sup>-century Northern California, Kroeber and Barrett (1960) observed hafted knives with bifacially flaked points. They describe a typical example as "...a nicely chipped flint blade, hafted in a wooden handle, wrapped and pitched for firmness" (92). In what is now northwest Washington, hafted microlithic tools found in the wet sites of the Hoko River (Croes and Hackenberger 1988) and Ozette (Kirk and Daugherty 2007) are described as fish butchering tools.

At Fivemile Rapids in the Dalles, archaeological examples of fish processing 'blades' are described as made from thin conchoidal or lamellar flakes of chert with straight or convex edges occasionally on opposing sides (Cressman et al. 1960:48, 91; Minor et al. 1999). Rousseau (2004) proposes that prehistoric tools from the Canadian Plateau were bifacial and lanceolate, hafted with a blade on both the proximal and distal end. He argues that these unusual tools (admittedly without an ethnographic basis) arose c. 3500-1200 BP as a result of

increasing logisticality and functional specialization. Near Kettle Falls, Ray (1933:43) mentions hafted bifacial chert fish butchering knives, whereas Chance and Chance (1977, 1982) describe tabular handheld forms.

This variability may reflect distinct functional requirements of fish butchering. Cu'pik women have observed that more than one tool is required to butcher salmon (Frink et al. 2003); the first to pierce, and the second to make shallow, precise slices. Graesch notes that slate cutting surfaces need to be finely ground and oiled to minimize sticking, with long blade edges to score flesh without cutting the backing skin (Ibid). In British Columbia, Graesch reports "because the beveled edges on slate knife blades are typically not sharp enough to penetrate the thick skin of most salmon ... the initial dorsal incisions and removal of the head (which required cutting through the vertebral column) were likely accomplished with flakes, retouched flakes, or bifaces" (2007:582).

This would implicate unmodified flakes in fish butchery although they are likely under-reported for this and other functions (also see Andrefsky, this volume). Handheld slate knives may have been designed and used for only a subset of fish butchering tasks: filleting and scoring (Ibid). Some of the slate Fraser River tools show both chipped and ground edges, which Graesch argues represent functionally different working edges (p. 586).

Similar qualities are desirable for processing hides. Thus fish butchering tools were apparently suited for a variety of other uses: Unifacial tabular knives are commonly reported as hide scrapers (Chance and Chance 1977:74; Mourning Dove in Miller 1990:103). Chance and Chance (1977) state later in the same sentence "That at least some of the (tabular) knives were used for cutting fish is attested by numerous informants" (Ibid). Thus, while these tools may reflect the functional requirements of fish butchering, they were almost certainly used for other tasks.

Multifunctionality of tools is well-documented for other lithic tools including projectile weaponry, particularly among foragers with diverse subsistence processing requirements (see Shott 1986 and Greaves 1997 for summaries). Reference knowledge from

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ethnographic and traditional sources can be used to strengthen linking arguments between technological requirements and tool morphology for specific activities. Salmon processing clearly required skill, concentration, and speed (Frink et al. 2003:117), which conditioned for tools with superior piercing, slicing, and filleting capabilities as well as ease of manufacture and repair.

Of all raw material types, slate butchering tools appear most often in the ethnographic literature (Burley 1980; Frink et al. 2003; Graesch 2007; Matson 1983). Along the Fraser River in British Columbia, slate outcroppings were close to fishing localities and toolmakers could acquire cobbles of good quality within a short walk's distance (Graesch 2007:585). Since foragers usually travelled to fishing grounds loaded with camping equipment, expedient tools from nearby sources minimized transported burdens (Ibid. p. 582).

Frink *et al.* (2003) quote the preference of Cu'pik women of western Alaska for tools that are easy to use, reduce processing time, and require less resharpening (118). Slates that were "soft and poorly cemented, breaking along bedding planes into thin plates or scales and terminating in joint-planes or irregular fractures" reduced manufacturing time because the plates required little cortical reduction or thinning (Ibid).

In a salmon butchering experiment, Cu'pik women assessed performance of traditional slate ulu replicas compared to modern steel ulus with sharp pointed corners. Overall, the women preferred steel ulus because the pointed corners could make the initial perforation, the blade was stronger, and the edge did not require retouch or sharpening as often (Ibid p.120-121). However, the women stated that once the perforation was made with a piercing tool, the duller slate edge of the traditional slate ulu was better at filleting without cutting the essential 'backing' skin (also see Morin 2004).

The use life of fish processing tools and rate of discard probably depended on the raw material. Frink et al. (2003) note that Cu'pik women resharpened their slate knives after processing each salmon. Thus a woman processing at a rate of 60 fish in one day could potentially exhaust one slate knife per day! However, knives made of more durable raw material like chert or

quartzite may have lasted for months or multiple seasons.

Tools that were exhausted or broken beyond repair were discarded in higher numbers near fish butchery locales (Ibid. p. 596) so exhausted hand-held unifacial tools made of tabular raw material should exhibit reduced surface area relative to thickness. If large numbers of fish butchering tools were made for each season, we expect that some with utility value remaining would have been left on-site for recovery and refurbishing in future seasons.

In sum, expectations for fish butchering tools used in large-scale processing events include

1. Raw material that is easily accessed and worked (e.g., local source; tabular fracture planes);
2. Formal characteristics that meet functional requirements of piercing/slicing *and* scoring/filleting;
3. Varied morphology discernible at the level of an assemblage rather than individual tools;
4. Large accumulations of exhausted or broken tools at processing localities, co-varying with intensity and frequency of site use;
5. Smaller numbers of tools with use life remaining also present at processing localities; and
6. Some use of fish butchering tools for hide processing and other tasks.

We can now make a model statement about expected characteristics of fish butchering technology and tools.

*Intensive fish butchering tools should be easy to make and transport, and perform both piercing and shallow slicing functions with minimal repair, refurbishment, or replacement. Salmon processing tools, features, and by-products should be functionally and spatially distinct from, although associated with, procurement and residential areas. Discarded tools should accumulate at or near processing areas, covarying with frequency, intensity, and duration of site use.*

We will now evaluate an archaeological assemblage of tools from the Kettle Falls area relative to the model

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statement. Our objective is not to produce a classificatory system for salmon butchering tools, a range of expected variability in forms across space, or a systematic study of change in form over time. Rather, we consider the conditioning effects of organizational characteristics of fish processing upon specific, archaeologically visible, morphological traits.

### THE KETTLE FALLS COLLECTION

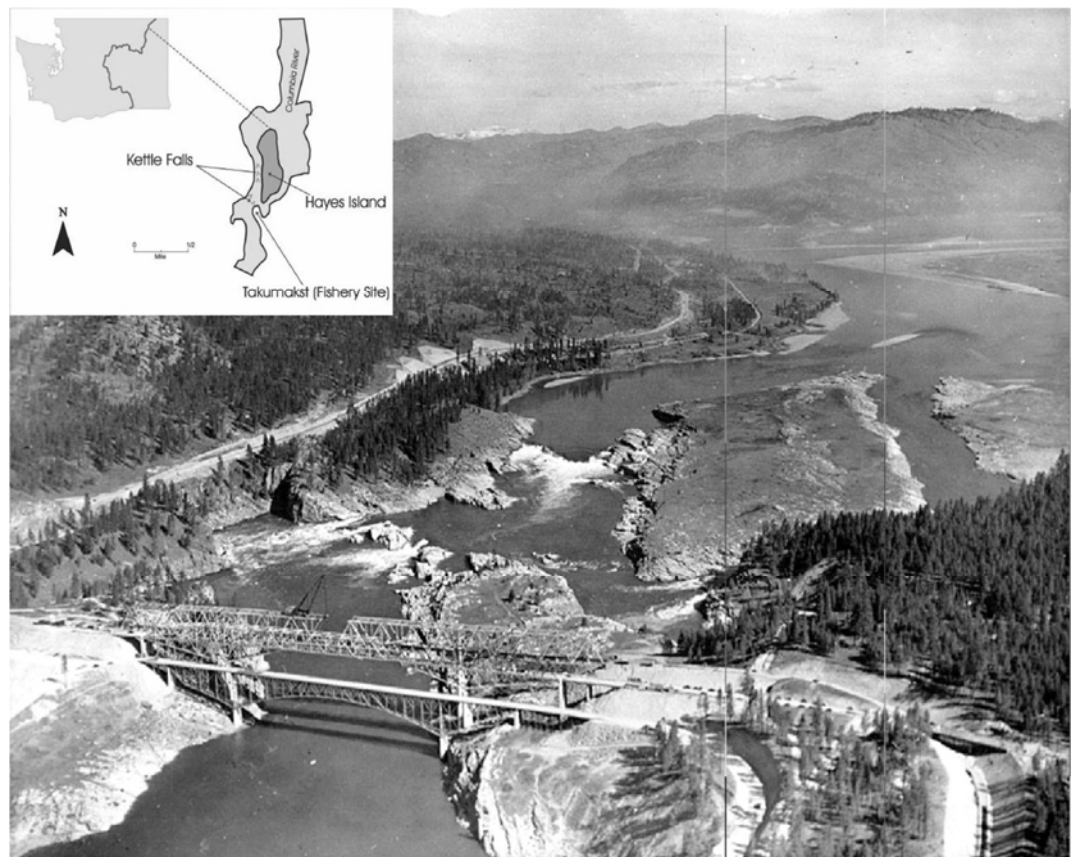
Due to erosion and other dynamic site formational processes, artifacts recovered from Kettle Falls range from c. 9,000 to Euro-American contact, with the majority dating to the Takumakst culture historical period (c. 2000-1700 BP; Chance and Chance 1982; Pouley 2008). The study sample of tabular tools from the known fishing site of Hays Island (45 FE-45; also called the Ksunku Site) and adjacent locations at Kettle Falls

**Table 2.1. Kettle Falls Area Sites Sampled.**

Site	Sample Size
45 FE-43	N = 9
45 FE-45 (A and B)	A = 176; B=21
45 ST-95	N = 18
45 ST-116	N = 6
45 ST-119	N = 17
45 ST-201	N = 6

(Figures 2.4-2.5; Table 2.1) is curated at the Confederated Tribes of the Colville Archaeological Repository in Nespelem, WA.

More than 11,000 tabular tools have been recovered over decades of archaeological work, and many more remain *in situ*. We selected a sample of 253 tabular tools from six Kettle Falls area sites (45 ST 119 and 45 FE 45 were each excavated over several years were each



**Figure 2.4-2.5. Kettle Falls and Hayes Island in northeastern Washington State (map by J. Pouley 2008:4, used by permission of the author), and aerial view of Kettle Falls prior to Grand Coulee Dam construction.**



treated as a unified collection). Tools were selected for sampling if they were tabular, 1 cm or less in maximum thickness, and not clearly a projectile point or other bifacial tool.

Due to the non-representative nature of the collection (c. 2%, selected as they were pulled), our analysis will describe and evaluate characteristics of sampled tools relative to the model statement rather than arrive at a statistically derived conclusion. The important fishing locality of Takumakst or Fishery Site (45 ST-94) was not included in this study and should be prioritized for future analysis.

Artifacts were selected for this study if they were

1. Tabular (roughly equal thickness along both axes formed by parallel fracture planes in the source material)
2. 1 cm or less in maximum thickness
3. Not clearly a projectile point or other bifacial tool

Chance and Chance (1977, 1982) view tabular, bifacially retouched tools from 45 ST-45 and other sites as a distinct artifact class (1982:74). Excavators, and subsequently curators, have labelled tabular artifacts from Kettle Falls sites and assigned them to a functional category of “tabular knife”. After reviewing the collection catalog we feel the above characteristics match well with this designation in all but an insignificant number, although we use the more generic term “tabular tools.” For this study, the weight, maximum length, maximum width, and thickness of artifacts were measured, as well as maximum thickness and thickness at one working edge. Each artifact was photographed with a metric scale with two map views.

## RESULTS

Using the model statement, we address individual expectations for the Kettle Falls sample below.

### **1. Fish butchering tools had low transport and manufacture costs.**

The Kettle Falls tools are primarily made of two local raw material sources: tabular quartzite from the Colville formation, which is located right at the 45 FE-45/Hayes Island site and nearby at 45 ST-98/the Kwilkin Site; or micaceous quartzite interleaved with micaceous schist (also called argillite) at the mouth of the Kettle River c. 2.5 miles upstream (Chance and Chance 1977, 1982; Depuydt, personal communication; Martinez, personal communication).

A few small slate tools were present in these sites but not sampled. As with Fraser River fish butchering tools, the Kettle Falls tabular tools were easy to manufacture and transport: a raw material source lies within a day's stroll from the main fishing locality. This raw material fractures into c. 1 cm. thick pieces that require minor retouch to become functional tools.

### **2. The assemblage should reflect multifunctionality in which tools exhibit piercing/perforating features as well as shallow curvate ones.**

The sampled tools do show variability in form, with piercing functionality reflected in acutely angled (<90°) points (Figures 2.6a, 6b, 6c, 6g, and 6h), and filleting functionality reflected in 2-3 mm-thick edges that are straight (Figures 2.6a, 6e), shallowly curved (Figure 2.6c, 6d), or tightly curved/ovate (Figures 2.6f, 6g, and 6h).

A subset of 171 tools was examined for morphological characteristics. Of these, 79% (N=135) exhibited both piercing and filleting characteristics (with a subset of tiny tools c. 5-8 cm. in maximum length that appear to be functionally different), and 21% (N=36) exhibiting only filleting capability.

These categories agree somewhat with Chance and Chance's formal designations for tabular artifacts (1977, 1982).

1. Cornered or cutting knives, with angled edges between 90 and 180 degrees, most likely used to perforate or pierce;
2. Pointed knives with angled edges more acute than 90 degrees, most likely used to make deeper perforations;



Figures 6a, 6b, 6c



Figures 6d, 6e



Figures 6f, 6g, 6h

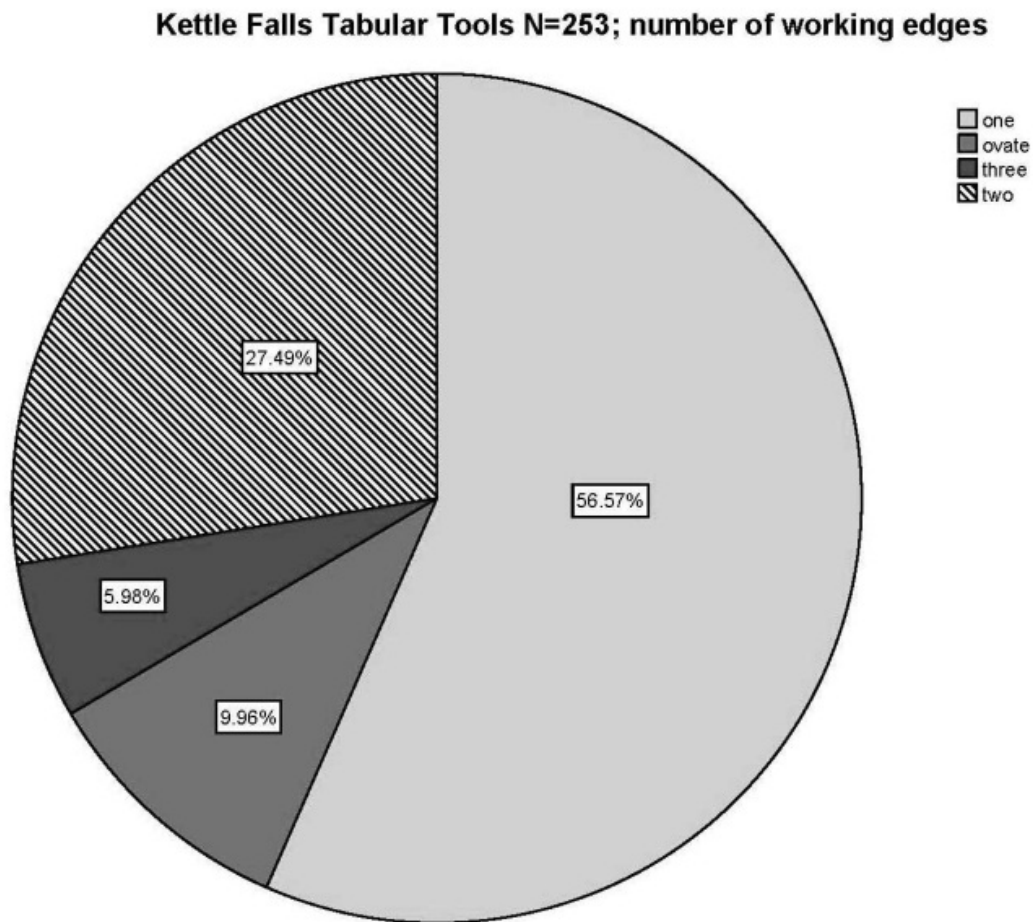


3. Ovate or semi-lunar knives with tightly curved edges most likely used for filleting, and
4. Concave knives, which are considered as unfinished semi-lunar knives.

However, the Chance categories do not take into account the *combined* piercing and filleting capabilities of the majority of the Kettle Falls individual tools. In this sample, acute piercing points and curved filleting edges are observable in individual tools and at the assemblage level.

**3. Fish butchering tools should have multiple working edges to minimize re-sharpening**

The Kettle Falls sample shows that the majority of tabular tools (56%) have one worked edge, excluding ovate examples (which comprise 8% of the assemblage)(Figure 2.7). About 34% of the sampled tools have two or three straight edges. Our expectations were not supported by the sample, but a mitigating factor may be the high durability of the Kettle Falls argillite and quartzite raw material, reducing the rate of edge wear.



**Figure 2.7. Working edges, Kettle Falls sample of tabular tools (N=253)**

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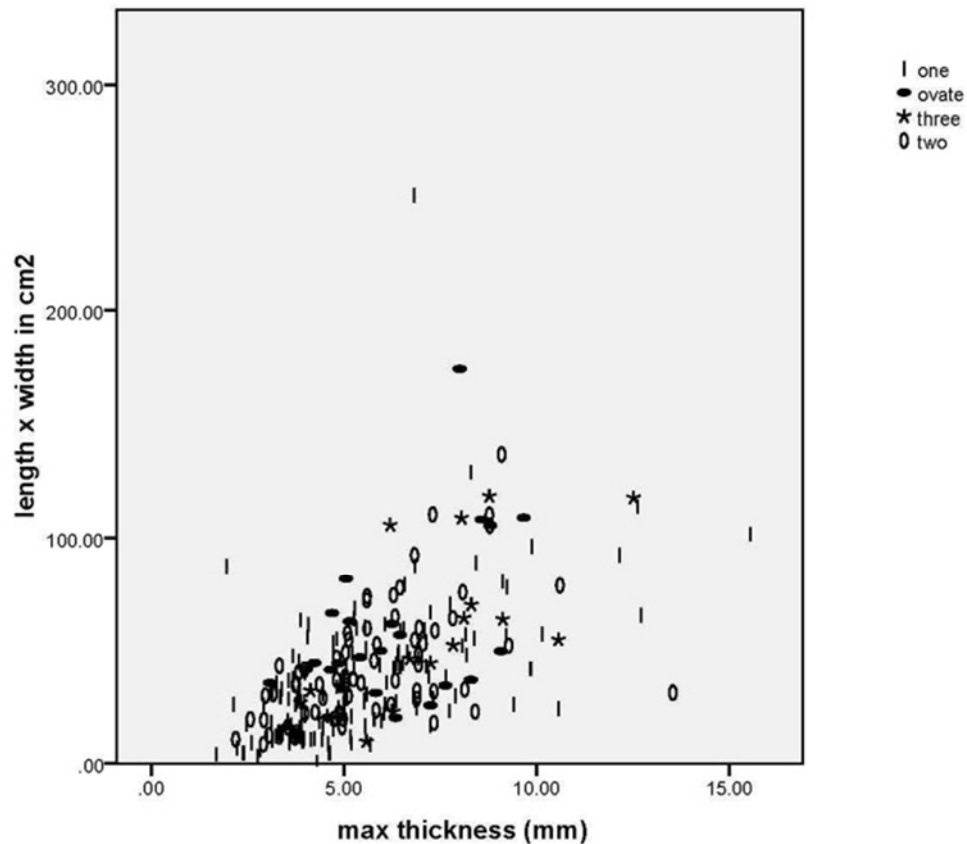
**4. Discarded and broken tools will accumulate in large quantities near key access locations. Corollary: Still-useful tools may have been left on-site and refurbished upon return.**

To date, the total number of tabular tools recovered in the Kettle Falls vicinity is 11,541. Site 45 FE-45 (Hays Island) alone accounts for 6,005 tabular tools, and 45 ST-94 (Takumakst) for 4,325 (Figure 2.8). Most of these tools are densely packed in thin strata, with highest numbers near the surface (Chance and Chance 1977), possibly as a result of reservoir-related deflation of sediments.

If women intended to refurbish and re-use the tools at Kettle Falls, we expect that the ratio of surface area to thickness should be variable, and tabular tools with less use-life remaining will be thicker relative to their surface area (Figure 2.9). Our analysis shows that, regardless of shape or number of working edges, the Kettle Falls tools mostly retain some utility; the thickness relative to surface area is consistent regardless of tool shape, and as can be seen Figures 2.6a-6h, acute angled piercing points and curved or elongated



**Figure 2.8. Tabular tool exposed on surface at Hays Island, with water action visible. Photo: Brent Martinez, 2004.**



**Figure 2.9. Surface area (approximated by max. length x max. width) to thickness ratio by tool form.**

**5. Salmon processing tools, features, and by-products should be functionally and spatially distinct from, although associated with, procurement and residential areas. Discarded tools should accumulate at or near processing areas, covarying with frequency, intensity, and duration of site use.**

Kettle Falls is comprised of several discrete archaeological sites; the greatest concentration of fish butchering artifacts appear on raised areas such as Hays Island in the drainage channel or on the immediate banks of the river, downslope from residential areas (Chance and Chance 1977; 1985). Sites located to the south of Kettle Falls, away from the main fishing area, contain significantly fewer fish butchering tools (Pouley 2008).

## DISCUSSION

Morphological characteristics of fish butchering tools reflecting manufacture and function can be predicted at the level of an assemblage. Analysis of the Kettle Falls collection supported expectations that, among groups who practice large-scale salmon processing, fish butchering tools will be made of raw material that is easy to access and lends itself to quick manufacture (in this case, slim fracture planes) wherever possible. This is consistent with Andrefsky's finding (this volume) that tool form found on sites relates to tool function, human choices and raw material availability.

We expected most tools would have more than one working edge to minimize re-sharpening time, but this does not appear to be the case at Kettle Falls. The expectation that tools will accumulate in large numbers where processing was intensive and long-term is supported, and every tool in the sample retains some usefulness. These expedient but high-performing tools may have collectively formed 'site furniture' (*sensu* Binford 1979) left by women intending to return each season. Salmon processing continued at Kettle Falls until the flooding of Lake Roosevelt in the early 1940s so the lithic butchering tools we see in such high numbers today had likely been replaced by metal knives.

The Kettle Falls sites themselves are consistent with expectations that fish processing on a large scale happened in areas associated with but separate from residences, and that numbers of fish processing tools should taper off in less intensely used sites.

A contrasting case is the Five Mile locality of the Dalles in Oregon, another renowned salmon fishery characterized by large archaeological deposits of fish remains (Cressman et al. 1960; Butler and O'Connor 2004). The total number of artifacts stipulated as fish butchering tools at Five Mile does not exceed 100 for all strata combined (Cressman et al. 1960), compared to more than 11,000 tools known for the Kettle Falls area. This could result from several factors: first, large portions of the Five Mile site were demolished for highway construction. Second, the original number of fish butchering tools may have been relatively small due to manufacture from chert, a high quality, durable raw material suitable for curation and transport.

It is not yet known where the Dalles raw material source is located. If the source is distant, and bladelike tools of thin conchoidal or lamellar flakes required greater manufacturing effort (Cressman et al. 1960:48, 91; Minor et al. 1999), women had incentive to make fewer butchering tools, and curate and transport them. Thus the quality and accessibility of raw material should directly influence the degree of butchering tool accumulation at fish processing locales.

Across the Intermountain West, where small, mobile task groups fished for spatially and seasonally dispersed species such as cutthroat trout, chub, pikeminnow, and mountain whitefish, we would not expect large accumulations of salmon butchering 'site furniture'. MacDonald's analysis of lithics from around Yellowstone Lake (this volume) concludes that fishing was not an important component to subsistence there despite the proximity of prime fish habitat.

According to Shott, increased mobility would necessitate a smaller number of more flexible tool classes, each capable of application to a broader range of tasks (1986:23). The interesting microcore/microlith complexes discussed by Lee et al. (2013) illustrate the diversity of tool forms that can be expected with

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Intermountain Western fishing, and potentially conservation of high quality raw material.

Archaeologically, tools used for fish butchering in non-intensive settings are expected to serve a variety of functions as personal curated gear, and be deposited in small numbers at multi-purpose sites. Overprinting of varied functions would likely eliminate residue or use wear evidence for fish butchering. In fact, *the disparity between ethnographically observed fishing and scanty archaeological evidence in most of the Intermountain West is consistent with the expected scarce and ambiguous archaeological evidence for fishing.*

In O'Shea's analysis of Paleolithic tool assemblages, he notes that certain questions regarding tool use may not be answerable: "... context, residues, microwear, and some experimentation might establish the roles (of tableware) in our subsistence; but (a future) archaeologist would certainly not be able to infer the ratio of salads to T-bone steaks in our diet, nor the relative significance of fish versus potatoes" (2007:226).

However, this doesn't eliminate the possibility of subsistence intensification in response to Euro-American pressures. Global ethnographic information about forager intensification indicates that a 'typical' sequence shifts from large-bodied terrestrial game to smaller terrestrial species and aquatic resources, then plants (Binford 2001; Kelly 1996). Thus, evidence of roughly contemporary terrestrial game intensification would corroborate and bolster the case for aquatic intensification. Such evidence could include increases in low utility meat elements; traps, drives, and other innovative hunting techniques to maximize yields; increases in smaller bodied game; and bone grease processing and other intensive methods to extract maximum nutrition.

In the northern Intermountain West, oral histories and archaeological evidence suggest that Blackfoot hunters moved into montane zones in response to Euro-american incursions on traditional plains hunting grounds (Zedeño 2013). Sheep traps, which appear in the Central Rocky Mountains at c. 1700-1800 AD, are another indication of a tactical shift in terrestrial hunting practices (Scheiber and Finley 2010).

Ethnographic observations of fish butchering tools in common use as hide scrapers at Kettle Falls, a major fishing locality, are suggestive of disruptions in traditional seasonal patterns of mobility and subsistence. Further study of archaeological evidence across the prehistoric/proto-historic divide will likely show that subsistence intensification -- using aquatic resources where available -- occurred in response to land and resource pressures from the profoundly disruptive process of Native-Euro-American colonization.

### CONCLUSION

We've shown that the Kettle Falls assemblage of fish butchering tools were organized under specific requirements that can be inferred directly from ethnographic reports. These requirements allow us to anticipate patterns in form and distribution of fish butchering tools in large-scale settings like anadromous migration runs in the larger rivers. However, small-scale, intermittent fishing and multi-functionality of lithic tools typical throughout most of the Intermountain West makes overprinting and obscuring fish-related residues and use-wear likely and renders diagnosis of fishing ambiguous and minimal at best.

The cultural evolutionary process of intensification from Euro-American contact or any other systemwide trigger can't be addressed using fishing lithics alone. Rather, the question requires a wide-spectrum analysis of subsistence tactics including procurement, processing, and storage of terrestrial animals, aquatic animals, and terrestrial plants. Ethnographic knowledge about subsistence is the most obvious frame of reference for developing testable hypotheses for expectations in the archaeological record. Increasing our knowledge about these processes in the Intermountain West has ramifications for of the intersection between unique historic events and predictable processes in other colonized parts of the world.

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### CHAPTER 3

## A SIMPLE METHOD FOR IDENTIFYING HOUSEHOLDS USING LITHIC ASSEMBLAGES: A CASE STUDY FROM A FOLSOM CAMPSITE IN MIDDLE PARK, COLORADO

BY NICOLE M. WAGUESPACK AND TODD A. SUROVELL

#### ABSTRACT

*All people, past and present, construct shelter, yet for prehistoric hunter-gatherers, the archaeological record yields little direct evidence of the presence of household architecture. The residences of nomadic peoples are typically built in ways and with materials that leave few if any durable traces, but the physical delineation of interior and exterior space should impact activity patterns in ways that are likely to result in visible material signatures. In this paper, we develop a simple method for the identification of household areas using spatial properties of lithic assemblages. We simulated artifact accumulation within a household containing a central hearth feature, accounting for both primary and secondary discard activities. We then compare simulated patterns to spatial patterns at Barger Gulch Locality B, a Folsom campsite in Middle Park, Colorado. We argue that by examining the spatial distribution of only two variables, chipped stone artifact density and the percentage of burned artifacts, hearths, households, and exterior yard spaces can be distinguished.*

In much of the archaeological record direct evidence of residential dwellings are absent. Countless sites, a percentage of which must certainly represent residential occupations, consist only of scattered stones and bones. Such is the record of millions of hunter-gatherer sites from across the globe and typical of the Early Paleoindian record of the Americas. The often complete lack of wall

remnants, prepared floors, post molds, and/or other distinct architectural features presents an undeniable example of when an absence of evidence does not provide evidence of absence. In the case of Paleoindians, we have little direct or indirect evidence of household structures (Frison 1982; Frison and Bradley 1980; Irwin-Williams et al. 1973; Jodry 1999; Robinson et al. 2009; Stiger 2006; Surovell and Waguespack 2007), yet it seems wholly illogical to presume that the vast majority of Paleoindian peoples did not utilize residential dwellings.

Based solely on preserved architectural elements, we are left to contemplate a Pleistocene landscape occupied by hunter-gatherers that were, quite literally, homeless. Considering that all people construct shelters, no matter how impermanent or hastily constructed they may be, indicates that an absence of architectural evidence should by no means imply an absence of architectural behaviors. The construction of shelters to insulate us from environmental forces is one of the fundamental components of the human cultural adaptation. As many others have done, we are left only to explore the material consequences of built structures in the absence of the structures themselves. Fortunately, previous archaeological (e.g.; Stapert 1989, 1990, 1991/92, 2003; Stapert and Johansen 1995/1996; Stapert and Terberger 1989), ethnoarchaeological (e.g., Bartram et al. 1991; Fisher and Strickland 1991; Graham 1998; Kamp 2000; O'Connell et al. 1991) and ethnographic (e.g., Binford 1990; Boismier 1991; Hendon 1996) work has identified some basic attributes of how residential dwellings impact the distribution and deposition of material culture.

In residential sites, household dwellings (i.e. houses) serve one very simple purpose; they create a contained space in which some behaviors, individuals, and conditions are meant to be kept in and others out. Houses can delineate private from public, friend from stranger, and warmth from cold by fundamentally demarcating space into the categories of "inside" and "outside." This straightforward division has broad implications for how the archaeological record forms in interior versus exterior spaces. We began to explore this issue after recognizing a consistent pattern in the spatial

distribution of burned artifacts at Barger Gulch, Locality B (BGB), an early Paleoindian site in Middle Park Colorado.

At BGB, spatial regularities in the density of burned and unburned artifacts surrounding hearths suggested that three of four hearth features were used in a consistent fashion. While it seems reasonable to expect that hearths would exhibit distinct artifact burning signatures, it is less intuitive to expect patterned differences in artifact frequencies and burning percentages well beyond hearth margins. Similarities in artifact distributions encircling multiple hearth features within a single site exhibiting spatial breaks at distances suggestive of behavioral margins (i.e. large enough to fall within reasonable dimensions of a forager house), led us to explore how structures would impact the formation of artifact assemblages. In this paper, we develop and apply a simple method for the identification of hearth and household features using the spatial distribution of two simple lithic variables that are frequently collected, artifact density and the percentage of burned artifacts.

#### **BARGER GULCH, LOCALITY B**

Composed of eleven known Paleoindian localities, the Barger Gulch (5GA195) site was an area of recurring human occupation during the late Pleistocene and early Holocene. Locality B is a large residential site of Folsom age that occurs on a high ridge east of Barger Gulch, approximately 40 m above the current stream level. Barger Gulch is a small southern perennial tributary of the Colorado River in the Middle Park, Colorado, a basin in the Southern Rocky Mountains that forms the headwaters of the Colorado River. The site occurs at 2,322 m ASL near the valley bottom in the western side of Middle Park, approximately 8 km east of the town of Kremmling, Colorado.

Over nine field seasons from 1997 through 2007, we excavated a total 164 m<sup>2</sup> of deposits. Excavations proceeded in 1x1 m units, which after the testing phase, were subdivided into 50 x 50 cm quads. Most excavation occurred in large contiguous excavation blocks (Figure 3.1), and this paper concerns three of those. The Main Block includes 68 m<sup>2</sup> of excavated area, and generated

more than 26,000 artifacts. Eight meters to the east southeast is the East Block, characterized by extremely high artifact density. From a contiguous area of 41 m<sup>2</sup>, the East Block produced more than 36,000 pieces of chipped stone. Sitting 20 m to the south of the East and Main Blocks, the South Block was an area of low artifact density for BGB with only 3,270 pieces recovered, although our work there included only 26 m<sup>2</sup> of excavation. Other areas of the site bring the total excavated assemblage to over 75,000 pieces.

In prior work, we and others have described various aspects of the lithic assemblage (Daniele 2003; Kornfeld and Frison 2000; Kornfeld et al. 2001; Laughlin 2005; Surovell 2009; Surovell et al. 2000, 2001a, b, 2003; Waguespack et al. 2002, 2006; Zink 2007) and site geology and formation (Brantingham et al. 2007; Mayer et al. 2005, 2007; Surovell et al. 2005). In brief, the site is shallowly buried, and the Folsom occupation surface in our excavation areas was encountered on average 29 cm beneath the modern ground surface (ranging from 0 to 63 cm in depth). Not surprisingly, BGB shows evidence of disturbance, particularly in the form of upward displacement of artifacts (Brantingham et al. 2007; Laughlin 2005). Nonetheless, the site appears to retain a high degree of spatial integrity (Laughlin 2005; Surovell and Waguespack 2007).

In a prior paper (Surovell and Waguespack 2007), we examined spatial patterning in the Main Block, which at the time written, had an area 40% smaller than its current and final form. In that work we hypothesized that the hearth feature in the center of this excavation area occurred within a structure, and we are increasingly confident of that assessment today. Our arguments were based primarily on the application of ring and sector analysis (Stapert 1989), which examines artifact counts in concentric rings radiating out from a hearth's center. Since that paper was written, we have identified three additional hearth features at the site (Figure 3.1), although their identification was by no means straightforward. We begin within a brief description of how hearths were identified at BGB and then move on to spatial patterning associated with those hearths.

LITHICS IN THE WEST

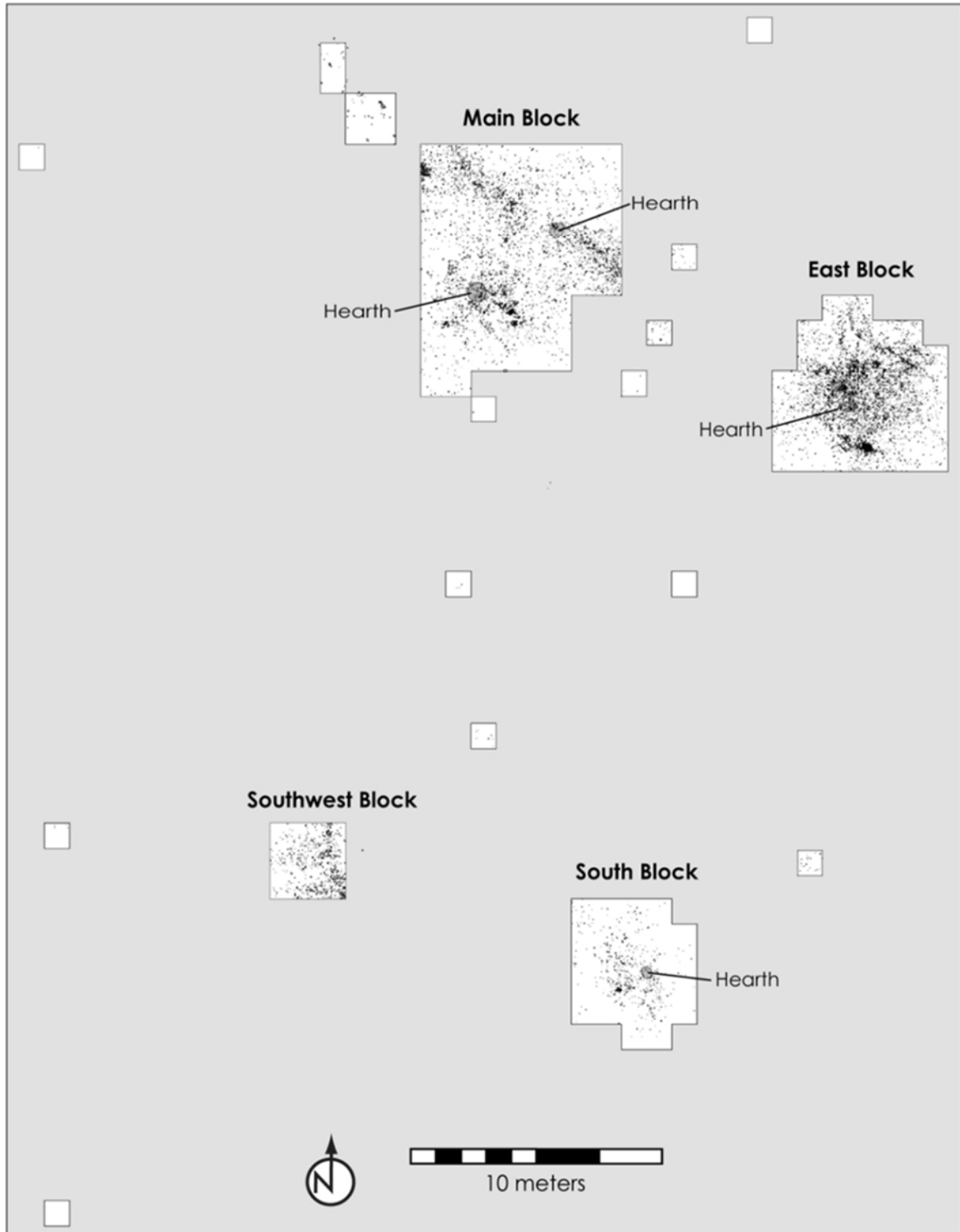


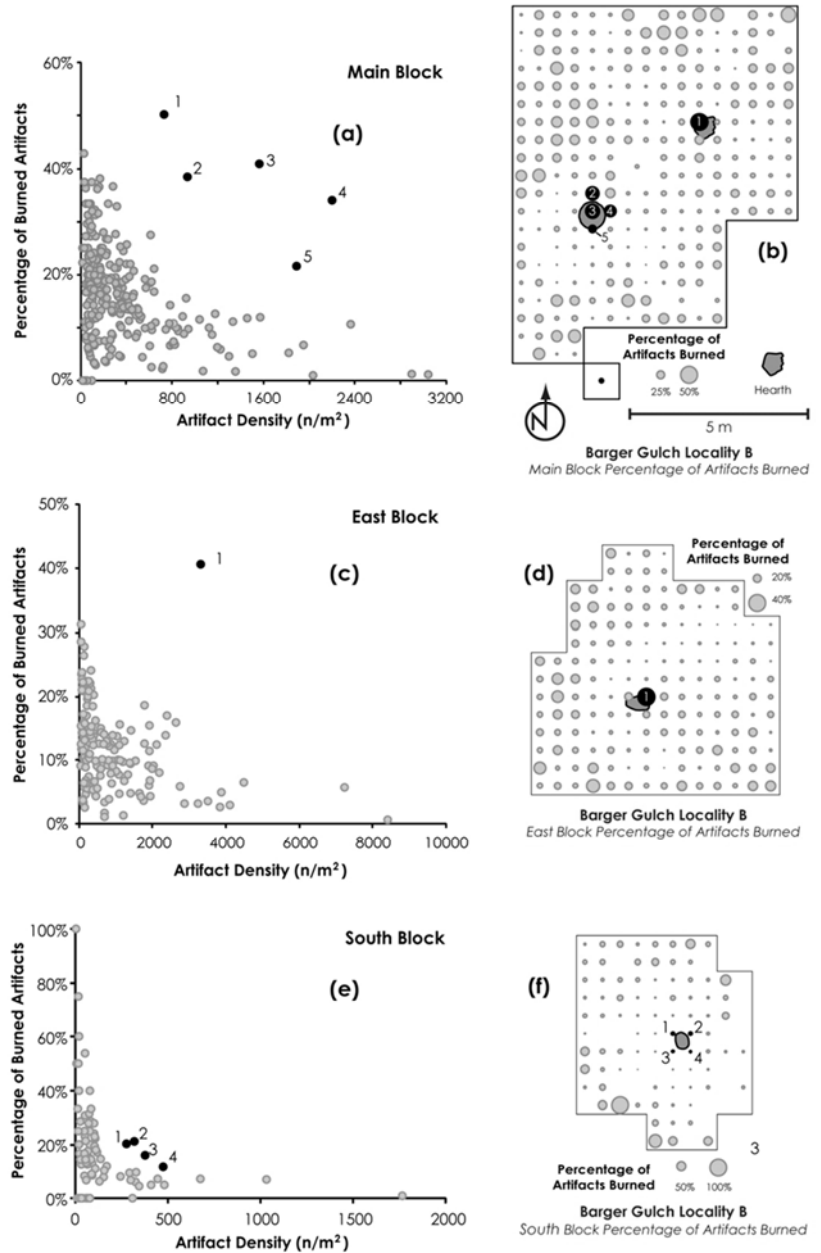
Figure 3.1. Plan map of excavations at Barger Gulch Locality B. Small black dots represent mapped chipped stone artifacts, and gray polygons indicate hearths.

**DETECTING HEARTHTHS**

While limited evidence of hearth features were detected during excavation of BGB, three of the four hearths identified could easily be referred to as “invisible hearths” as described by Sergant et al. (2006). The first hearth discovered, the central hearth of the Main Block (Figure 3.1), was found not in the field but through analyses of the spatial distribution of burned materials. The northeastern hearth in the Main Block, by contrast, looked as one would expect during excavation. It appeared as a charcoal stained and oxidized pit feature containing many burned artifacts. The hearths in the East and South Blocks, however, were of the “invisible” variety. Those two features exhibited extremely weak sedimentary expression during excavation and were very difficult to physically delineate. Field identification of hearth features, however, were later confirmed by a simple analytical technique using the observed relationship between artifact density and the percentage of burned artifacts by excavation unit.

Manifested as a wedge-shaped distribution (Figure 3.2), there is a general inverse relationship between artifact density and the percentage of burned artifacts by excavation unit in each BGB excavation area. In general, areas with low artifact densities exhibit a wide array of percentages of burned

artifacts. As artifact densities increase however, the percentage of burned artifacts shows a corresponding decline. Outliers to this trend are exclusively associated with hearths (Figure 3.2), clearly demonstrating the inordinately high percentage of burned items located within hearths regardless of the density of artifacts they contain. It is easy to conceive of areas of the site with



**Figure 3.2. The relationship between artifact density and the percentage of burned artifacts for excavation quads (50 x 50 cm) or units (1 x 1 m) for the Main (a), East (c), and South (e) Blocks. Black dots indicate excavation quads associated with hearth features, as shown in the corresponding maps of percentage of burned artifacts to the right (b, d, and f).**

## LITHICS IN THE WEST

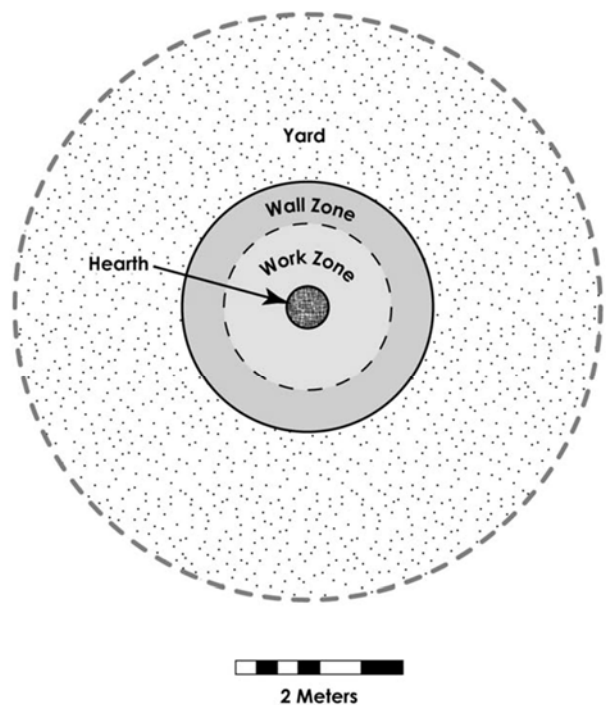
dense unburned artifact accumulations (up to thousands of pieces of chipped stone per m<sup>2</sup> in some areas) as representing primary work areas where flintknapping debris and discarded tools were deposited in high numbers. But why do some areas of the site contain low densities of artifacts but a high percentage of which are burned?

Our hypothesis is that portions of the site exhibiting low artifact densities and high relative burning frequencies represent the dispersal of materials through cleaning and dumping of hearth contents away from hearth associated work areas into secondary disposal areas. If so, the distinctive wedge shaped distribution between artifact density and burning percentage would be the result of two behavioral processes: the accumulation of largely unburned materials in work areas situated near hearths (which exhibit unusually high burning frequencies regardless of artifact density) and the cleaning and eventual discard of hearth/work related materials into refuse areas. Such a distinction implies that hearths create work spaces where artifact densities and burning frequency can vary dramatically and in a manner wholly distinct from non-hearth associated spaces where burned materials are only secondarily deposited. In the case of BGB, we argue that this pattern of artifact density and burning is the result of differential interior and exterior use of space by site occupants.

### SIMULATING THE FORMATION OF HOUSEHOLD LITHIC ASSEMBLAGES

To examine the factors underlying the formation of the wedged shaped relationship between artifact density and the relative frequency of burned artifacts, we created a simple simulation of artifact discard as it might occur within and outside of a household. Discard is driven by probability distributions that were created, admittedly, largely intuitively but reflect realistic household parameters and BGB artifact densities. We assume a circular 3 m diameter structure with a hearth in its center based on common hunter-gatherer residential structural dimensions (Binford 1990; Gamble & Boismier 1991; Kroll & Price 1991). The modeled household is

roughly divided into three zones radiating outward from its midpoint (Figure 3.3). The hearth occupies a small circular area 0.5 m in diameter in the center of the structure. The area from 0.25 m to 1 m from hearth center, we call the “work zone,” the area where common activities such as flintknapping are most likely to take place. The remaining area, a 0.5 m wide ring against the wall of the structure, we call the “wall zone,” an area where little primary discard takes place, but artifact accumulation occurs due to the secondary displacement of items into low utility spaces against walls and storage of bulky items. Outside of the structure is a ring 2 m in diameter that we call the “yard zone,” an area in which materials removed from the hearth and interior space are discarded.



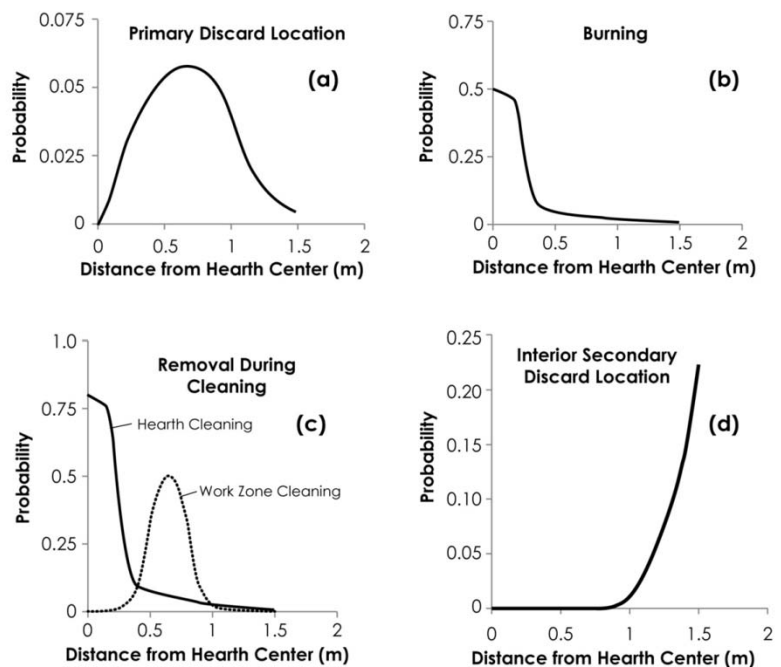
**Figure 3.3. The spatial layout of the hearth, household, and yard area used in the simulation.**



## LITHICS IN THE WEST

The simulation includes three subroutines that run sequentially. First, artifacts are discarded during flintknapping. While numerous refuse producing activities are likely to occur around hearth features, we focus on the production and discard of lithic debris simply because of the durability and ubiquity of chipped stone artifacts in the prehistoric record. The exact number of artifacts can be varied, however we simulated arbitrary production scenarios of 2,000 and 10,000 pieces. The location of a particular artifact is determined by distance and angle from the hearth center; for simplicity in the simulation, angle was chosen randomly from a uniform distribution (0 to 360°). Distance was chosen from a probability distribution (Figure 3.4a) where any value between 0 and 1.5 m is possible, but discard is mostly likely to occur within the work zone between 0.25 and 1 m from hearth center. After an artifact's location was determined, it was assigned a value of "burned" or "not burned" on the basis of a probability distribution that declines from hearth center (Figure 3.4b). In our modeled assemblages, all artifacts have a chance of being burned or not, but the likelihood of an artifact exhibiting burning declines sharply beyond the edge of the hearth. Occasionally, artifacts well outside of the hearth zone are burned, an assumption we feel is justified because hearths can slowly migrate over the course of an occupation and because burned lithic artifacts can be ejected from hearth features when they are thermally fractured. Using this particular distribution, roughly 75% of burned artifacts occur within 0.5 m of the center of the hearth. Likewise some artifacts within the hearth feature itself are not burned. We are also comfortable with this assumption since at Barger Gulch, we identified artifacts as being burned only if they exhibited clear thermal fractures.

Once primary discard is completed, the artifact assemblage is subjected to two cleaning routines. First, some artifacts within the work zone are removed to the



**Figure 3.4. Probability distributions governing the artifact discard, burning, and cleaning, as a function of distance from hearth center, used in the simulation. a. The probability of primary discard location. b. The probability of an artifact exhibiting burning. c. The probabilities of an artifact being displaced during cleaning of the hearth and work zone. d. The probability of discard location within the wall zone following cleaning of the hearth.**

wall zone. This initial movement of artifacts could occur through intentional removal of debris out of the hearth associated work area or through the inadvertent migration of artifacts due to human movement (e.g., scuffage [Schiffer 1987:127]). The probability that an artifact is displaced during this process is roughly normally distributed and spans the entirety of the work zone (Figure 3.4c). Artifacts cleaned or displaced in this manner are removed to the wall zone, their exact location again being determined by a probability distribution, which declines from a maximum value at the wall to a value of zero near the edge of the wall zone (Figure 3.4d).

In the second cleaning routine, the hearth is cleaned, and its contents are removed to the exterior of the

structure, a behavior that has been repeatedly observed in ethnographic settings (e.g. Bartram et al. 1991:97; Fisher and Strickland 1991: 223; Hitchcock 1987:401; Hodder 1982; Mallol et al. 2007; O’Connell 1987; O’Connell et al. 1991:67). Again, a probability distribution (Figure 3.3c) governs the likelihood that any given artifact is removed to the exterior of the household during hearth cleaning. Artifacts within 0.5 m of the hearth are most likely to be removed during cleaning, but beyond that distance probability declines sharply. Artifacts removed during hearth cleaning are relocated to a randomly chosen location on the outside of the structure within 2 m of the wall. After each procedure, the density and percentage of burned artifacts are tallied in each 50x50 cm grid square containing at least one artifact.

In actuality, the formation of household assemblages is unlikely to occur in three serial steps as we have simulated the process. Instead, cleaning most likely occurred episodically as varying rates of materials accumulate in the hearth and associated work area. However, changing the simulation to more realistically reflect the actual sequence of flintknapping and cleaning events would not change the results. As long as our basic assumptions hold true— that proximity to the hearth determines the likelihood of an artifact being burned in interior spaces, that interior hearths and adjacent work areas are cleaned, and that hearth debris is deposited in “outside” spaces, the general spatial distribution of burned and unburned artifacts remains consistent.

#### **SIMULATED ARTIFACT DENSITY AND BURNING**

In Figure 3.5, we present maps of burned and unburned artifacts along with scatter plots relating artifact density to the relative frequency of burned artifacts for each step in the progression of a simulation run involving the discard of 2,000 artifacts. Prior to any secondary displacement of items, artifact densities are highest in the hearth area at the center of the household and steadily decline in density toward the wall (Figure 3.5b). Despite a relatively low probability of discard within the hearth itself, the hearth zone is characterized by the highest artifact density as it has the smallest

area. When viewed in scatter plot form, the hearth appears as an outlier both in terms of density and percentage of burned artifacts with high values for both variables (Figure 3.5a). Among the remaining areas of the structure, initially there is no relationship between density and relative burning frequency but the relationship begins to emerge once cleaning begins.

After the work zone cleaning subroutine is run, artifacts become more dispersed within the household as artifacts occur in greater frequencies in the wall zone and adjacent to the wall itself (Figure 3.5d). The wedge-shaped distribution begins to emerge, but the hearth area still occurs as an outlier with respect to density since no artifacts are displaced from the hearth itself during the cleaning of the work zone (Figure 3.5c). Once artifacts are removed from the hearth to the exterior of the structure, a low density halo of artifacts spans the entirety of the yard area (Figure 3.5f) and the inverse relationship between artifact density and burning percentage becomes fully formed (Figure 3.5e). Due to removal of artifacts from the hearth feature, its density declines to intermediate values, although the percentage of artifacts exhibiting burning in the hearth does not change.

In the simulation the inverse wedge-shaped relationship between artifact count and relative burning frequency emerges, therefore, as a byproduct of cleaning behaviors, which act as a sampling phenomenon. When artifacts are removed from the hearth and work zone, samples of artifacts are displaced from areas of high density and are dispersed to zones of low density. Although the sample drawn from each area should be representative of the area as a whole (e.g., if 50% of artifacts from a hearth exhibit thermal damage, on average 50% of those in the sample should as well), because artifacts that are removed from these areas are dispersed during secondary discard, the result is that they occur in excavation areas characterized by relatively low density and a wide of range burning percentages.

LITHICS IN THE WEST

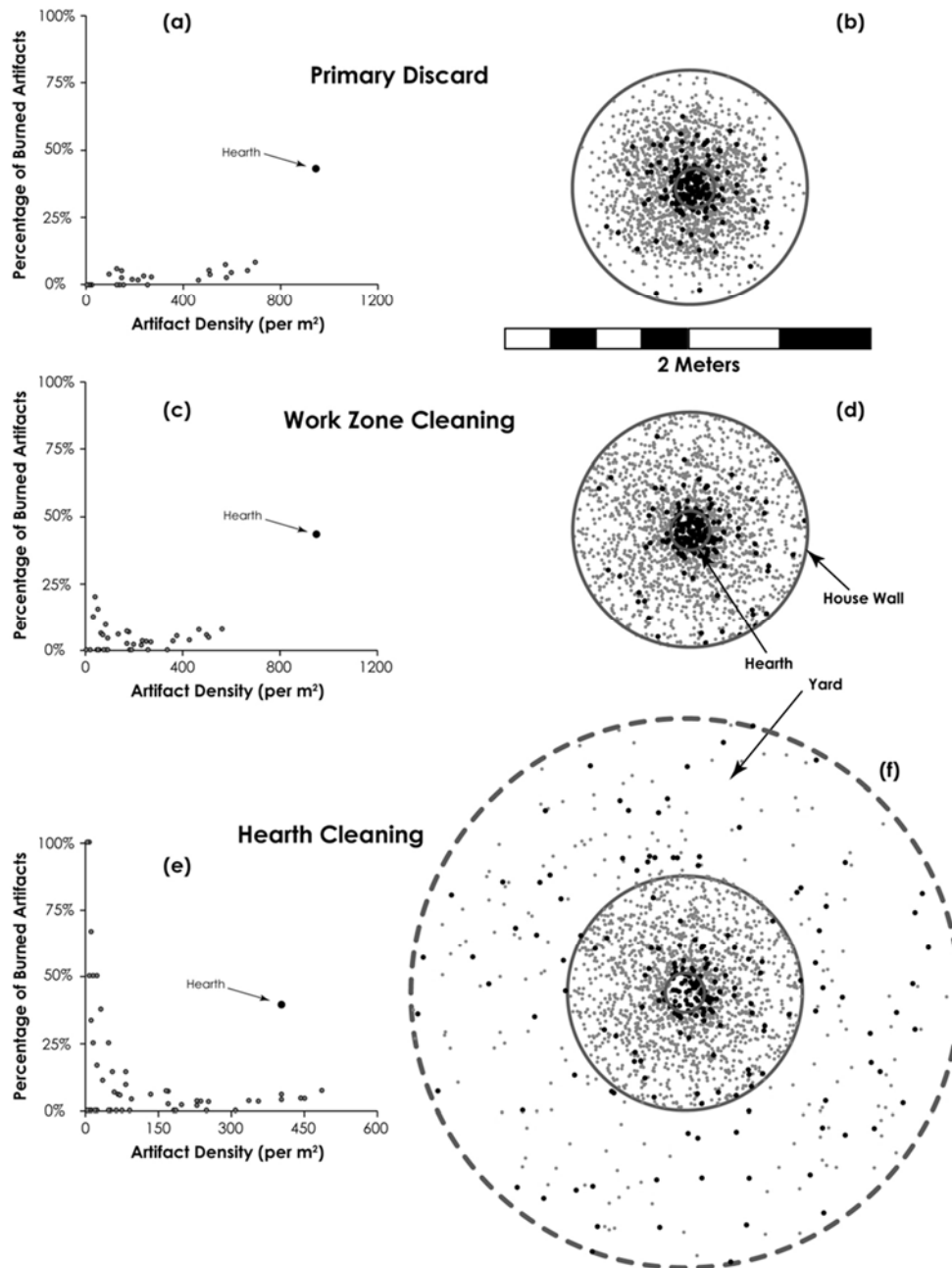


Figure 3.5. The relationship between artifact density and the percentage of burned artifacts for a simulation run using 2,000 artifacts after the primary discard (a), work zone cleaning (c), and hearth cleaning (e) subroutines have run.. Black dots in scatter plots indicate the 50 x 50 cm grid unit associated with the hearth. The associated maps to the right (b, d, & f) show the location of burned (black dots) and unburned (gray dots) artifacts following each subroutine.

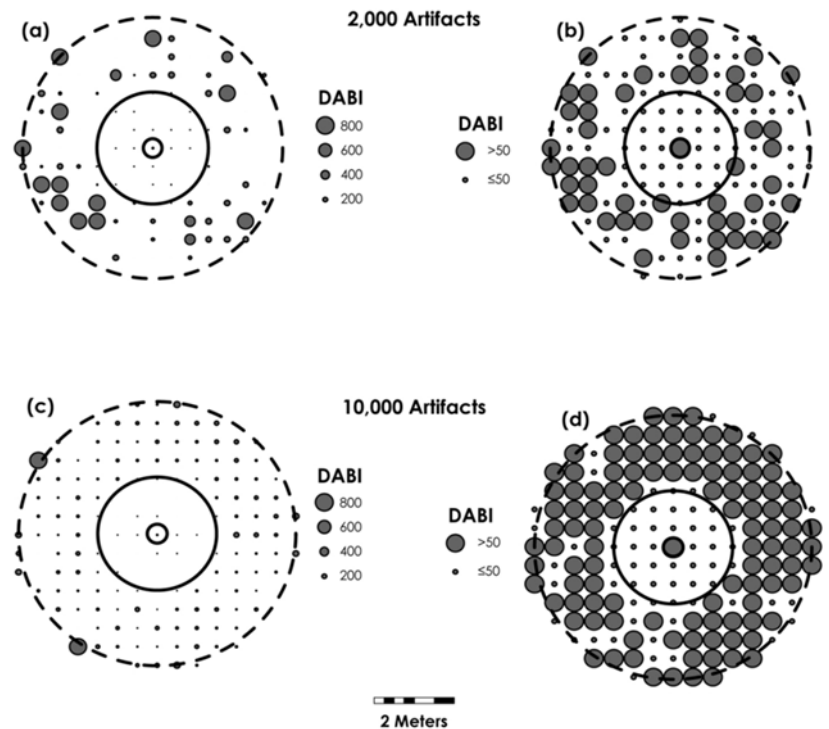
Under the simulated conditions, it is expected that work and secondary discard areas within the house should be characterized by intermediate to high artifact densities with low percentages of burned artifacts. The hearth area should be characterized by intermediate densities and high percentages of burning, and the exterior yard area should have low artifact densities and extremely variable relative frequencies of burned items.

### SIMULATED AND ACTUAL SPATIAL PATTERNING

Having demonstrated that hearth-centered discard within interior spaces coupled with cleaning behaviors can produce inverse relationships between artifact density and the percentage of burned artifacts similar to those observed at Barger Gulch, we now turn to spatial comparisons between simulated and actual artifact distributions. To do so, we combine the power of both variables into a single variable, which we call the *Density and Burning Index* (DABI):

$$DABI = \frac{b \cdot 10^3}{\ln(d)}$$

where *b* is the relative frequency of burned artifacts and  $\ln(d)$  is the natural logarithm of artifact density (per m<sup>2</sup>). Artifact density is log-transformed to normalize its distribution. The ratio of these two terms is multiplied by 1,000 (essentially converting it to a permil value) to produce more intuitive numbers as the ratio without the multiplier typically results in decimal values. Large values of the DABI occur in areas that exhibit relatively low densities and high percentages of burned artifacts, and small values occur where artifact densities are high but relatively few of those pieces are burned. In other words, the index should provide a way of characterizing space as a continuum from areas dominated by cleaning and dumping of hearth contents (high values) to areas dominated by primary or secondary unburned



**Figure 3.6.** The spatial distribution of DABI values in simulation runs with 2,000 (a & b) and 10,000 (c & d) artifacts. The figures to the left show raw DABI values, and those on the right show DABI relative to a threshold value of 50.

flintknapping debris (low values), except that low values can also occur in areas characterized by low artifact densities and little burning.

In Figure 3.6, we present mapped DABI values for simulation runs involving 2,000 and 10,000 artifacts. Both show similar patterning, although it is more clearly expressed with larger numbers of artifacts. In both versions of the simulation, DABI values exhibit a wide range from 0 to over 700 (Figure 3.6a and 3.6c), and when raw values are mapped the spatial patterning that results is not particularly clear. When values are mapped relative to a threshold value however, in this case DABI values of greater or less than 50, the distinction between work and refuse areas becomes apparent (Figure 3.6b and 3.6d). Except for the hearth itself, all areas within the household are characterized by low DABI values. In

the yard area, a mixture of high and low DABI values occurs depending upon the percentage of burned artifacts present. The position of the wall is roughly demarcated by a transition from an area of continuously low DABI values surrounding the hearth to an area of mostly high but mixed DABI values outside.

The patterning in DABI associated with all four hearths at Barger Gulch is very similar and appears to delineate work areas from refuse zones (Figure 3.7). Associated with the central hearth in the Main Block is an oval work area of low DABI roughly 3.5 x 4 m in dimension. The hearth itself, as in our simulations, is characterized by a high DABI value as are a handful of excavation quads to its north. Work zones associated with the northeastern hearth in the Main Block are also evident but take on a long linear shape stretching from southeast to northwest along a zone approximately 1.5 m in width and 6 m in length. We suggest that the differences in shape and size result from the central hearth having occurred within a structure (Surovell and Waguespack 2007), while the northeastern hearth was outdoors. The narrow, linear, and directional pattern of discard associated with the northeastern hearth is likely a byproduct of smoke avoidance and bidirectional prevailing winds common in mountain valleys. Within the confines of a structure, the effects of wind on the positioning of flintknapping are mitigated resulting in a work zone that completely encircles the hearth. The remaining areas of the Main Block appear clearly as refuse zones dominated by high DABI values, although as in the simulation, low values occur sporadically as well.

Patterning associated with hearths in the East and South Blocks is remarkably similar to that of the central hearth of the Main Block (Figure 3.7). A large work zone surrounding the East Block hearth is evidenced by a contiguous zone of low DABI values 3.5 m in width and 5 m in length. The hearth and a few quads to its southeast and adjacent peripheral areas are characterized by high DABI values. The same pattern is present in the South Block, but it occurs at a smaller scale where the work zone is only 2.5 x 3 m in size. We hypothesize that like the Main Block central hearth, the East and South Block features also occurred within structures.

## CONCLUSIONS

In our simulation and interpretation of DABI values, we have approached the spatial distribution of chipped stone as a reflection of interior and exterior behavioral patterns. Analyses of lithic materials segregated by raw materials, tool and debitage types, manufacturing strategy, morphology, and design attributes have proven invaluable to Paleoindian studies, but based on the data presented here, we have approached lithic artifacts more simply as objects distributed between interior and exterior spaces. Approaching chipped stone artifacts so mundanely and with complete disregard for their technological and typological attributes is admittedly a bit unorthodox. But our argument for the identification of interior and exterior spaces relies on assumptions that concern only the accumulation of material within hearths, houses, and exterior spaces. What those materials *are* in that light does not impact the delineating function of structures. As discussed, artifact density and burning frequencies may not provide suitable evidence of built structures in all archaeological contexts. Likewise, our assumptions regarding artifact accumulation and cleaning behaviors cannot be supported as universally realistic. However, the ability to potentially analyze and compare lithic assemblages both within and between households and interior/exterior spaces, provides a unique scale of insight into the hunter-gatherer archaeological record.

In environments where conditions favor the majority of debris producing tasks to be performed in indoor spaces near hearth features and site occupation span is long enough to subsume multiple cleaning episodes, clear patterns in artifact density and burning percentages seem reasonable to expect. Ethnoarchaeological studies have demonstrated that preferred activity locations, hearth cleaning behaviors and discard locations (e.g., Bartram Kroll and Bunn 1991:97; Fisher and Strickland 1991: 223; Hitchcock 1987:401; Hodder 1982; O'Connell 1987; O'Connell et al. 1991:67) are coarsely consistent among nomadic peoples (albeit derived from a small sample) but also subject to cultural and situational variables.

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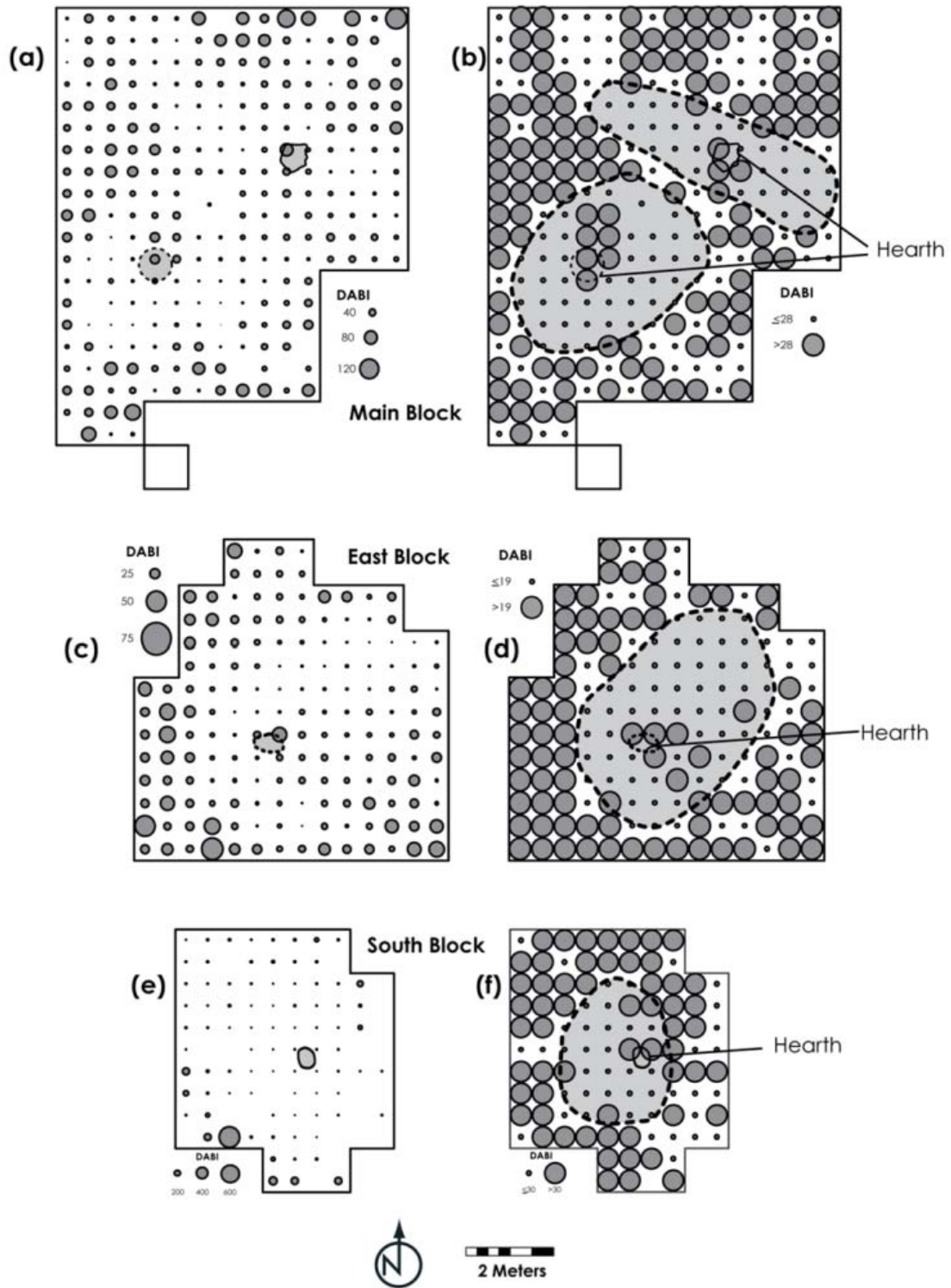


Figure 3.7. The spatial distribution of DABI in the Main (a & b), East (c & d), and South (e & f) Blocks. The figures to the left show raw DABI values, and those on the right show DABI relative to threshold values. Gray polygons on the maps to the right indicate the locations of hypothesized work zones.

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One can easily imagine situations where household structures lack interior hearths and where primary discard occurs preferentially or exclusively in exterior spaces. The consistent wedge-shaped relationship between these two critical variables across the site remains compelling however, and this pattern even if explained some other way, implies the repetitive and patterned use of areas associated with hearth features. While a multitude of processes could be responsible for this pattern at BGB, in a residential site located in the Rocky Mountains occupied during the Younger Dryas, houses would seem to present a practical necessity and a reasonable interpretation given the evidence.

With caveats in mind, we suspect that DABI values are likely to vary in a manner consistent with BGB at other residential sites in the archaeological record well beyond Middle Park and the terminal Pleistocene. Beyond the assumptions inherent to our simulation, our analyses are also contingent upon the archaeological data available. At BGB, we are fortunate that the horizontal scale and precise provenience control of excavations and the quantity of artifacts recovered provide a suitable sample for detecting spatial use. Sites with extremely low artifact densities (not uncommon in the Paleoindian record) and/or with small or dispersed excavation areas are unlikely to exhibit sufficient variation in DABI values regardless of whether hearth and/or houses were present. Lithic raw material at BGB, primarily Troublesome Formation chert, shows clear signs of burning in the form of crazing, potlidding, and highly angular fractures. In assemblages composed of raw materials where the designation of burned versus unburned is difficult to determine it may be impossible to reliably derive DABI values. Yet we have no reason to consider the BGB site wholly unique, as countless other hunter-gatherer sites are likely to represent residential occupations with interior hearths. In such cases, the distributional properties of burned and unburned artifacts may provide a simple and widely available means of distinguishing interior from exterior spaces and their associated behaviors.

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## CHAPTER 4

# MINIMUM ANALYTICAL FLAKED STONE NODULES AND CLOVIS TECHNOLOGICAL ORGANIZATION AT THE SHEAMAN SITE, WYOMING

BY MARY M. PRASCIUNAS

### ABSTRACT

*Minimum Analytical Nodule Analysis (MANA) can provide a powerful tool for examining prehistoric technological organization. The debitage-rich flaked stone assemblage from the Sheaman site in eastern Wyoming provides a rare opportunity to examine Clovis technological organization through MANA. Traditional interpretations of early Paleoindian technological organization view Paleoindian technology as designed to fulfill the requirements of highly mobile populations by conserving raw material and reducing the weight of the transported toolkit. Recent critiques, however, suggest that Paleoindian technology is much more variable than traditionally assumed. This paper describes the results of a MANA designed to test the validity of traditional interpretations of early Paleoindian technological organization by examining the Sheaman site flaked stone assemblage. Results of the analysis support a traditional view of early Paleoindian technological organization, and highlight several unique aspects of Clovis technological planning strategies.*

### INTRODUCTION

Traditional interpretations of Paleoindian technological organization view Paleoindian technology as designed to fulfill the requirements of highly mobile populations by reducing the weight of the transported toolkit and conserving raw material in the face of

uncertain access to high quality source areas.

Paleoindians achieved these design considerations by using high quality raw material often obtained from distant sources, extending the use lives of tools through reworking and resharpening, and increasing the portability of the toolkit by manufacturing tools for multiple uses. The need for multifunctional, long use-life tools also resulted in reliance on bifacial core technology, which is often considered another defining characteristic of the period (e.g., Amick 1999:2; Bement 1999:149; Boldurian 1991; Collins 1999:23; Custer 1984:51; Hofman 1992:199; Kelly and Todd 1988:237; Wilke et al. 1991).

Bamforth (2002) discusses the development of this traditional view of Paleoindian technological organization, rooted in the early work of archaeologists such as MacDonald (1968) and Witthoft (1952) in northeastern North America, and laid out explicitly by Kelly and Todd (1988). The theoretical model put forth by Kelly and Todd (1988) provided a comprehensive framework within which to interpret early Paleoindian behavioral and technological strategies across North America. Briefly, the model explains the extreme mobility of Clovis populations by an Arctic adaptation to large game hunting in an unpopulated environment undergoing rapid environmental change. Environmental change, coupled with resource depletion due to hunting of naïve fauna, forced Clovis foragers to move rapidly into new territories. This same hunting adaptation allowed Clovis foragers to cross ecological boundaries without having to acquire new subsistence-related knowledge. An adaptation that both permitted but also required territorial mobility could have pushed colonists southward with or without demographic pressure (Surovell 2000).

The type of Paleoindian land use this model describes has come to be called a “high technology forager” system (Kelly and Todd 1988:239), taking into account its unique combination of both collector and forager characteristics (*sensu* Binford 1980). The “high-tech forager” model came with a number of specific and archaeologically recognizable predictions regarding early Paleoindian technology and behavior. These predictions include continent-wide behavioral consistency, short-term and

redundant landscape use, a technology that fulfills the requirements of a highly mobile population, and lack of long-term storage strategies. In terms of lithic technology, the high-tech forager model predicts the presence of highly curated artifacts manufactured from exotic raw materials from distant sources, a heavy reliance on bifacial technology, tools that show evidence of design for multiple uses (e.g., reuse, reworking, recycling), and conservation of raw material and extension of tool life through extensive resharpening (Kelly and Todd 1988:237-238).

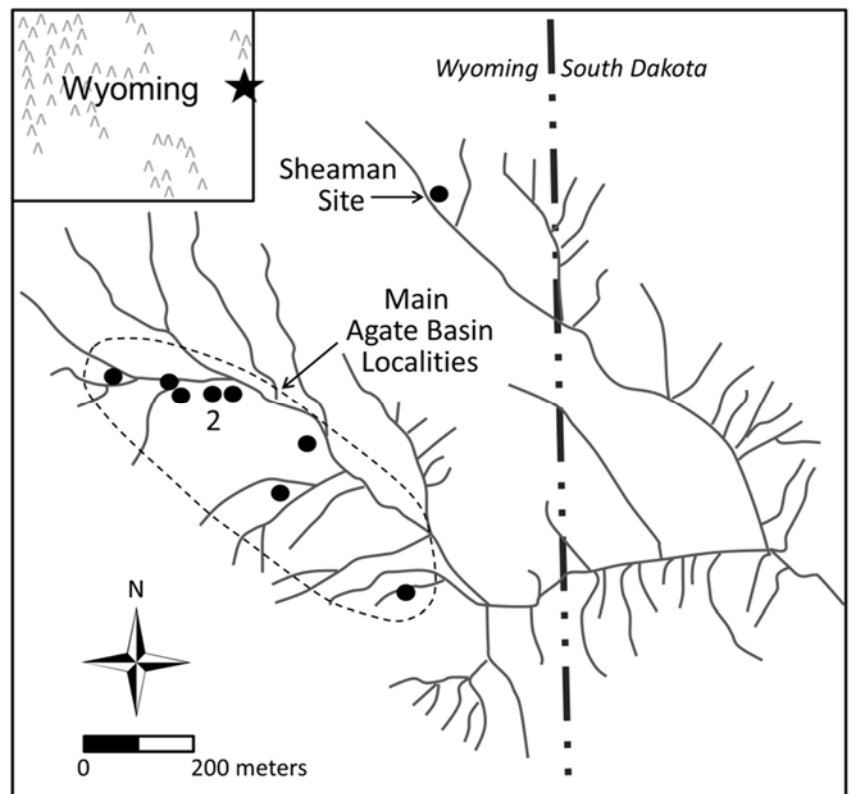
Although the high-tech forager model was originally used to explain early Paleoindian, and specifically Clovis, technological and behavioral strategies, it is often extended to encompass the entire Paleoindian period (Bamforth 2002). Critics like Bamforth (2002, 2003; Bamforth and Becker 2000) have countered that few Paleoindian sites actually meet the assemblage level expectations of the high-tech forager hypothesis. For instance, Bamforth's (2002) review of published data and analysis of the Allen site lithic assemblage show that the technological predictions of the high-tech forager model are not realized at many post-Clovis Paleoindian sites. LeTourneau (2000) and Lothrop (1989) have similarly suggested that bifacial technology may not have been as central to Paleoindian lifeways as traditionally assumed.

However, as the earliest widespread occupants of North America, Clovis technological and behavioral strategies may very well be unique compared to later Paleoindian manifestations. Following Bamforth's (2002) call for more systematic assemblage-level tests of the high-tech forager hypothesis, this paper examines the lithic assemblage from the Sheaman Clovis site in eastern Wyoming. The technique of Minimum Analytical Nodule Analysis (Larson and Kornfeld 1997) is used to determine whether the assemblage fulfills the predictions of the high-tech forager

hypothesis, and to assess the potential uniqueness of Clovis technological planning strategies. A brief description of the Sheaman site is first provided, followed by a discussion of Minimum Analytical Nodule Analysis (MANA) and its ability to reveal strategies of technological organization.

#### THE SHEAMAN SITE (48NO211)

The Sheaman site (48NO211) is a Clovis period camp site located in eastern-central Wyoming, roughly 650 m northeast of the Agate Basin site (48NO201; Figure 4.1). The Agate Basin site contains Folsom, Agate Basin, and Hell Gap components, but the Sheaman site contains the only known Clovis component within the area (Frison and Stanford 1982). Both sites are located within the Moss Agate Arroyo drainage system. The Sheaman site is



**Figure 4.1 . Sheaman and Agate Basin Site locations in eastern-central Wyoming, within the Moss Agate Arroyo drainage system. Adapted from Frison and Stanford (1982:7).**

located on the east bank of a tributary of Moss Agate Arroyo near a small spring that flows nearly year round (Frison and Stanford 1982).

Much of the Sheaman site was excavated by University of Wyoming crews under the direction of George C. Frison during the late 1970s (Frison and Stanford 1982). These excavations revealed what appeared to be a single component Clovis site, recovering a Clovis projectile point and a cylindrical ivory point or foreshaft with a beveled base. Also discovered during excavation were several thousand pieces of flaked stone debitage; large flake tools; red ochre-stained bison bone fragments associated with an oval-shaped, red ochre-stained area of soil; and several other light concentrations of fragmented bison bone. The presence of a newborn bison mandible suggests a spring or summer occupation. More recent investigations are being conducted by the George C. Frison Institute of Archaeology and Anthropology and the University of Wyoming to determine if additional areas of the site remain (Kornfeld et al. 2001; Meyer et al. 2005).

Much of the debitage recovered from the site epitomizes Clovis lithic technology (Bradley 1982, 2010; Stanford and Bradley 2012:49-50). For instance, large percussion biface thinning flakes are common, as are *outré passé* terminations. Refitting studies have enabled the reconstruction of biface production sequences which conform to what is known about the Clovis biface reduction/production process (e.g., Bradley 1982, 2010; Bradley et al. 2010; Frison and Bradley 1999; Stanford and Bradley 2012).

Obtaining reliable radiocarbon dates for the site has been difficult due to abundant bioturbation. Recent radiocarbon dating and stratigraphic analyses provide evidence for an age of  $11,224 \pm 50$   $^{14}\text{C}$  yr BP for the Clovis occupation, based on charcoal and insoluble organic matter recovered from three bulk sediment fractions (weighted average of AA-40988, 40989, and 40991; Haynes et al. 2004). However, additional radiocarbon analyses conducted by Waters and Stafford (2007) indicate that more recent materials are also present at Sheaman. The foreshaft recovered during the 1970s excavations, initially thought to be ivory but

subsequently identified as cervid bone or antler, yielded an average date of  $10,305 \pm 15$   $^{14}\text{C}$  yr BP (average of UCIAMS-11675, 21992, and 21993; Waters and Stafford [2007]). Although additional investigations will be necessary to clarify issues of stratigraphic association and radiocarbon discrepancies, the lithic assemblage is assumed to be Clovis based on both the Clovis-age radiocarbon date (Haynes et al. 2004), and the technological characteristics of the assemblage (Bradley et al. 2010; Bradley 1982, 2010).

#### **MINIMUM ANALYTICAL NODULE ANALYSIS (MANA) AND TECHNOLOGICAL ORGANIZATION**

Minimum Analytical Nodule Analysis (MANA) involves classifying lithic material into analytical units, or nodules, based on raw material types, followed by sorting within raw material types by color, texture, inclusions, or any other differentiating characteristics (Larson and Kornfeld 1997:7). Ideally, this process results in nodules containing flakes that came off of the same piece of raw material. In other words, nodules should represent individual flintknapping events. Applications of MANA include clarifying site formation issues and assessing vertical and horizontal integrity, as well as informing on prehistoric technological organization (Larson and Kornfeld 1997). In the latter, the concern of this paper, nodule constituents themselves are examined to gain information about the flow of materials through a site (e.g., Hall 2004; Knell 2004; Larson and Kornfeld 1997; Sellet 1999; 2004). By examining the composition of nodules, it is possible to differentiate between individual production, use, and discard events within an assemblage (Larson 1994; Larson 2004). For instance, a complete nodule consisting of production debris along with the manufactured tool would indicate expedient on-site use and discard of the tool. Similarly, a nodule consisting of biface thinning flakes but lacking a biface would indicate that the biface was manufactured at the site, but then removed.

The composition of nodules, however, reflects more than simply what did or did not happen at a site. It also provides a window into the predictability of future

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events and informs on the overall technological organization of a cultural system (Binford 1977, 1979; Carr 1994; Kelly 1988; Nelson 1991; Torrence 1989).

The methods of MANA are similar to those of refitting, and MANA can be considered “virtual refitting” in the sense that physical refits are not necessary to infer that two flakes came from the same piece of raw material (Sellet 1999:42). Refitting can be used to supplement MANA, or MANA can be used to find refits. While it is true that MANA is based on subjective raw material sorting, making its objectivity and reliability low to medium compared to some other analytical methods (Larson 2004:9), refitting within nodules provides a high degree of reliability and objectivity to the nodule classification. The reliability of many of the nodules identified within the Sheaman assemblage has been reinforced with abundant refits. MANA is in some respects more useful than refitting alone because in spite of substantial time and energy invested in refitting studies, it is possible that very few refits will be found (Larson and Kornfeld 1997:15). With refitting, even if the researcher *knows* that two artifacts *must* fit together somehow, or must at least be very close to refitting, no information is gained unless the refit is found. In contrast, MANA in such a case still allows the extraction of technological information where traditional refitting does not.

Drawbacks to MANA (and refitting) are that both are extremely time consuming. Additionally, MANA depends on the ability to visually differentiate between nodules on the basis of physical characteristics, and so may not be possible with homogeneous raw material types (Larson 2004:15). MANA is most useful when a raw material type contains enough internal variability that individual nodules can be readily distinguished on the basis of similar color, texture, inclusions, or other differentiating characteristics. For the Sheaman site, overwhelmingly dominated by Mississippian chert which is extremely variable in terms of color, texture, and inclusions, MANA is indeed not only possible, but preferable to a traditional attribute analysis which would result in many reduction events being lumped together under one raw material category.

A final criticism of MANA (as well as refitting) is the possibility that unexcavated portions of the site contain artifacts that, when and if recovered, would alter the composition and therefore the interpretation of the nodule. In the case of the Sheaman site, Frison and Stanford (1982) concluded that very little if any of the site remained after the 1970s excavations. While excavations by the University of Wyoming in 2004 suggest that some areas may contain additional intact deposits, it is still the case that the vast majority of the site has likely been excavated.

### Nodule Types

Larson and Kornfeld (1997:10) discuss two basic divisions of Minimum Analytical Nodules (or MANs): single item nodules (SIN) and multiple item nodules (MIN). SINS contain either a single flake or a single tool, while MINs contain more than one flake or various combinations of debitage, tools, and cores. Each nodule configuration implies different strategies of technological organization. For instance, if a SIN contains a tool, then the tool was manufactured at another location and transported into the site; the tool may or may not have been used at the site; it was not maintained at the site; and it was finally discarded (or lost) at the site. The nodule thus represents a strategy of tool curation (Binford 1973, 1977, 1979). A SIN that contains a single flake may represent one of the following: a resharpening episode that indicates on-site maintenance and removal of a curated item; removal of the flake from a transported core; or a transported blank that was never manufactured into a tool. Flake size and morphology can help determine which of these possibilities the SIN likely represents. In any case, tool curation and possibly maintenance are once again indicated.

Multiple item nodules containing only debitage provide evidence of on-site tool production and/or maintenance and, since the tool was not recovered along with the debitage, subsequent removal of the tool from the site. MINs containing debitage along with tools provide evidence of on-site tool manufacture, expedient use, and discard. Sellet (1999:46) notes that MINs could also have been manufactured elsewhere and transported

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into the site. For instance, multiple tools or tool blanks could have been manufactured off-site from the same core. As the number of items in a nodule increase, however, particularly debitage too small to make useful tools, the more likely it is that MINs represent reduction/production episodes that occurred on-site. Table 4.1 summarizes the composition of single and multiple item nodules, the behaviors that create each nodule type, and their implications for technological organization.

**Table 4.1 Summary of nodule types, associated behaviors, and implications for technological organization (after Larson and Kornfeld 1997:11).**

Content	Single Item Nodule (SIN)		Multiple Item Nodule (MIN)		
	flake	tool	debitage	debitage and tools	tools only
Behavior	off-site manufacture and on-site resharpening; resharpened item removed	off-site manufacture and on-site discard with no on-site maintenance	on-site tool production and/or maintenance	on-site tool production, use, and discard	on-site discard of tools manufactured off-site
Implications for Technological Organization	tool curation and maintenance	tool curation without maintenance	tool curation and/or maintenance	expedient tool manufacture and use	tool curation without maintenance

### Scenarios of Raw Material Procurement, Use and Discard

Expectations of nodule composition have been modeled by Sellet (1999:61-70) for different scenarios of raw material procurement, use, and discard. These scenarios flesh out the basic SIN/MIN nodule divisions of Larson and Kornfeld (1997) and provide a useful baseline from which to interpret nodule composition. Sellet (1999:63) notes that while many possible procurement, use, and discard scenarios exist, only some are likely to have been implemented by prehistoric foragers. These scenarios are briefly discussed below.

*Scenario 1.* Off-site procurement, off-site manufacture, off-site use/maintenance, off-site discard. This scenario describes items within the transported

toolkit that pass through the site without being used or discarded on-site. The presence of such items cannot be inferred from any part of the lithic assemblage, making them essentially archaeologically invisible, and thus not detectable with MANA.

*Scenario 2.* On/near site procurement, on-site manufacture, on-site use (or rejection), on-site discard. This scenario describes a locally procured piece of raw material that enters the site, is manufactured into a tool or a blank, is used expediently (or rejected), and discarded. The exploited material does not become part

of the transported tool kit. Not only should the tool be present at the site, but the associated manufacturing debris should also be present. All stages of reduction should be present and refitting should be possible. Early stage reduction may be recognizable by cortical flakes.

*Scenario 3.* On/near site procurement, on-site manufacture, off-site use/maintenance, off-site discard. In this scenario, the manufactured item in

scenario 2 becomes part of the transported toolkit and is removed from the site, rather than used and discarded on-site. Debitage in this scenario could consist of early stage debris, if something like a biface was manufactured and removed from the site. Such a scenario might be common at quarry sites. While Sellet states that little if any late stage debris should be present, debitage could consist of early and late stage debris if, for instance, a projectile point was manufactured.

*Scenario 4.* Off-site procurement, off-site manufacture and use, on-site use/maintenance, on-site discard. In this scenario, a tool or core of nonlocal raw material that was manufactured somewhere else is used on-site and finally discarded because it is exhausted. If a core or biface, debitage will be late stage since the item

has already been exploited off-site. If a finished tool like a projectile point or scraper, associated manufacturing debitage should not be present, except for possibly resharpening flakes. In other words, the tool or core is part of the transported toolkit, and is nearly exhausted when it enters the site.

*Scenario 5.* Off-site procurement, off-site manufacture and use, on-site discard. This scenario is similar to Scenario 4 except that no on-site use occurs prior to the on-site discard. This is unlikely for cores and bifaces, because if a core or biface was exhausted, it probably would not have been transported to a site just to be discarded there. We can envision this scenario for finished tools however, that might have been discarded at the site without actually having been used there if they were being, or about to be, replaced. Discarded tools are likely to be exhausted or nearly exhausted. Such a tool refurbishing scenario might occur at a quarry, or a camp near a quarry. In this case, we would expect to find no associated manufacturing or maintenance debris.

*Scenario 6.* Off-site procurement, off-site manufacture and use, on-site use, off-site discard. In this scenario, a nonlocal piece of raw material is manufactured and possibly used off-site, is brought into the site and used, and then removed from the site. If the item is a core or biface we would expect to find late stage debitage that refits. If a finished tool was brought into the site and used and then transported off-site, the only evidence of its passage through the site might be resharpening flakes.

*Scenario 7.* On/near site procurement, on-site manufacture and use, off-site use, a return to on-site use, on-site discard. This scenario might be characteristic of a relatively long occupation span such as a residential base camp from which logistical forays were made. Tools manufactured (and possibly used) on-site would be transported off-site to accomplish certain tasks and then would return to the site for further use and final discard. It would be extremely difficult, however, to determine whether or not such tools were actually transported and used off-site prior to being brought back, as any maintenance or resharpening needed after off-site use would likely be done on-site. Therefore these tools

would appear to have been manufactured, used, and discarded expediently even if they were not. Cores and bifaces would probably not have been used in this fashion simply because it would be simpler and more efficient to take finished tools on logistical forays.

Following a description of the types of nodules present in the Sheaman assemblage, we will return to these scenarios to help interpret Clovis technological organization.

#### MINIMUM ANALYTICAL NODULES AT THE SHEAMAN SITE

In 2006, I conducted a Minimum Analytical Nodule Analysis of the Sheaman site flaked stone assemblage, which consisted of 4,918 items<sup>1</sup>. I classified the lithic material into analytic units, or nodules, based initially on raw material types, followed by sorting within raw material types by differentiating characteristics such as color, texture, and inclusions. Seventy-nine distinct nodules were recognized within the assemblage. Fifty-three nodules are multiple item nodules, and 26 are single item nodules. Nodule composition is summarized in Table 4.2, and described below by raw material type (see Prasciunas [2008] for geologic and geographic details of the identified raw materials). Table 5.2 also provides total numbers of flakes and tools contained in the identified nodules, summed by raw material type. Raw material identifications were made or verified by Jim Miller, a geoarchaeologist with extensive knowledge of and familiarity with toolstone sources across the Plains (e.g., Miller in Frison 1991), using both macro-and microscopic methods.

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<sup>1</sup> I also conducted an attribute analysis of the debitage, which is not described in this paper. Following Surovell (2003), I used a size cutoff of 1.5 cm (maximum flake dimension) for individual flake attribute analysis, and flakes <1.5 cm were analyzed in mass by nodule type. See Prasciunas (2008) for details of the attribute analysis.



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Table 4.2. Summary of Sheaman site nodules by raw material, nodule type (MIN/SIN) and composition. Total numbers of flakes and tools contained in nodules are also provided, summed by raw material type.

Raw Material	Local?	Nodule Type	Composition	Number of Nodules	
Mississippian chert <i>Total (flakes +tools)=3577</i>	No	MIN	Debitage only	22	
		MIN	Debitage + tools	14	
		SIN	Single flake	3	
		SIN	Single tool	12	
				<i>Total</i>	<i>51</i>
Mississippian porcellanite <i>Total (flakes)=13</i>	No	MIN	Debitage only	1	
					<i>Total</i>
Cloverly/Morrison orthquartzite <i>Total (flakes +tools)=193</i>	No	MIN	Debitage only	3	
		MIN	Debitage + tools	2	
		SIN	Single flake	5	
		SIN	Single tool	1	
				<i>Total</i>	<i>11</i>
Knife River Flint <i>Total (flakes)=326</i>	No	MIN	Debitage only	1	
					<i>Total</i>
Non-volcanic glass <i>Total (flake)=1</i>	No	SIN	Single flake	1	
					<i>Total</i>
Playa lake chert <i>Total (tool)=1</i>	No	SIN	Single tool	1	
					<i>Total</i>
Powder River Basin clinker <i>Total (flake)=1</i>	No	SIN	Single flake	1	
					<i>Total</i>
Scenic chalcedony <i>Total (flakes +tools)=20</i>	No	MIN	Debitage + tools	1	
					<i>Total</i>
Miocene chert <i>Total (flakes +tools)=508</i>	Yes	MIN	Debitage only	1	
		MIN	Debitage + tools	1 (with core)	
		SIN	Single flake	1	
					<i>Total</i>
Miocene porcellanite <i>Total (flakes)=20</i>	Yes	MIN	Debitage only	1	
					<i>Total</i>
Tongue River Silicified Sediment <i>Total (flakes)=252</i>	Yes/No	MIN	Debitage only	6	
					<i>Total</i>
Plate chalcedony <i>Total=1</i>	Unknown	SIN	Single flake	1	
					<i>Total</i>
				<i>Total Multiple Item Nodules (MIN)=53</i>	
				<i>Total Single Item Nodules (SIN)=26</i>	

Note: Does not include artifacts too small or too burned to nodualize.

**Nonlocal Raw Material Types<sup>2</sup>**

*Mississippian Chert/Porcellanite:* The majority of the nodules in the Sheaman assemblage were manufactured from nonlocal Mississippian chert (51 of 79 nodules, or 65%; Table 4.2). The likely source of this material is the Guernsey Formation of the Hartville Uplift, whose closest source lies roughly 80 kilometers southwest of the site. Of the nodules manufactured from Mississippian chert, most (36 of 51 nodules, or 71%) are multiple item nodules that contain debitage only or debitage and tools. The debitage in both types of MINs is overwhelmingly dominated by bifacial thinning flakes. All tools within Mississippian debitage + tool MINs are very lightly used biface thinning flakes, which represent expedient use of suitable flakes struck during biface reduction/production, rather than a tool meant to be part of the transported toolkit itself. Thus the Mississippian MINs containing debitage only and debitage + tools provide evidence of the number of bifaces that were reduced or produced from Mississippian chert on-site, and then removed to once again become part of the transported toolkit (n=36).

Fifteen of the Mississippian nodules are SINs. Three SINs contain flakes, and 12 contain tools (Table 4.2). Eleven of the tool-bearing SINs contain flake tools, and one contains the only Clovis point recovered at the site. The SINs containing flakes provide evidence of on-site tool resharpening, and indicate maintenance of bifaces and/or tools that were brought into the site and then removed to once again become part of the transported toolkit (n=3) (Table 4.1). The SIN tools represent items brought into the site that were not resharpened or maintained there, and that were then removed from the transported toolkit and discarded on-site. There are many more SIN tools of Mississippian chert than any other raw material type.

Only one nodule of Mississippian porcellanite is present in the assemblage (Table 4.2). It is a debitage only MIN that indicates on-site maintenance of a tool that was part of the transported toolkit.

*Cloverly/Morrison Orthoquartzite:* Cloverly/Morrison orthoquartzite nodules consist of five MINs (three debitage only and two debitage + tools) and six SINs (five flake only and one tool only nodule; Table 4.2). The likely source of this material is the Spanish Diggings quarry in the Hartville Uplift, 90-140 kilometers southwest of the site. Similar in structure to the Mississippian MINs, debitage in the debitage only orthoquartzite MINs and one of the debitage + tools nodules consists mostly of bifacial thinning flakes, and the flake tools in one of the debitage + tool MINs are very lightly and expediently used biface thinning flakes. These MINs, like the Mississippian MINs, therefore provide evidence of the number of bifaces that were reduced, produced, or maintained on-site, that were then removed to once again become part of the transported toolkit (n=4). The other debitage + tool MIN, however, contains a large bifacial thinning flake tool with few associated flakes, most of which are <1.5 cm, which may represent maintenance debris rather than evidence of on-site production of the tool (refits between the tool and flakes were not found, but only the proximal portion of the flake tool was recovered). This flake tool may be more like a SIN than a MIN in that it may have been transported into the site in very near its current form, where it was then possibly used and/or resharpened and discarded. Another alternative is that this flake tool was struck on-site from a biface that was subsequently removed, and the associated flakes represent part of the tool manufacturing debris.

The five orthoquartzite single item flake nodules indicate on-site maintenance or resharpening of tools manufactured off-site, that were then removed from the site and continued to be part of the transported toolkit (although in several cases these single flakes are fairly coarse-grained, and could represent spalls off of hammerstones or chopping tools rather than deliberate tool maintenance). The single orthoquartzite tool nodule contains a split cobble chopper.

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<sup>2</sup> Nonlocal raw material is defined following Surovell [2003], as material acquired more than 20 km linear distance from the site, or the maximum distance a pedestrian forager could reasonably travel in one day.

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*Knife River Flint:* One nodule of Knife River Flint is present in the assemblage. The sources area for Knife River Flint lies roughly 520 kilometers north and slightly east of the site. The nodule contains debitage only. It should be noted, however, that Knife River Flint is a very homogeneous material type and it may not be possible to separate into MANs. Additionally, much of the Knife River Flint in the assemblage was burned, which would have made identification of distinct nodules, if present, even more difficult. In any case, the presence of debitage only indicates on-site production and/or maintenance of an item (or items) that was then removed from the site. If more than one nodule is actually represented by the debitage in the debitage only MIN, then more than one item was produced or resharpened and removed from the site. Once again, debitage is dominated by bifacial thinning flakes.

*Nonvolcanic Glass/Playa Lake Chert/Powder River Basin Clinker:* Nonvolcanic glass from the northern Powder River Basin roughly 175 kilometers north of the site and Powder River Basin clinker are represented by single artifacts. Both of these nodules are single item flake nodules (Table 4.2). This indicates that tools of these material types entered the site already manufactured, were resharpened/maintained at the site, and again removed to remain part of the transported toolkit. Playa lake chert, whose source area lies at least 300 kilometers from the site, is also represented by only one artifact, but in this case is a small (<1.5 cm), heavily burned flake tool fragment. The nodule is therefore a single item tool nodule. This nodule represents a tool that was brought into the site in finished form and discarded without maintenance, possibly because it was exhausted.

*Scenic Chalcedony:* On MIN of Scenic Chalcedony is present in the assemblage. The source area of White River Group Scenic chalcedony lies east of the Black Hills roughly 145 kilometers from the site. The nodule contains mostly small (<1.5 cm) flakes, and two flake tools, and represents on-site production, use and/or maintenance, and discard.

*Tongue River Silicified Sediment:* One debitage only MIN of Tongue River Silicified Sediment is a nonlocal

variety known from the Powder River Basin of northern Wyoming, roughly 175 kilometers from the site. This nodule indicates on-site production or maintenance of a tool that was subsequently removed from the site.

### Local Raw Material Types

*Miocene Chert/Porcellanite:* Miocene chert is present in the form of two MINs and one SIN. Most of the material is clearly of local origin. The source of the debitage only MIN, however, is unclear. This nodule contains bifacial thinning flakes and represents on-site production of a biface that was then removed. The other MIN contains the local Moss Agate material, and consists of core reduction debitage along with the reduced core itself. This is the only core present in the assemblage, and along with its associated reduction debris (none of which appear to have been utilized) represents on-site reduction or testing of local raw material that was then rejected, possibly because of non-ideal flaking properties. The SIN contains one small (<1.5 cm) flake. Rather than representing on-site tool resharpening or maintenance as suggested by Table 5.1, however, this small flake fragment (lacking a platform) is coarser grained than the other Miocene chert nodules, and may represent a spall from a grade of Miocene chert used for a hammer or chopping tool, rather than a deliberate flake. The nodule of local Miocene porcellanite, similar to that of the local Moss Agate nodule, contains unutilized core reduction flakes. Although the core itself was not recovered, it is unlikely it was removed from the site.

*Tongue River Silicified Sediment:* Five of the six debitage only MINs of Tongue River Silicified Sediment consist of the locally available coarse-grained variety, and are most likely spalls from hammer or chopping tools rather than deliberate flakes, although they could represent resharpening flakes from heavy duty tools like choppers.

### Raw Material of Unknown Origin

*Plate Chalcedony:* Plate chalcedony of unknown origin is represented by a single artifact, and is a single item flake nodule. This indicates that a tool of this material type entered the site already manufactured, was

resharpened/maintained at the site, and again removed to remain part of the transported toolkit.

### INTERPRETING NODULE COMPOSITION

Returning to the question of whether the Sheaman assemblage fulfills the predictions of the high-tech forager model, it is useful to translate the model's technological and behavioral expectations into archaeological terms. If Clovis populations were highly mobile big-game hunters that ranged over extremely large territories, we would expect nonlocal raw materials to be present within the assemblage. In the context of an unknown or incompletely known landscape, we would also expect the presence of nonlocal, high quality raw materials to reduce the risk of not encountering local raw materials of high enough quality to fulfill technological needs. Highly mobile foragers should also conserve raw material as a response to inconsistent access to high quality toolstone. Such conservation should be apparent in a highly curated toolkit in which the use-lives of tools are extended through maintenance, resharpening, and recycling into different tool forms. A heavy reliance on bifacial core technology is also a fundamental component of the model, and should be obvious by the presence of bifaces themselves and/or bifacial reduction debris. If bifaces were used first as cores and then as blanks for tools, then many flake tools should be manufactured on flakes struck from bifaces, and amorphous cores and core reduction debris should be very rare or absent.

We would also expect to see evidence of a tool replacement strategy appropriate for foragers exploiting resources within the context of an unknown or incompletely known landscape. What might such a tool replacement strategy look like? Kuhn's (1989) model of tool replacement, based on Binford's (1980) forager-collector dichotomy, argues that mobility will affect how and when people choose to replace tools. In this model, collectors, characterized by high rates of logistical mobility, should replace tools all at once and in advance of exhaustion. This will reduce the risk of equipment failure and ensure that they are not without the proper

equipment when it is needed away from camp. Foragers, characterized by high rates of residential mobility, should replace tools gradually as they become exhausted.

Replacement of all tools at once or a "gearing up" strategy (Binford 1977, 1978) means that tools are produced in anticipation of use, and that tool needs are to some extent known. It ensures that tools will be available in the future, when time for manufacture may be limited. Gearing up activities are likely to take place in residential camps during periods of free time (Binford 1978; Kuhn 1989:34). This strategy requires the availability of enough raw material to satisfy tool manufacture needs, and so necessitates either moving the entire group to the quarry for some amount of time (as described by Reher [1991] for the Spanish Diggings quarries), or sending small logistical parties to the quarry to either manufacture tools on the spot, or bring material for tool manufacture back to camp. Gearing up allows the toolkit to sustain periods of stress, accommodating tool needs until the next gearing up event. Thus gearing up might occur when critical resources such as food and raw material are not expected to overlap for some amount of time (Binford 1980:10; Sellet 1999:58).

In contrast, if food and lithic resources are known to overlap, and thus future access to raw material is secure, tools will likely be replaced progressively as needed and as raw material becomes available. This strategy requires less raw material at a single point in time than gearing up, and does not necessitate specialized trips to raw material localities. With such a gradual tool replacement, raw material acquisition was likely embedded in subsistence activities (Binford 1979:259; 1980).

The forager method of gradual tool replacement requires that raw material availability can be accurately anticipated, and would therefore be most appropriate in the context of a known landscape. The high-tech forager model would therefore predict a gearing up, rather than gradual, tool replacement strategy, which would allow the toolkit to sustain periods of stress. Archaeological evidence of a gearing up strategy might include discarded tools, possibly completely exhausted depending on time elapsed since the last gearing up

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event, as well as evidence of tool manufacturing activities. The tools manufactured on-site should not be present, as they would have been removed to become part of the transported toolkit. Tools manufactured on-site should be larger than those discarded there, and tools should be manufactured from the same raw material. Alternatively, with a more gradual tool replacement strategy, the components of the toolkit remain constant through time, with every exhausted tool replaced by a new equivalent one as they are discarded. The types of raw materials present should be more variable because they were acquired through an embedded procurement strategy. Discarded tools may not be much smaller than those manufactured, should have less evidence of intensive use and conservation through reworking/recycling, and numbers of tools discarded at the site should be similar to the numbers of tools manufactured (Sellet 1999:59-61).

With the above expectations developed, we can now use MANA to test the degree to which the Sheaman assemblage fulfills the predictions of the high-tech forager model.

### Raw Material Use

The Sheaman site flaked stone assemblage is overwhelmingly dominated by nonlocal raw material, which makes up roughly 98% of the entire assemblage (Table 4.3; see Prasciunas 2008). This is particularly interesting considering that knappable quality chert and porcellanite do occur in the immediate site area as lag deposits. For instance, at the Folsom component at Area 2 of the Agate Basin site, only about 650 meters southwest of Sheaman (see Figure 4.1), 41 percent of the total artifact assemblage is manufactured from local raw material (Surovell 2003). The presence of channel flakes, flake tools, and bifaces manufactured from local raw material in the Agate Basin assemblage (Surovell 2003) demonstrates that at least some locally available raw material was indeed of high enough quality to manufacture Folsom points and/or other tools, and begs

the question why so very little local raw material is present at Sheaman. With its extreme emphasis on non-local raw material, representing distances traveled of up to 520 kilometers (see nodule descriptions above), the Sheaman site certainly conforms to the raw material use expectations of the high-tech forager model.

**Table 4.3. Counts of local and nonlocal raw material from the Sheaman site by artifact class (unknown material excluded).**

Artifact Type	Local Material	*Nonlocal Material	Sum
Debitage	103	4285	4388
Flake Tools	0	64	64
Cores	1	0	1
Bifaces	0	2	2
Channel Flakes	0	1+	1+
Projectile Points	0	1	1
<b>Sum</b>	<b>104</b>	<b>4353</b>	<b>4457</b>
<b>Percent</b>	<b>2.33%</b>	<b>97.67%</b>	

\*Nonlocal raw material is defined following Surovell [2003], as material acquired more than 20 km linear distance from the site.

### Tool Conservation

Few tools were discarded at the Sheaman site, and it is therefore difficult to evaluate the degree to which tools were utilized and conserved. The majority of the recovered SIN tools, however, were not heavily reworked or exhausted, and the toolkit in general was not under stress as evidenced by an abundance of tool manufacturing debris. Conservation of raw material as a response to inconsistent access to high quality toolstone is therefore a prediction of the high-tech forager model that is not fulfilled by the Sheaman assemblage. However, whether or not evidence of tool conservation is apparent at a particular site will depend on strategies of tool replacement and the site's role in the acquisition and exploitation of raw material (e.g., Ingbar 1994). Because of its relationship to tool replacement strategies, evidence of tool conservation is discussed further under *Tool Replacement Strategy* below.

### Reliance on Bifacial Core Technology

Only two bifaces are present in the entire flaked stone assemblage (Table 4.3). If the presence of bifaces is used as a measure of reliance on bifacial technology, we would conclude that very little biface manufacture and/or reduction occurred at the site, and thus that its occupants did not rely heavily on bifaces. The debitage, however, tells another story. Approximately 86% of the debitage from Sheaman subjected to an attribute analysis consists of clearly identifiable bifacial thinning flakes<sup>3</sup>, indicating that even if bifaces were not recovered, they were certainly manufactured and/or reduced at the site.

Even knowing this, though, it is still not possible to know exactly what the counts of bifacial thinning flakes mean in terms of numbers of bifaces that were actually reduced or manufactured at the site. Because so much of the assemblage was manufactured from the same raw material type (Mississippian chert), an argument could be made that most of the bifacial thinning flakes at the site represent debris from only one biface reduction/manufacturing episode. Simple counts could therefore overemphasize the amount of bifacial reduction that actually occurred at the site. MANA provides a better way to evaluate the respective importance of reduction technique than simple artifact count, because the number of nodules is independent of reduction intensity.

More than 40 debitage only/debitage + expedient tool minimum analytical nodules dominated by bifacial thinning flakes were identified in the Sheaman assemblage, indicating that at least that many bifaces passed through the site. The relative absence of core reduction, and the total absence of core reduction on nonlocal raw material, indicates that Clovis groups transported only bifaces and flake tools, and relied on bifaces as cores for sources of expedient flake tools to

satisfy on-site tool needs. There is no evidence that cores were transported, as suggested by Bamforth and Becker (2000) for later Paleoindian sites.

Even if cores have a small probability of discard in sites with short occupation spans because they are long use-life tools, as argued by Bamforth and Becker (2000), we still might expect to see core reduction debris manufactured from nonlocal raw material, if not the cores themselves. At Sheaman, the only evidence of core reduction comes from local raw material, and it is extremely limited. Kuhn (1994:435) and Surovell (2003:225) have shown that the transport efficiency of carrying tool blanks exceeds the transport efficiency of carrying cores. If transport efficiency is a major factor influencing toolkit design, then cores should not be transported between sites (Surovell 2003:224). The evidence from Sheaman suggests that cores were not a part of the mobile toolkit, and that transport efficiency was a major factor influencing toolkit design. Surovell (2003:220), following Kuhn (1994) also suggests that transported tools should be manufactured from bifacial thinning flakes to maximize transport efficiency. SIN tools from Sheaman, or those items that were transported as tools into the site, were manufactured predominantly on bifacial thinning flakes, providing further evidence for the transport efficiency of the mobile toolkit.

In sum, the heavy reliance on bifacial technology evident at Sheaman, coupled with the use of bifaces as cores and the overall transport efficiency of the mobile toolkit, fulfill the expectations of the high-tech forager model.

### Tool Replacement Strategy

An examination of flake size provides a better understanding of what the MINs and SINS in the assemblage actually represent in terms of biface reduction/production or tool maintenance activities. Within the context of specific nodules, flake size can provide an indication of reduction stage. For instance, if a nodule consists of only a few small pressure flakes, it is likely that it represents tool maintenance rather than earlier stage biface reduction. As noted above, I used a

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<sup>3</sup>The attribute analysis (including flakes >1.5 cm) identified 676 bifacial thinning flakes versus 106 core reduction flakes in the Sheaman assemblage. 693 flakes were classified as indeterminate and are excluded from the above frequency calculation (see Prasciunas 2008).

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size cutoff of 1.5 cm (maximum flake dimension) for individual flake attribute analysis, and flakes <1.5 cm were analyzed in mass by nodule type (see Prasciunas 2008). Flakes <1.5 cm therefore were not identified in terms of flake type, and I assume for this discussion that while small flakes certainly can be produced during early stage biface reduction, their presence and abundance nonetheless provides a reasonable indication of early versus late stage tool production.

Table 4.4 shows numbers of debitage bearing nodules (single flake, debitage only, and debitage + tools) by raw material type and flake size. Debitage bearing nodules manufactured from Mississippian chert contain many flakes that are both greater and less than 1.5 cm, as well as nodules containing only small flakes (<1.5 cm) and only large flakes (>1.5 cm) (Table 4.4). This suggests that different stages of bifacial reduction occurred at the site, an interpretation supported by refitting studies (Frison and Stanford 1982). In some cases, nodules of Mississippian chert were completely reduced from fairly early stages to finished bifacial tool forms (those nodules containing abundant flakes both > and < 1.5 cm), in other cases bifaces were only partially reduced and left in an early stage form (those nodules containing only flakes >1.5 cm), and in still other cases late stage bifaces were reduced to a final or nearly final bifacial tool form (those

nodules containing only flakes <1.5 cm), such as a projectile point. The presence of at least one channel flake in the assemblage (Frison and Stanford 1982:153) supports the suggestion of projectile point manufacture (Table 4.3).

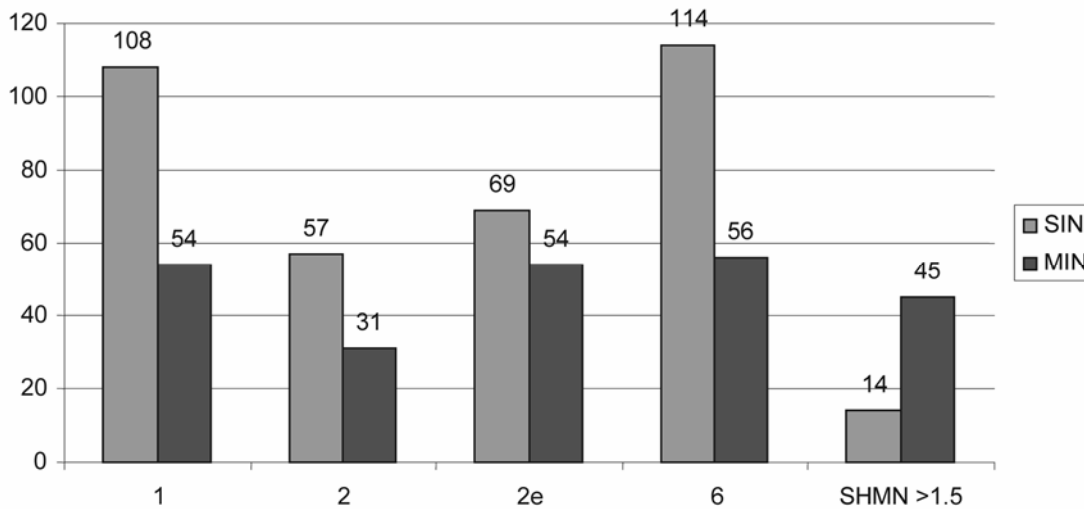
Leaving aside flakes <1.5 cm and only considering flakes >1.5 cm, an analysis of variance using flake mass as a proxy for overall flake size indicates significant differences in flake size among the different nodules of Mississippian chert ( $F=1.82$ ,  $df=25$ ,  $p=.009$  [a Kruskal Wallis test also yields a p-value of .009]). This means that even when only flakes >1.5 cm are considered, it is still clear that different stages of bifacial reduction occurred at the site, or at least that bifaces of different sizes were reduced/produced on-site from the same raw material type.

This same on-site staged manufacture is not apparent with other nonlocal debitage bearing nodules, probably because they were manufactured from raw material acquired further from the site, and had thus been subjected to more intensive utilization. For instance, other nonlocal debitage bearing nodules tend to consist mostly of later stage tool production debris (or debris that is mostly <1.5 cm), such as the nodules of Mississippian porcellanite, Knife River Flint, Miocene porcellanite, and Scenic chalcedony (Table 4.4).

**Table 4.4. Numbers of debitage-bearing nodules at the Sheaman site by raw material and debitage size.**

<i>Raw Material</i>	Debitage			Comments
	<i>only &gt;1.5 cm</i>	<i>only &lt;1.5 cm</i>	<i>both</i>	
Mississippian chert	4	8	27	
Mississippian porcellanite	0	0	1	mostly <1.5 cm
Cloverly/Morrison orthoquartzite	0	7	3	
Playa lake chert	0	0	0	
Non-volcanic glass	0	1	0	
Plate chalcedony	0	1	0	
Powder River Basin Clinker	1	0	0	
Knife River Flint	0	0	1	mostly <1.5 cm
Miocene chert	0	1	2	
Miocene porcellanite	0	0	1	mostly <1.5 cm
Scenic chalcedony	0	0	1	mostly <1.5 cm
Tongue River Silicified Sediment	0	1	5	
<i>Sum</i>	5	19	40	

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**Figure 4.2. Counts of Single Item Nodules (SIN) and Multiple Item Nodules (MIN) from levels 1, 2, 2e, and 6 from the Hell Gap site (from Sellet 1999:196; Figure 112) and from the Sheaman site (only including flakes >1.5 cm).**

The flake size data, then, suggest that most nonlocal raw material types were introduced into the site as prepared bifaces, either in late stages of reduction that were then finished or nearly finished on-site, or as finished tools that were then maintained or resharpened. Nodules of Mississippian chert, however, provide evidence that both early and late stage bifaces were brought into the site, some of which were left in early stages when the occupants departed, and some of which were reduced to finished or nearly finished tools. Even nodules of Mississippian chert, however, generally lack cortex, indicating that the raw material procurement locality was far enough away from the Sheaman site to make field processing economical (Metcalf and Barlow 1992). The overwhelming dominance of Mississippian chert in the assemblage, coupled with the fact that some Mississippian nodules appear to represent fairly early stages of biface reduction, suggest that the Sheaman site was one of the first stops since visiting the raw material procurement locality.

*A Comparative Sample.* To better understand what the nodules identified at the Sheaman site can tell us about the tool replacement strategies of the site's occupants, it is useful to have a comparative sample.

Sellet (1999) conducted a Minimum Analytical Nodule Analysis of the flaked stone assemblage recovered from four Paleoindian levels at the Hell Gap site in eastern Wyoming, roughly 160 kilometers southwest of the Sheaman site. The Hell Gap site, which contains a stratified record of Paleoindian occupation spanning 2,000 years (Larson et al. 2009), is located on the Hartville Uplift, a source of the same high quality Mississippian chert as that present in the Sheaman assemblage. Sellet's MANA and reconstruction of technological activities from Paleoindian levels 1, 2, 2e and 6 from Locality 1 at the Hell Gap site provides a comparative sample against which to evaluate and interpret nodule composition at the Sheaman site.<sup>4</sup>

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<sup>4</sup> Although Sellet (2004) also conducted a MANA of tools and debitage from Area 2 of the Agate Basin site, this analysis was aimed at quantifying projectile point manufacture, and is therefore not as relevant to understanding Sheaman nodules as his more comprehensive MANA undertaken at the Hell Gap site.



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**Table 4.5. Chi-square values and probabilities for counts of MINs and SINS from Hell Gap Locality 1 levels (from Sellet 1999:196) and the Sheaman site. Counts shown in Figure 4.2.**

	Hell Gap level 1	Hell Gap level 2	Hell Gap level 2e	Hell Gap level 6
Sheaman	$\chi^2=32.24, p<.001$	$\chi^2=23.83, p<.001$	$\chi^2=6.84, p<.001$	$\chi^2=33.36, p<.001$
Hell Gap Level 1		$\chi^2=.09, p=.76$	$\chi^2=3.32, p=.07$	$\chi^2=.01, p=.94$
Hell Gap Level 2			$\chi^2=1.61, p=.21$	$\chi^2=.14, p=.71$
Hell Gap Level 2e				$\chi^2=3.66, p=.06$

Figure 4.2 above shows counts of SINS and MINs from Hell Gap by level (from Sellet 1999:196; Figure 112) and the Sheaman site. To be comparable to Sellet’s analysis, only nodules that contain flakes >1.5 cm are included. While counts of SINS appear to be related to counts of MINs at Hell Gap (i.e., the more SINS present, the more MINs present), Sheaman appears to have fewer SINS than expected based on numbers of MINs. Chi-square tests indicate that Sheaman does indeed have significantly fewer SINS and more MINs than expected compared to every level at Hell Gap (Table 4.5). In contrast, there are no significant differences between counts of SINS and MINs between levels at Hell Gap.

This suggests that unlike at Hell Gap, significantly more tools were manufactured at Sheaman and then removed (measured by counts of MINs) than were left behind at the site (measured by numbers of SINS). This

strong emphasis on manufacturing activities is consistent with some type of gearing up strategy (Binford 1978), rather than with gradual tool replacement. A strategy of gearing up is especially evident considering that most of the SINS >1.5 cm at Sheaman are flake tools and nearly all of the MINs at Sheaman represent bifacial reduction/production. In other words, even though biface manufacture was the primary activity that occurred at the site, no discarded or rejected bifaces were left behind.

Another informative comparison is between the types and frequencies of nodules present at Hell Gap and those present at Sheaman. As discussed above, Sellet’s (1999:61-70) scenarios of raw material procurement, use, and discard provide a useful baseline from which to interpret nodule composition. For his MANA of debitage recovered from Hell Gap Locality 1, Sellet (1999:69-71)

**Table 4.6. Relationship between Sellet's nodule categories (1999:69-71) and procurement and exploitation scenarios (1999:62-69). Arrows note correspondence between categories and scenarios.**

Acquisition	Exploitation	Discard	Nodule Categories	Exploitation Scenarios	Description
On site	On site	On site	1 →	2	Local material used and discarded expediently
On site	On/Off site	Off site	2 →	3	Local material used on/off site, removed from site
Off site	On/Off site	On site	3 →	4	Nonlocal material used on/off site, not removed from site
Off site	On/Off site	Off site	4 →	6	Nonlocal material used on/off site, removed from site
Off site	On/Off site	On site	5 →	4/5	Nonlocal material used on/off site, not removed (e.g., finished tools)

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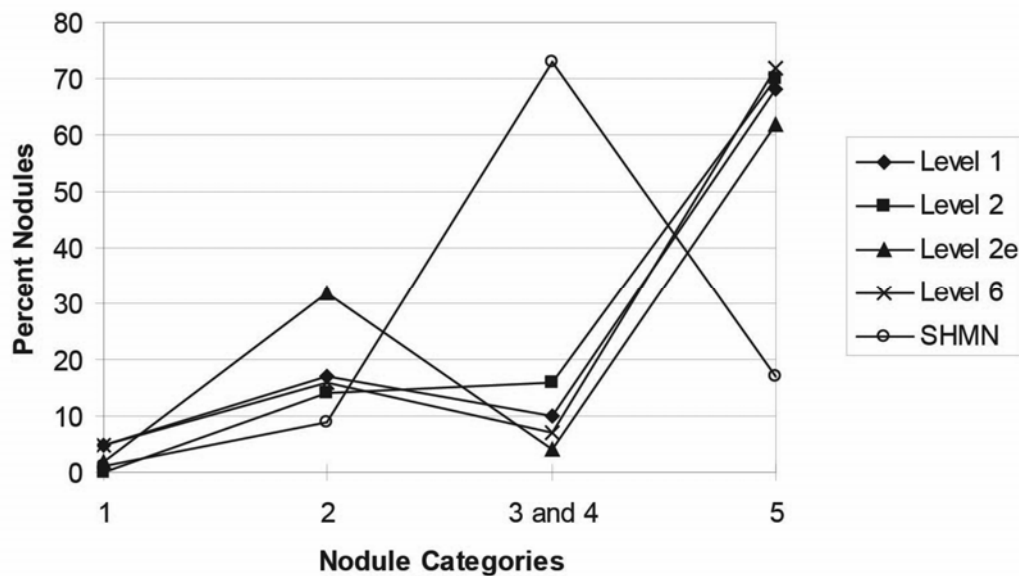
distinguished five categories of nodules, each of which relates to one or more of his seven scenarios of lithic acquisition and exploitation (described above; see Table 4.6 above for summary).

Category 1 refers to raw material that was acquired, exploited, and discarded on-site (Sellet's [1999:64] Scenario 2), in other words, local raw material that was expediently used and discarded. Category 2 refers to raw material that was acquired on-site, exploited both on and off-site, and then removed from the site (Sellet's Scenario 3). Category 3 refers to raw material acquired off-site, exploited off- and on-site, and discarded on-site (the bifaces or cores of Sellet's Scenario 4). Category 4 refers to raw material that was acquired off-site, exploited off- and on-site, and then again removed from the site and discarded off-site (Sellet's Scenario 6). Finally, Category 5 refers to material acquired off-site, exploited on and/or off-site, and discarded on-site (the finished tools described in Sellet's Scenarios 4 and 5).

Figure 4.3 shows the percentage of nodule categories in levels 1, 2, 2e, and 6 at Hell Gap Locality 1 (from Sellet 1999:236) and the Sheaman site (Sellet grouped

Categories 3 and 4 together because small numbers of artifacts made these nodules difficult to differentiate [Sellet 1999:234-235]). Although certain technological differences are apparent between levels at Hell Gap, there is also an underlying unity in terms of the structure of the transported toolkit. For instance, all levels are dominated by nodules containing finished tools of nonlocal material (Category 5). The next most abundant nodules in general contain local material and lack finished tools (Category 2). Nodules containing evidence of expedient manufacture, use, and discard of local raw material (Category 1) are barely represented. This means that in all levels at Hell Gap examined by Sellet, many more tools were discarded on-site than were manufactured there. In contrast, the percentages of nodule categories present at the Sheaman site exhibit a distinctly different pattern (Figure 45.3). Although similar to Hell Gap in terms of having a very low percentage of nodules containing evidence of expedient manufacture, use, and discard (Category 1), Sheaman site nodules are overwhelmingly dominated by nonlocal biface production/reduction debris, without associated

**Figure 4.3. Percentage of nodule categories in levels 1, 2, 2e, and 6 at Hell Gap Locality 1 (from Sellet 1999:236; Figure 149) and the Sheaman site.**



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bifaces (Category 3/4). Also in contrast to Hell Gap, relatively few nonlocal finished tool nodules (Category 5) are present at Sheaman. This means that, unlike at Hell Gap, many more tools were manufactured on-site at Sheaman than were discarded there.

Also unique to Sheaman is the very low percentage of nodules containing evidence of expedient tool manufacture and transport (Category 2) relative to nonlocal biface production/reduction nodules (Category 3/4). This percentage is likely even lower than that shown in Figure 5.3 because Figure 5.3 includes nodules of local raw material that may represent spall from hammerstones or choppers rather than deliberate tool manufacture. Both categories 2 and 3/4 indicate on-site manufacture of items that were then removed to become part of the transported toolkit, but Category 2 involves local raw material while Category 3/4 involves nonlocal material. The dominance of Category 3/4 indicates reliance at Sheaman on tools (bifaces) that were already in the system, rather than tools that were manufactured on the spot from local raw material. The levels at Hell Gap typify a gearing up strategy that might be expected at a quarry site, where tools are discarded all at once, and the toolkit is refurbished from local raw material at the same time (categories 2 and 5; Sellet 1999:65-67). This makes sense considering that the area immediately surrounding Hell Gap contains abundant high quality raw material (Miller 1991).

*Discussion.* The comparison of Sheaman and Hell Gap nodule types raises several questions. First, why are there so few finished nonlocal tool nodules (Category 5) at Sheaman compared to Hell Gap? Second, why are there so many more nonlocal tool manufacturing nodules (Category 3/4) at Sheaman compared to Hell Gap? Third, why did the occupants of Sheaman choose to manufacture so many tools at the Sheaman site (as evidenced by the extreme abundance of Category 3/4 nodules at the site) rather than at the quarry, which would have minimized the carrying costs associated with transporting the toolkit? A consideration of site location/function may help answer the first two questions. Unlike Hell Gap, Sheaman is not located at the raw material procurement locality. The occupants of

Sheaman may have discarded their tools in need of replacement closer to the quarry from which they obtained their high quality Mississippian chert, knowing that they now had sufficient raw material to replace them. When they reached Sheaman, they would have had few tools left to discard. If this was the case, then we would not expect to find evidence of toolkit stress in the form of exhausted and heavily reworked tools at the Sheaman site itself. However, the SIN flake tools that were discarded at Sheaman are for the most part large, and do not appear to be exhausted. Why would these tools be left behind? Although these items are SINs and so were not manufactured on-site, they are all manufactured from Mississippian chert and so had likely not been part of the transported toolkit for long. Possibly their discard at Sheaman represents the assembly of an optimal toolkit following gearing up, when raw material availability was not an issue.

If Clovis groups did not know when or where they would next encounter suitable raw material, it seems likely they would take advantage of opportunities to acquire high quality raw material, possibly replacing large components of their toolkits all at once. Therefore, the high-tech forager expectation of finding tools that are exhausted and heavily reworked might not be reasonable at all sites (such as those immediately following a gearing up event), even if Clovis foragers did at times intensively utilize the raw material they transported. To ensure tool availability in an unfamiliar landscape where future events are unknown, Clovis tool replacement may have followed more of a collector strategy, with tools at times being heavily reworked, but at other times replaced well in advance of exhaustion. In this regard, Clovis foragers might be considered “high-tech collectors” rather than “high-tech foragers”.

However, it is important to remember that the forager-collector dichotomy and associated tool replacement strategies are not, and were never meant to be, mutually exclusive (Binford 1980:12; Kelly 1983: 301; Sellet 2004:1561). In particular, (and as argued by Kelly and Todd [1988]), the landscape use, settlement strategies, and technological organization of Clovis colonizers may exhibit unique combinations of collector

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and forager traits for which there are no analogs. For instance, while Kuhn's (1989) tool replacement model links gearing up with collectors, who are in turn characterized by high rates of logistical versus residential mobility, Clovis foragers may very well have had high rates of residential mobility while still choosing to gear up. Shott (1986) has shown a negative correlation between the number of residential moves per year and toolkit diversity, arguing that as residential mobility increases, tools become more multifunctional and less specialized. The Sheaman toolkit, then, overwhelmingly dominated by bifaces at various stages of reduction, supports the high tech forager assumption of high rates of residential mobility while exhibiting a tool replacement strategy generally associated with collectors. The tool replacement strategy of the occupants of Sheaman appears to contain a unique combination of collector (gearing up) and forager (gearing up with generalized, functionally nonspecific, tool forms [i.e., bifaces]) characteristics.

The final question is why so much tool manufacture (i.e., gearing up) would have occurred at the Sheaman site rather than at the quarry itself, which would have minimized the costs associated with transporting the toolkit. Larson and Kornfeld (1997) discuss two important variables conditioning nodule composition: amount of time available for tool manufacture and predictability of future events (Torrence 1983). Amount of time available refers to either duration of occupation or amount of time allotted for tool manufacture. Nodule composition can be predicted based on different relationships between time available and event predictability (Larson and Kornfeld 1997:13-14). For instance, if production activities are not constrained by time and tool needs are known (because future events are known), we would expect MANs to contain the complete production sequences of specific tools without the tools themselves, which would have been transported off-site. If duration of occupation was long (rather than just abundant time allotted for manufacture), we might also expect some MANs to contain evidence of expedient tool manufacture, use, and discard.

At Sheaman, although duration of occupation does not appear to have been long (based on the virtual absence of expediently manufactured, used, and discarded tools), there was certainly abundant time allotted for tool manufacture. Perhaps time was a limiting factor at the quarry, so rather than manufacture tools there, even though doing so would decrease carrying costs, the occupants of Sheaman carried raw material in various stages of production until time allowed them to more completely replenish their toolkits. If Sheaman is a camp associated with a kill, which seems likely considering its proximity to other Paleoindian killsites in the same arroyo system (Frison and Stanford 1982) and the presence of bison bone at the site, perhaps time for tool manufacture was available either before or after the kill.

A consideration of site function, time, and predictability of future events provides a better understanding of why tool manufacture at Sheaman may have occurred when and where it did, and why the nodule constituents from Sheaman and Hell Gap differ. Even though Hell Gap is located at the raw material procurement locality and Sheaman is not, the technological organization represented by the two sites appears fundamentally different. Even if we excavated the raw material procurement locality where the occupants of Sheaman obtained their Mississippian toolstone, unlike at Hell Gap we would likely find little evidence of tool manufacture there. Based on the extreme abundance of biface reduction/production nodules of Mississippian chert in the Sheaman site assemblage, the occupants of Sheaman appear to have geared up on-site rather than at the quarry. Perhaps time for the occupants of Sheaman was limited at the raw material procurement locality in a way that it was not for the occupants of Hell Gap. Although speculative, this may mean that locations on the landscape such as the Hell Gap valley, that were productive in terms of diverse food resources, fuel, water, and high quality raw material (Sellet 1999:18) (all of which would be

necessary for any kind of long term camp), were unknown to Clovis groups<sup>5</sup>. Perhaps the occupants of Sheaman procured their Mississippian chert at a locality unsuitable for a stay of any duration, and so may have moved on without taking the time to replenish their toolkits there.

*Summary.* In sum, the tool replacement strategy employed by the occupants of Sheaman was one of gearing up, rather than gradual tool replacement. A gearing up strategy would be expected in the context of an unknown lithic landscape, when the availability of raw material cannot be accurately anticipated. The tool replacement strategy evident at Sheaman therefore fulfills the expectations of the high-tech forager model. The manufacture of generalized bifacial tools at various stages of production, rather than specialized and finished tool forms, also suggests that tool manufacture was designed to satisfy needs that were not entirely predictable, and therefore provides further support for the high-tech forager model.

## CONCLUSION

This study examined the Sheaman site lithic assemblage using Minimum Analytical Nodule Analysis to test the utility of the high-tech forager model for explaining Clovis technological organization. The Sheaman assemblage fulfills many of the predictions of the high-tech forager model, and supports a traditional interpretation of Clovis technological organization. Exhausted, heavily curated tools, however, were not recovered at Sheaman. The toolkit was clearly not under stress, as evidenced by the presence of abundant manufacturing debris and tools discarded prior to

exhaustion. Thus, the assemblage did not fulfill the high-tech forager model's prediction of raw material conservation. MANA helped explain this apparent contradiction, and allowed a more detailed picture of the technological decisions made by the occupants of Sheaman to emerge. The degree to which tools are utilized, maintained, or recycled will depend on strategies of tool replacement, as well as where one is sampling within a group's cycle of tool replacement. We should therefore not always expect to find evidence of the raw material conservation predicted by the high-tech forager model, even if such conservation occurred.

The Sheaman assemblage provides evidence of a "gearing up" type of tool replacement strategy, where many tools (mostly bifaces) were manufactured at the same time immediately following a visit to a raw material procurement locality. Few tools were discarded at Sheaman compared to the number of tools manufactured there, possibly because they were discarded at or near the raw material procurement locality, or possibly because Sheaman represents a very short occupation. While there is little evidence of conservation of the raw material type just acquired, the tools that made up the transported toolkit prior to arrival at the raw material procurement locality may or not have been heavily reworked or recycled prior to discard. The tool replacement strategy apparent at Sheaman differs from that of the Paleoindian levels at Hell Gap, and suggests that the occupants of Sheaman used the landscape in a different way than some of its later occupants.

In sum, while many post-Clovis Paleoindian sites may not conform to the expectations of the high-tech forager model (Bamforth 2002), the Sheaman Clovis site does. The strategy of technological organization evident at Sheaman includes a unique combination of collector and forager traits that might be expected among the earliest occupants of a region who possessed incomplete knowledge of the landscape. However, while the Sheaman assemblage does not falsify the predictions of the high-tech forager hypothesis, additional assemblage level tests of many more Clovis sites are necessary to

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<sup>5</sup> Although the Hell Gap site provides a nearly complete chronostratigraphic record of High Plains Paleoindian cultural complexes, the best evidence of a Clovis presence in the valley comes from a single Clovis point fragment recovered from a surface context (Larson et al. 2009). The lack of a clear Clovis occupation at the site is a topic of current research (Larson et al. 2009).

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determine whether the patterns identified at Sheaman are site specific, or are characteristic of Clovis in general.

### ACKNOWLEDGMENTS

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## CHAPTER 5

### GIS MODELING OF INTERMEDIATE SCALE LITHIC LANDSCAPES IN THE COLORADO ROCKIES: THE CASE OF BALLINGER DRAW

BY ROBERT H. BRUNSWIG AND DAVID DIGGS

#### ABSTRACT

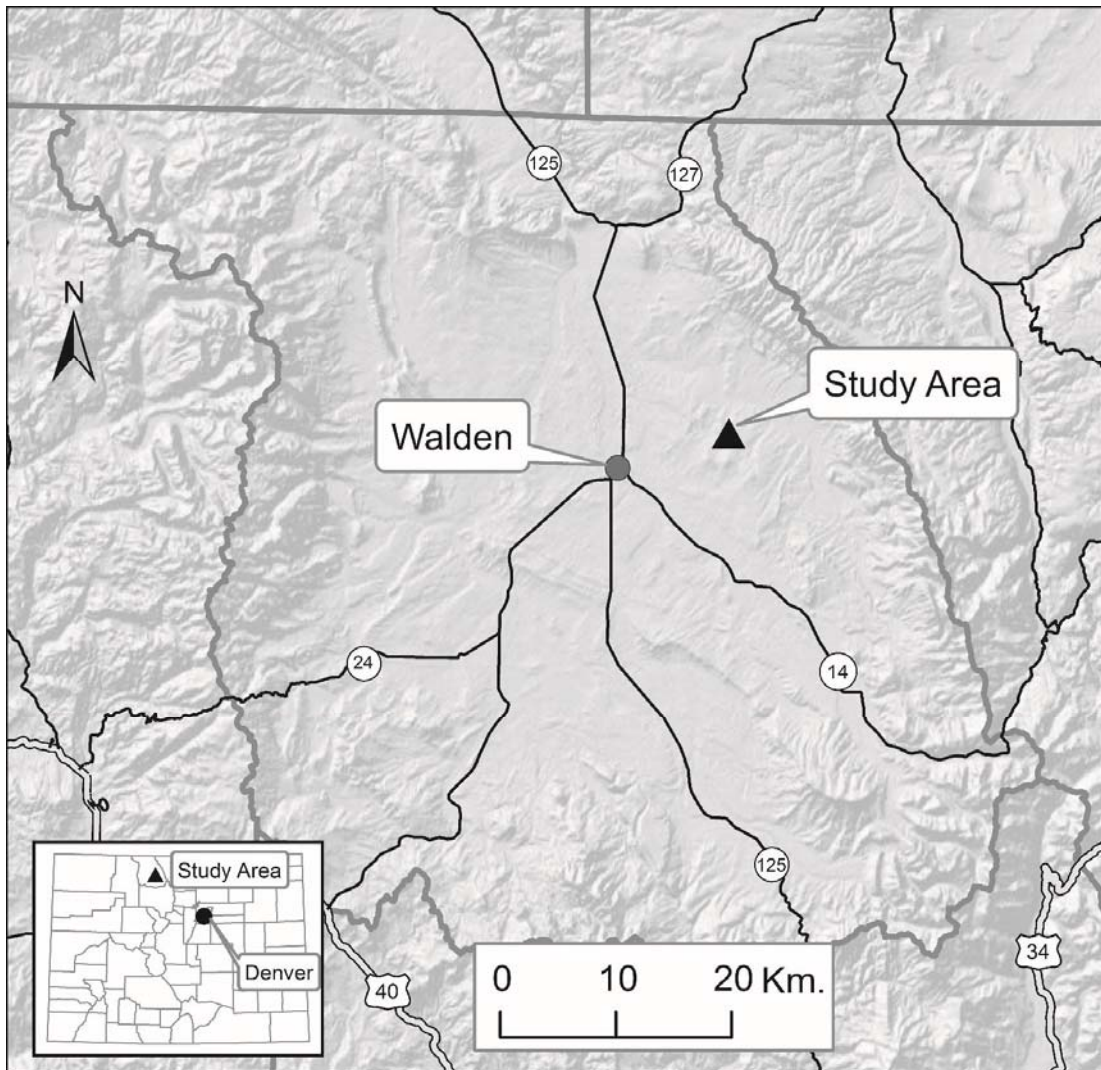
*The upper section of Ballinger Draw, a small spring-fed stream valley in Colorado's North Park valley, was intensively pedestrian-surveyed as part of the University of Northern Colorado's North Park Cultural Landscape Project from 2007 through 2010. Artifact scatters associated with nine sites were identified and documented within the 320 acre research area. One previously recorded site, 5JA421, was partially excavated, revealing three centuries of stratified Late Prehistoric Ute game and plant processing camp occupations, AMS radiocarbon-dated between AD 1080 and 1400. An isolated roasting pit feature at the same site was dated to AD 110 (Early Ceramic) and hearths from two other sites, 5JA1805 and 5JA1808, were dated to 3950 BC and AD 1080 respectively. Several thousand lithic artifacts, including 112 projectile points, were mapped with ArcGIS™ 10.0 software using GPS survey-grade (sub-meter) spatial data. Surface collected projectile point types belonged to Early Paleoindian (Goshen) through Early Historic cultural periods with every regionally known period being represented. This chapter focuses on GIS mapping and statistical spatial analysis (nearest neighbor, cluster) of collective and individual classes of lithic artifacts designed to discriminate prehistoric camp and activity areas throughout the research area. However, except for identifying spatial associations of diagnostic projectile points with some camp and activity area clusters, it is less possible to identify specific*

*chronological-cultural occupation localities within the long-term accumulated archaeological palimpsests draped over the Ballinger Draw land-forms. This chapter also broadly addresses a long-standing archaeological question of what constitutes a "site" versus the a less spatially discrete cultural "landscape".*

#### BACKGROUND

The University of Northern Colorado's Anthropology Department began sustained archaeological research in Colorado's Southern Rocky Mountains in 1998 with a five-year Systemwide Archeological Inventory Program (SAIP) in Rocky Mountain National Park (RMNP). The SAIP project was completed in 2002 after surveying and recording more than 400 prehistoric sites on 30,000 acres, many in remote alpine areas (Brunswig 2005; Doerner and Brunswig 2008). Although smaller research question-driven projects (e.g., spiritual landscape, paleoclimate, and mountain pass archaeo-environmental reconstruction studies) continue in the park, we expanded our research to the adjacent interior mountain basin valley of North Park northwest of Rocky Mountain National Park in 2003. Our long-term approach to conducting archaeological research in the Colorado Rockies emphasizes empirical, field-focused cultural landscape modeling (cf. Chapman 2006; Head 2001; Rossignol and Wandsnider 1992; Ucko and Layton 1999) utilizing Geographic Information System software as a key analytical tool.

Our data for mountain-landscape modeling derive largely from systematic interdisciplinary field studies of selected research polygons, termed research areas, sampled from diverse mountain environmental zones with associated ecological, geological, and hydrological systems ranging from high alpine tundra to mountain valley sage grassland. UNC research areas vary from a hundred to over a thousand acres depending on their ecological and geologic traits and resources. The objective of this chapter is to describe archaeological and GIS landscape analysis of one of our smaller research areas, Ballinger Draw, in northeastern North Park (Figure 5.1).



**Figure 5.1. Location map of the Ballinger Draw Research Area (labeled Study Area) with an inset map showing its placement within Colorado.**

Ballinger Draw is a third order, ephemeral tributary stream of the Canadian River. The Canadian River headwaters in mountains north and east of North Park, then crosses the park's northern margins to join the north-flowing North Platte River which exits the valley in its northwestern corner. The Ballinger Draw Research Area consists of 320 acres situated within a 200 m long stretch of the draw's upper headwaters section, a small east to west trending side valley, and confining hills and east-west narrow ridges. Previous to UNC's fieldwork, only a single site, 5JA421, had been recorded, but its

documented artifact inventory and the presence of bison bone eroding on the surface suggested long-term prehistoric hunting and processing occupations.

Even more significant for our investigations was the research area's environmental and topographic context; a confining and protective topography, deep alluvial and colluvial sediments where the side valley meets the stream, the presence of local springs, and an unusually rich concentration of Big Sagebrush Steppe plant species, including numerous economically important plants such

as rice grass, wild onion, golden current, and serviceberry (cf., Bach 2010).

UNC field crew and field school students conducted four seasons of surface-survey and excavations at Ballinger Draw between 2007 and 2010 (Brunswick and Sellet 2007, 2008a, 2008b, 2010, 2011a, 2011b). We identified artifact scatters associated with nine sites and excavated 40 square meters of the earlier recorded 5JA421 site. Excavation of the latter site uncovered a stratified series of shallow (~40 cm deep) continuously stratified game and plant processing camp occupations AMS radiocarbon-dated between AD 1080 and 1400 and affiliated, based on associated pottery and projectile points, with prehistoric Utes. Limited deep testing of selected excavation units found evidence of earlier camp deposits believed to represent Early Ceramic (ca. AD 100-900) Period occupations extending to a maximum depth of 1 meter.

Early Ceramic occupation of the site is attested by a high representation of surface-documented corner-notched projectile points belonging to that period and excavation of a roasting pit feature located outside its main excavation blocks and AMS-dated to AD 110. Other surface-recorded projectile point types provided evidence of earlier Late Paleoindian and Late Archaic site use.

Excavated hearths from two other research area sites, 5JA1805 and 5JA1808, were AMS-dated to 3950 BC (Early Archaic) and AD 1080 (Late Prehistoric) respectively. Several thousand lithic artifacts, including 112 partial to complete projectile points and 129 potsherds from a single Uncompahgre Brownware vessel (Ute), were recovered from surface-surveys and excavations at 5JA421 and limited test excavations of three other Ballinger Draw sites.

This chapter describes research design theory, method, and results of high resolution GIS mapping and statistical analysis of surface artifacts throughout the Ballinger Draw Research Area, with a detailed focus on site 5JA421, the most archaeologically complex and heavily investigated of the Ballinger sites. Addressing all the research area's sites in detail would entail a longer chapter than appropriate for this volume while a

thorough description of UNC's methodology and results from the 5JA421 site illustrates our overall research strategy and methodologies.

## METHODS

### GPS Survey and GIS Mapping and Modeling

During the past fifteen years, UNC cultural landscape research programs have systematically utilized geospatial technologies such as Global Positioning System (GPS) survey grade (sub-meter) site-specific, local area (multi-site), and sub-regional landscape documentation and Geographic Information Systems (GIS) mapping and modeling (cf., Brunswick 1997a, 1997b, 1999; 2005a; Brunswick and Diggs 2010; Brunswick, Doerner and Diggs 2012; Brunswick et al. 2009; Diggs and Brunswick 2009, 2012; Doerner and Brunswick 2008).

While standard pedestrian survey methods were followed, e.g., archaeology crew members walking in pre-determined overlapping transects, pin-flagging surface artifacts and features, etc., recording and documentation of archaeological materials have been accomplished within an evolving field documentation system which emphasized both field data record precision and minimal artifact recovery.

Today, UNC field teams systematically record individual sites and associated surface artifact positions with a survey-grade (sub-meter) Differential Global Positioning System (DGPS) unit, in our case the Trimble GeoXT™. At the same time, electronic GPS data are logged and field records and digital photographs of artifact and cultural feature types are recorded along with their materials, physical traits, and dimensions. Archaeological survey spatial data, collected with a survey-grade (sub-meter) GPS unit consistently provided three-dimensional accuracies of ~10-80 cm after computer field data post-processing (cf. Parkinson and Enge 1996).

GIS represents a key tool in our project's landscape archaeology approach, an approach which has been developed and tested with earlier UNC research programs (cf., Brunswick 2005b; Brunswick et al. 2009;

Brunswick, Diggs and Montgomery 2007; Diggs and Brunswick 2009, 2011; Diggs and Brunswick 2012).

### **Lithic Tool Classifications and Analysis for Ballinger Draw**

Both formal and informal tools are classified during field and laboratory analysis and documentation within a system of functional artifact classes and types established from past UNC field and laboratory project experience and lithic specialist studies and publications (cf. Andrefsky 1994a: 22-23; 2005a: 31-33 for discussions on formal and informal lithic tool classes). Artifact classification system and working definitions of formal and informal tool classes used for this study are described in more detail elsewhere but are briefly summarized below (cf. Brunswick 2005b:147-150; Brunswick and Sellet 2010: 26-35).

We define formal flaked tools as demonstrating substantial shaping and modification, with >49% of a tool's working edges showing continuous retouch and/or associated use-wear patterning. Formal flaked lithic tool types include projectile points, knives (hafted and unhafted), scrapers, awls, burins, drills, graters, spokeshaves, and choppers. Wherever possible, attempts are made to identify multiple functions, such as projectile points alternatively used as knives or scrapers. We also employ working edge angle and micro-wear pattern analyses to assist us in identifying successive use tool histories, e.g., tools which have been "rejuvenated" and transit from one function to serving another, such as broken projectile points having been reworked to serve as hafted or unhafted knives or scrapers.

We define formal ground stone tools as consisting of heavily modified and shaped working surfaces, >49% of total surface area, and including such functional types as grinding-stones (metates), hand-stones (manos), mortars and pestles, generalized abraders (for hides, bone, wood...), grooved shaft-abraders, and hammer-stones. Our informal tool class includes flaked and ground stone tools and defined within two sub-groups: 1) flaked tools with evidence of limited retouched edge modification (<50% working edges), and 2) ground stone tools with working surface wear (edge smoothing,

blunting, step-fracturing, or grinding...)but also with more limited (<50% of total surface area) shaping or work surface modification. Informal flaked and ground stone tools also include expedient tools with limited edge and work surface wear patterning but little or no evidence of retouch (flaked tools) or abrasion shaping/and or pecking (ground stone and impact tools).

Diagnostic projectile points recovered from Ballinger Draw lithic scatters included complete, partial, and fragmentary specimens. Their typological classification and cultural period affiliations were assigned after macroscopic and low-power microscopic analysis, comparison with publication illustrations and descriptions (Brunswick 2005b; Chenault 1999; Clark 1999; Gilmore 1999; Kornfeld, Frison, and White 2001; Pitblado 2003, 2007; and Tate 1999), and based on past field and lab experience with Western U.S. projectile points by the senior author. It is significant that nearly every known regional cultural period from Early Paleoindian through early historic times is represented at Ballinger Draw sites.

We have classified lithic debitage (tool production and refurbishment waste flakes) according to well-established but intentionally broad lithic tool-production/tool-refurbishment manufacturing stage, or reduction sequence, flake types, e.g., primary, secondary, tertiary, and shatter flakes (cf. Andrefsky 2005a: 187-190, 2005b: 6-7; Brunswick 2005b: 157-161; Cotterell and Kamminga 1987; Flenniken 1984; Magne and Pokotylo 1981; Shott 1994; and Yerkes and Kardulias 1993: 92-99, Figure 1).

Given the large numbers of debitage flakes documented during surface surveys and extensive excavations of 5JA421, two related but less rigorous approaches were utilized in identifying flakes into reduction stage debitage (flake) types. These consisted of survey-based identification of flake debitage based on in-field assessment of basic morphological and size traits (e.g., primary flakes with cortex, thinning and edge removal secondary flakes with or without cortex, tertiary edge retouch flakes, and generalized shatter flakes) and their tabulation during surface survey. Except for selective material type sampling, most survey-recorded

debitage was left in place. Excavation-recovereddebitage was subjected to more precise laboratory identification and tabulation using table top sorting and low-power lens examination of individual flakes.

For surface surveydebitage identification, we adopted use of a utilitarian cortex typology, employing the above noted four flake types; primary (full cortex), secondary (partial or no cortex), tertiary, and shatter (e.g., Morrow 1984 and Stafford 1980 for examples). Because an important survey system goal was to minimize collection and reduce curation costs represented in full recovery of lithicdebitage and flake tools, we sacrificed flake class and type field identification accuracy compared to that achievable in the laboratory for time and economy. On the other hand, care was taken in closely examining each piece of surface lithicdebitage *in situ* and hand-recording descriptive traits used to determine flake typology, material type, material source (if known), color, and unusual distinguishing characteristics, e.g., retouch scarring indicating tool refurbishment activity, burning. We also recognize that surfacedebitage profiles are likely to differ from those recovered from excavated contexts. Surfacedebitage is normally subject to selective removal or dispersal of flakes depending on size and weight through natural processes such as water and soil erosion, downslope gravity movement, animal burrowing, and trampling (Ensor and Roerner 1989; Kvamme 1996, 1998; Prentiss et al. 1988).

All 5JA421 excavation-recovered flakedebitage was subjected to more detailed morphologic trait analysis (cf. Andrefsky 2005a: 86-131), but limited time and funding prevented comprehensive study of each flake for individual traits such as platform and scar morphologies.

### Lithic Material Sourcing

Lithic sourcing studies of 5JA421 artifact assemblages, as well as those of the other Ballinger Draw sites, provide good information on the use of local versus more distant, nonlocal, tool material sources. For the purposes of our sourcing research, we define *local sources* as those known to exist within a 75 km radius while extralocal (nonlocal) lithic sources were defined as those exceeding

a 75 km radius boundary. While we realize our definition of local and nonlocal lithic tool sources is somewhat arbitrary, it provides us with a workable standard for separating more localized (local) versus more distant (non-local) resources. We used this boundary as a proxy for hunter-gatherer mobility patterns we felt appropriate for the region, basing it on an estimate of 3-4 days foot-travel in the region at a rate of 15-20 km/day common in often rugged, frequently vertical southern Rockies mountain interior landscapes (for other discussions of nonlocal and extralocal hunter-gatherer lithic source analysis cf. Andrefsky 1994b, 2005a:224-244; Brunswig 2005b:177-178; Jones et al. 2003; Loosely 2000). Others, such as Surrovell (2003) and Prasciunas (this volume) have chosen shorter distance parameters (a generic 20 km linear distance from a site or a radius of 40 km, a day's foot travel) for defining local versus nonlocal lithic resources. Our use of the longer-distance (75 km) local lithic source definition is driven by our knowledge of past hunter-gatherer access to extensive and widespread regional stone tool resources throughout North Park, Middle Park, and Rocky Mountain National Park (RMNP)(cf. Bamforth 1994, 2006; Black 2000; Brunswig and Sellet 2010: 36-37, 2011a: 47-52; Kornfeld, Frison and White 2001; Metcalf et al. 1991; White 1999; Wunderlich and Brunswig 2004). We also believe there is sufficient research evidence to suggest that 3-4 day travel trips were likely routine to North Park hunter-gatherers given the existence of high-mobility, upland-lowland hunter-gatherer seasonal transhumance patterns in the region for millennia (Brunswig 2004a, 2007: 283-299, 2013).

Ballinger Draw, being in a large interior sedimentary basin valley, provides an abundant source of good quality flakable stone in the form of chert, orthoquartzite, petrified wood, and basalt. The primary local chert type, known as Kremmling (or Troublesome) chert, is a tan to white translucent to opaque chert or chalcedony that is well-documented from sites and prehistoric quarries in Middle Park, south of North Park (Black 2000; Kornfeld, Frison and White 2001; Metcalf et al. 1991; White 1999; Saul 1964; Wunderlich and Brunswig 2004). It also occurs on nearly every hill-top and ridge-line in North Park as

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secondary gravels and cobbles, including Ballinger Draw. Surface surveys and excavations at 5JA421 have recovered small Kremmling chert cores and full cortex primary flakes, illustrating local exploitation of ridge top and hill gravels and cobbles.

Another very common local material is Dakota Orthoquartzite, a fine-grained gray quartzite that outcrops at a major quarry (Windy Ridge) in the northwest corner of Middle Park Valley, immediately south of North Park (Bamforth 1994, 2006). Small cobbles of Dakota Orthoquartzite also occur on North Park ridges and hill-tops, including those of Ballinger Draw, and large extinct stream outwash boulders of the material are known from a quarry site in the northwestern corner of North Park. Collectively, Kremmling chert and Dakota Orthoquartzite dominate lithic tools and flake debitage at all Ballinger Draw sites, ranging in frequency from 65% to 80%.

Another common material type is a dark to medium brown chert, also found on North Park ridges and hilltops, including those in Ballinger Draw. Seven brown chert projectile points found on both the surface and in 5JA421 excavation units were made of locally available North Park brown cherts. Petrified wood, found in substantial quantities at high ridge-lines in the center of North Park, also provided quality tool-stone for past hunter-gatherers.

At 5JA421 and eight other Ballinger Draw sites, a total of one hundred-twelve projectile points and projectile point fragments were recovered from surface surveys and excavation units. Of that number, forty-three (39.39%) are Late Prehistoric types, nineteen (16.96.1%) were Early Ceramic, twelve (10.71%) were either later Late Archaic or early Early Ceramic, ten (8.92%) were Late Archaic, two (1.79%) were Middle Archaic, eleven (9.82%) were Early Archaic, five (4.45%) were Late Paleoindian, and three were Early Paleoindian (Folsom and Goshen) (2.68%) in origin. Seven projectile point fragments (6.25%), mid-sections and tips, could not be type identified.

Our analysis of Ballinger Draw projectile points shows a very high preference for local lithic source materials. A majority (82.5%) of surface-collected projectile points

were made of local materials while only 6.25% of surface points came from nonlocal sources. Remaining points (11.25%) were classified as made of unknown source materials. The five nonlocal material projectile points came from multiple wide-ranging sources, including Hartville chert (South Central Wyoming), Bridger (Tiger) chert (northwest Colorado or Southwest Wyoming), oolitic chert from Southwest Wyoming, and Colorado Front Range Dakota Orthoquartzite.

Thirty-two projectile points recovered from excavated Late Prehistoric camp levels at 5JA421, dated between AD 1080-1400, also made of predominantly local materials (75%), followed by those made of nonlocal (12.5%) and unidentified (12.5%) source stone. Four nonlocal material projectile points from excavated site deposits were identified as made of Wyoming Hartville chert (2), Bridger (Tiger) chert (1) from northwest Colorado/Southwest Wyoming, and crystal quartz (1) from Colorado's South Park valley.

Obsidian artifacts, only recovered from 5JA421 excavations and surface contexts not at other sites, represent an important resource for lithic sourcing and reconstructing migration and trade patterns since their origin sources can be reasonably determined through spectral chemical element analysis. In addition to 5JA421 projectile points made of nonlocal chert and crystal quartz, we also recovered two obsidian points. Both were submitted for energy dispersive X-Ray Fluorescence (XRF) source analysis, with one, a Late Prehistoric point, being made of a recently identified obsidian source in La Poudre Pass, only 30 miles to the southeast, and a similar Late Prehistoric point sourced to Obsidian Cliff, Yellowstone, Wyoming, 430 miles to the northwest.

From 2007 to 2010, five obsidian tools, including the above noted projectile points, and sixty-six flakes were recovered from either the surface of 5JA421 or its excavation units. Of that number, twenty-two were subjected to XRF source analysis (cf., Hughes 2005, 2006, 2007, 2008a, 2008b, 2009, 2010a, 2010b, 2010c, 2012). Nearly every known major source of obsidian in the southern and central Rocky Mountains was identified; Yellowstone National Park (northwest Wyoming), Malad (southeast Idaho), Cerro Del Medio (northern New

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Mexico), and Wild Horse Canyon (east central Utah). The majority, however, came from the nearby La Poudre Pass obsidian source on the northwestern corner of Rocky Mountain National Park. However, given that nearly all obsidian came from Late Prehistoric level occupations, dated AD 900-1400, it demonstrates an extraordinary transfer of that lithic material class through direct and/or indirect trade and/or migration in Late Prehistoric times.

5JA421 debitage material source data from surface survey and excavation units are particularly revealing (Table 5.1). More than 5,000 flakes were recorded from the site, including 1,220 surface flakes and 4,034 flakes from excavation levels 1-7. Although a few excavation units penetrated below level 7 (~35 cm below surface), aggregate debitage data from the seven upper levels are

used here for comparison with surface debitage data. This allows direct comparison of a relatively and cultural period, the site's Late Prehistoric AMS-dated stratified occupations, with the site's longer-term surface-based, multicomponent palimpsest. Levels below 35 cm were judged to represent an earlier Early Ceramic occupation with only limited area excavation evidence.

Lithic material source data from both surface-recorded and excavated lithic waste (debitage) assemblages at 5JA421 allowed us to further assess the relative importance of local versus nonlocal materials for tool manufacturing and refurbishment. Those data, summarized in Table 5.2, demonstrate significant differences in surface versus excavated debitage lithic source data.

**Table 5.1. 5JA421 surface and excavation level debitage totals and flake type percentages.**

Site Context	n	Primary %	Secondary %	Tertiary %	Shatter %
Surface	1220	5.16	53.2	35.57	6.07
Late Prehistoric Excavation Levels (1-6)	4034	0.05	1.39	91.08	7.49

**Table 5.2. Comparison of 5JA421 surface and excavation unit-derived debitage by material source.**

Site Context	n	Local (within 75 km)	Non-local (beyond 75 km)	Unknown Source
Surface	1220	64.6	00.00	35.36
Late Prehistoric Excavation Levels (1-7)	4034	85.58	14.26	0.16



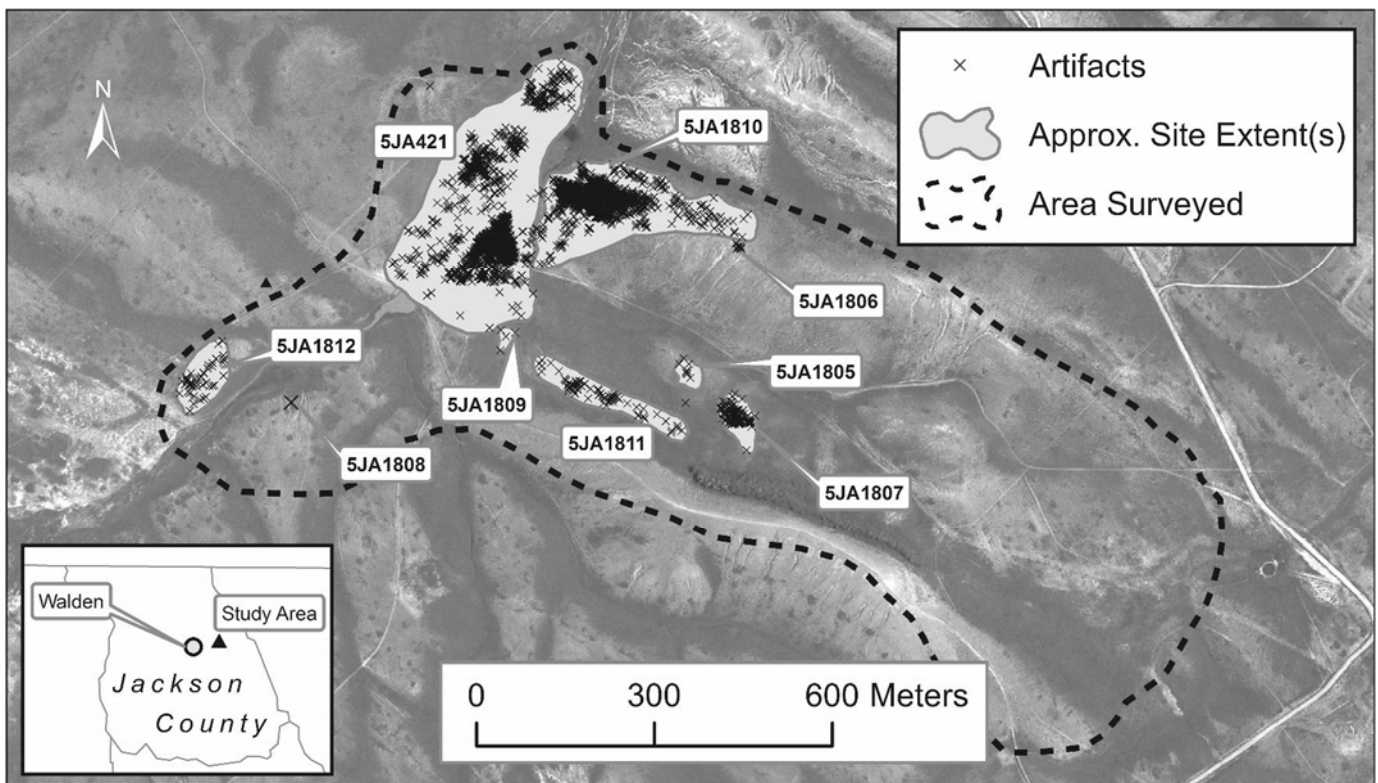
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Two factors are believed to account for the differences. First, identification of survey flake sources was done in the field at the time of recording and if there was any question whether flakes were of local or non-local origin, they were simply designated unknown, explaining the high percentage of unknown source material. Excavated debitage, on the other hand, benefited from laboratory analysis and direct macroscopic, microscopic, and UV fluorescence analysis comparison with lithic samples from seven mountain and plains states in UNC's lithic source collection. This allowed greater accuracy in determining excavated debitage sources. Even factoring in potential errors from the lack of lab-based source identification of uncollected informal tools and debitage during surface survey, it is apparent there was significant use of local source

materials ranging from 65% (surface survey) to 86% (from Late Prehistoric excavation units). It is also certain that variability in flake source materials exists in different site surface clusters given they are part of a complex palimpsest of different period occupations, each of which may have had left differing local to non-local lithic material patterning. This latter possibility will be explored in subsequent GIS analysis of surface data sets.

### METHODS AND RESULTS OF GIS STATISTICAL ANALYSIS OF 5JA421 SURFACE LITHIC ARTIFACTS

Our first step in GIS mapping and analysis of Ballinger Draw artifacts was assembly of a database file of all surface artifacts, their types, and spatial locations. Figure 5.2 shows a GIS map overview of the Ballinger Draw



**Figure 5.2.** GIS map of GPS-recorded surface artifacts and sites (artifact clusters) overlaid on a 1 m resolution geo-referenced NAIP aerial photo. Note the Ballinger Draw stream channel in the upper left and the side-valley ridge lines and interior valley from upper left to lower right.

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Research Area with projections of artifact clusters that constitute individual sites. Note that two of the sites, 5JA421 and 5JA1810, tend to converge along their eastern and western margins, respectively. Technically, that convergence normally means they would be classified as a single site. However, we ultimately decided to designate them as separate sites due to our perception they appeared to represent two relatively distinct cultural phenomena, e.g., a dense stratified concentration of animal and plant processing camps with probable outlier activity, later stage processing areas (5JA421) and a ridge-top series of short-term living camps repeatedly in use over more than ten millennia (5JA1810).

Remaining sites in the area appear, on the basis of archaeological evidence, to represent a mix of short-term hunting and gathering camps (5JA1805, 5JA1807, 5JA1809, and 5JA1812) and physically discrete special purpose activity areas (5JA1806 and 5JA1811). We made the distinction between camps and activity areas as

camps having multi-use tool kits and hearths and/or roasting pits while activity areas were inferred by their limited tool types and general lack of hearth (fire-cracked rock [FCR] and/or small rock rings) or roasting pit (FCR concentration) features.

5JA1806 and 5JA1808 represent somewhat unusual cases. 5JA1806 is a scatter of heavily weathered artiodactyl bone, possibly elk, eroding out of a ridge-slope drainage swale with associated flake debitage and a single Early Archaic projectile point. Our working hypothesis for 5JA1806 is it represents a single kill and butchering event where a post-butchered carcass was rapidly buried by slope erosion colluvium and only recently re-exposed by modern erosion. The second case, 5JA1808, was a rock-filled hearth or roasting pit buried by alluvium in an upper Ballinger Draw spring-fed fen. It was discovered during profile cleaning of a deep head-cut eroding into the fen from down-stream. The buried feature's upper portion was 60 cm below the modern fen surface and *in situ* charcoal was AMS-radiocarbon dated

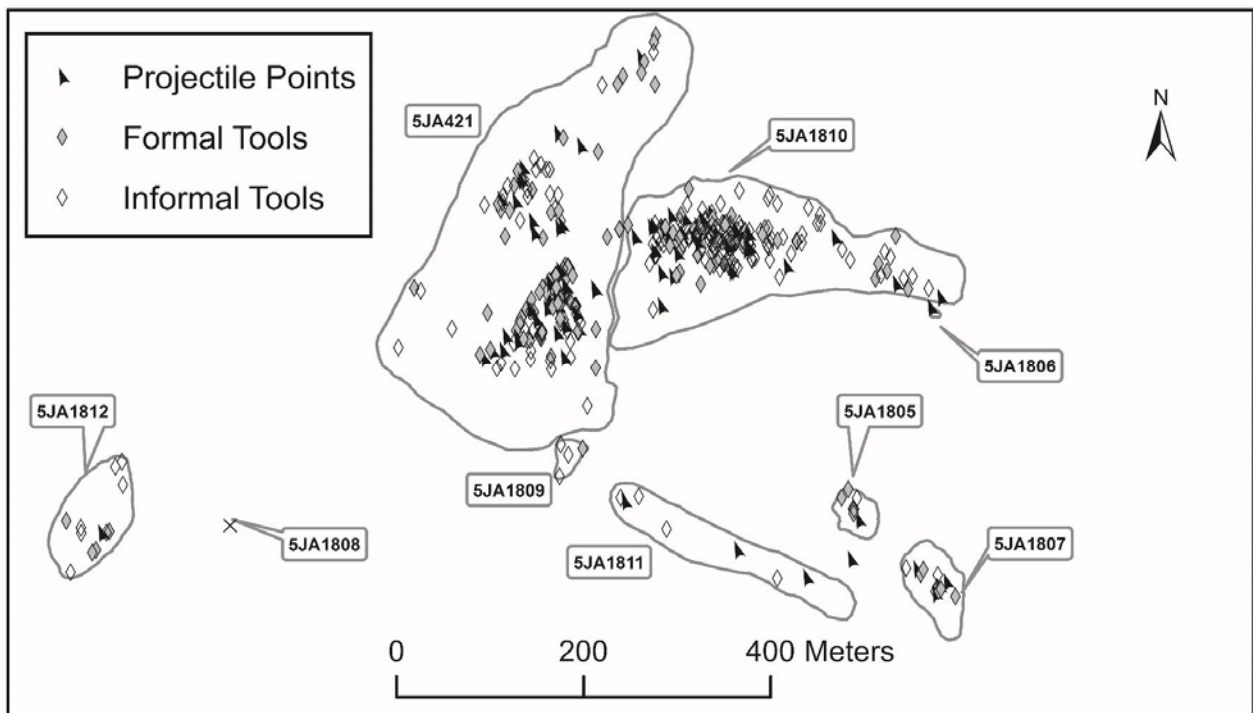


Figure 5.3. GIS blank-background projection of lithic tools within Ballinger Draw site boundaries.

to AD 910.

Figure 5.3 (above) shows the distribution of projectile points, formal tools, and informal tools for all Ballinger Draw sites, but omits the “clutter” of debitage locations (see Figure 5.2) which, in the denser sites, obscures visualization of lithic tool locations. What is significant about this GIS map is it shows that most of the sites and outlier artifact clusters of the two larger sites (5JA421 and 5JA1810) are more than simply flake concentrations, but most have activity-related lithic tools and culturally chronologically diagnostic projectile points.

GIS analysis *within* individual sites, particularly those with high artifact densities, provides a number of potential advantages for both analysis and interpretation of spatial distributions of individual tool types or collective mixes of tool types and debitage. When used in large areas such as the Ballinger Draw Research Area, GIS spatial analysis offers the opportunity to experiment with (and model) a siteless archaeology approach, allowing surface distributions of archaeological materials to potentially reveal landscape patterning of past human behavior (cf. Dunnell and Dancy 1983; Ebert 1992; Kvamme 1998: 127-129). Of course the effectiveness of a siteless survey strategy depends on surface artifact visibility, constrained natural conditions for rapid and deep burial of archaeological remains (alluviation, colluviation, eolian action), and minimal surface disturbance (water and wind erosion, human and animal actions).

Spatial pattern analysis techniques used in this study allowed us to assess the statistical validity of observed spatial clustering and/or dispersion of surface artifacts. It is important to remember that just because a pattern (in this case of various artifacts and their associated classes) appears “clustered” or “dispersed” to the human eye, it doesn’t mean that the apparent clustering/dispersal can stand up to the rigors of geostatistical testing.

#### **FOCUS ON AN INDIVIDUAL BALLINGER DRAW SITE: METHOD, ANALYSIS, AND RESULTS OF 5JA421 GIS AND ARCHAEOLOGICAL STUDIES**

In the following section, we use our results of archaeological and GIS analyses of 5JA421 to illustrate how we applied our GIS-enabled research design and methodologies to reconstruct Ballinger Draw’s prehistoric landscape. For instance, in our early investigations at 5JA421, we assembled GPS field data from the originally documented site area (cf., Armstrong and Struthers 1980; Rupp 1992) into a series of archaeological artifact class GIS layers. Subsequently, we expanded our surface surveys and GPS recording of artifacts outward from the site, expanding its artifact-scatter defined boundaries each new project year. We used projections of GIS maps and density patterns to guide our placement of excavation units. Those projections, as we demonstrate below, became increasingly useful as survey data and GIS mapping progressed project year to project year.

In our first year (2007), we excavated three separate test excavation units based in part on artifact surface density. In years 2 (2008), 3 (2009), and 4 (2010), we expanded the original test units into their own multi-unit excavation blocks, eventually excavating a total of 48 1 m<sup>2</sup> excavation units. GIS mapping of surface materials played an important role in situating and expanding excavation blocks for maximum effect. Figure 5.4 shows side-by-side GIS maps graphics of surface flake debitage and fire-cracked rock (FCR) distribution patterns with an inset map of the final excavation blocks and units.

Debitage and fire-cracked rock (inferred hearth or roasting pit locations) distribution and clustering patterns were used, along with topographic variables (e.g., stream terrace versus hill-slope), to help to inform excavation placement strategy. As shown in Figure 5.4, placement and expansion of the site’s excavation blocks closely mirrored its densest surface artifact cluster patterning. Density patterning also suggests that even more subsurface deposits lie well beyond currently excavated areas.

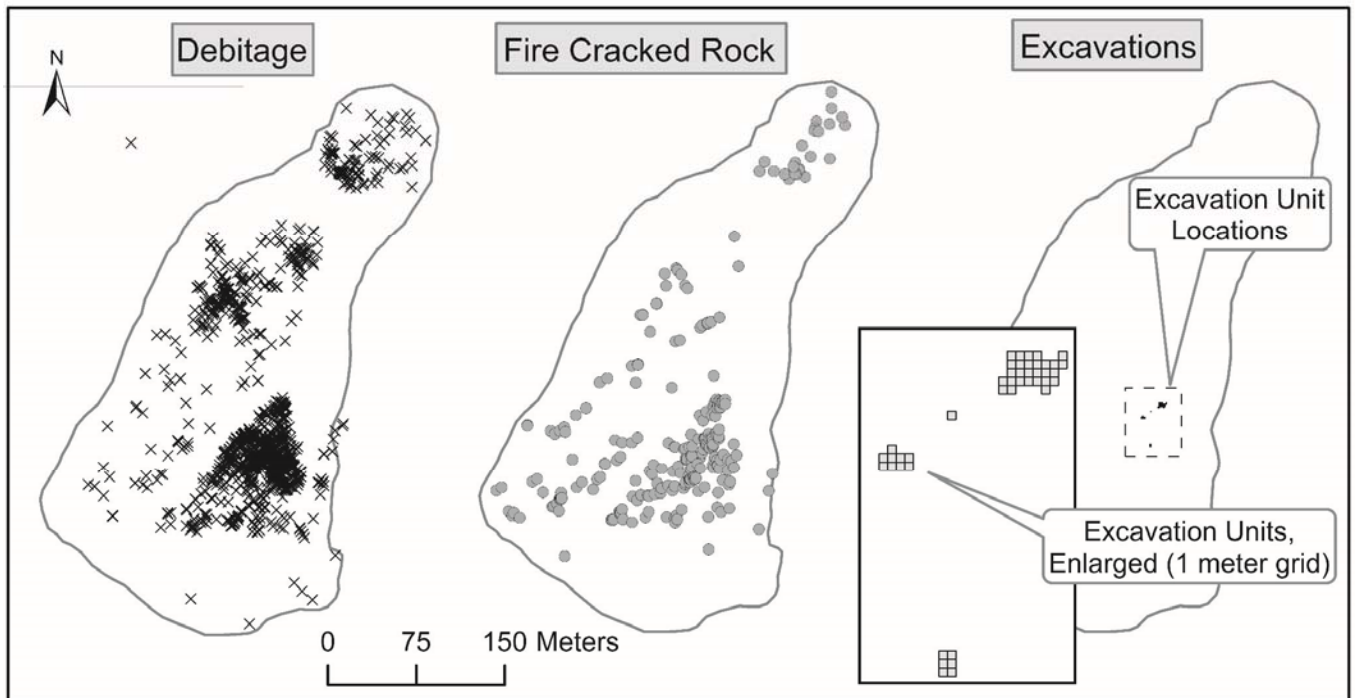


Figure 5.4. GIS maps of 5JA421 debitage and fire-cracked rock patterns and final locations of site excavation blocks.

#### GIS ANALYSIS METHODOLOGY

ArcGIS™ 10.0 has a number of statistical techniques which allowed us to assess distribution and clustering of surface artifacts within site boundaries, including average nearest neighbor analysis, multi-distance spatial clustering (using Ripley's K function), and hot spot/cold spot analysis (e.g., Rosenshein 2010a, 2010b).

A particularly powerful tool was hot and cold spot analysis. Hot and cold spot analysis is a data analysis technique used to examine concentration and dispersion in spatial datasets, their sub-classes, visually interesting patterns, and identification of outlier artifact clusters (Gibbs 2012; Gordon 1999; Johnston 2012; Maes 2012). Areas are highlighted within the context of geostatistics, identifying statistically significant areas of clusters and dispersion (cf., Rosenshein 2010a, 2010b; Spiker and Warner 2007: 201-202). Archaeological applications of GIS-based hot spot/cold spot analysis range from macro (regional) and meso (mid-level landscapes, such as Ballinger Draw) scales to site-specific micro-scales (Crema, Bevin and Lake 2010; Johnston 2010; Kvamme 1996, 1998).

In the case of 5JA421, we initially observed what appeared to be clear visual clustering of different artifact categories in GIS plot maps and, with advanced statistical correlation and cluster analyses, found much of that clustering to be statistically confirmed. A more nuanced view within the site's boundaries showed that, while there were numerous small areas of very intense artifact clustering (hot spots), other areas, while appearing to be clustered, simply were not as statistically significant. This suggests that purely GIS visualized artifact clustering on a landscape may, in at least some cases, be more apparent than real when subjected to statistical testing. This discovery also helped us better focus our field investigations as they advanced year-by-year, e.g., targeting certain site area locations for archaeological testing and excavation where surface evidence of past cultural activity appeared most focused.

The spatial pattern characteristics of individual categories of artifacts (i.e. formal tools, debitage, etc.) were analyzed in a four step process. First, the average nearest neighbor technique was applied to each surface artifact category. Second, the Multi-Distance Spatial

Clustering (Ripley's K function) was determined for each category. Third, the data was re-compiled for use in Hot/Cold Spot Analysis. Finally, this recompiled data was used to conduct Hot/Cold Spot Analysis. Each step helped us to understand one part of the distribution pattern of each artifact category. In addition, each step informed us for the selection of parameters in each next step.

The distribution of a surface artifact category was first analyzed using the Average Nearest Neighbor tool in ArcGIS. This technique told us whether a dataset of points (artifact category) was clustered, random, or dispersed. Our null hypothesis was that the artifacts were randomly distributed. In most cases we were able to reject the null hypothesis (using z-scores and p-values calculated by the tool) and state that, for example, fire-cracked rock was clustered and its cluster patterns were statistically significant. This approach constitutes a broad measure of clustering, but it doesn't really tell us anything about 'where' within the site clustering occurs. It's true that in many cases the technique simply verifies what is visually obvious.

At this step in the process, we knew a given artifact category was "clustered" but we wanted to examine the nature of that clustering more in-depth. The Multi-Distance Spatial Cluster Analysis (Ripley' K Function) tool aided us in assessing statistically significant clustering or dispersion over a range of distances. Presented in graphical form, the technique helped us to assess whether already proven clustering (via Average Nearest Neighbor) was focused in a relatively small distance range or whether the clustering was more spread out. But again, while useful in identifying more specifically the nature of the clustering, the technique also did not tell us precisely 'where' the clustering is strongest or weakest within the site.

Our third and next step in analysis of the clustering/dispersion of artifact categories was a data preparation step. In order to analyze the 'where' of clustering/dispersion our data needed to be weighted. As is, the data are simply nominal in nature. That is, one artifact at one location. The Hot Spot Analysis (Getis-Ord Gi\*) technique requires input data to be in interval or

ratio format. We used two tools in ArcGIS to create this weighted data. First, the Integrate tool was used to set a predefined distance, which then "snapped" together nearby events (each artifact). The Collect Events tool then provided a 'count' of events (artifacts) at each location. The distance tolerance input for the Integrate tool is a key decision. We selected relatively small distances for most of the artifacts, between .5 and 2 meters. Two important caveats about this process need to be noted. First, selection of the distance tolerance is somewhat arbitrary. However, we felt that our use of relatively small distances did not significantly alter the nature of the data. Second, the Integrate/Collect process significantly decreased the number of points used in subsequent geostatistical analysis. In some cases the reduction in points can make our next step (Hot/Cold Spot Analysis) nonviable because of small sample size.

Our final step was to use ArcGIS's Hot Spot Analysis (Getis-Ord Gi\*) tool to explore artifact distributions within the site. This technique has the potential of showing areas within the sites that are hot spots (statistically significant clustering) and cold spots (statistically significant dispersion). Our results, described below, varied with different artifact categories.

#### **Formal Tools Analysis Results**

The Average Nearest Neighbor analysis indicated that formal tools are clearly clustered with a mean distance between formal tools of 8.6m (random expectation 18m). Both Z-score and p-value for this analysis affirmed that formal tools had statistically distinctive clustering (Table 5.3). The Multi-Distance Spatial Clustering (Ripleys K function) results showed most of the clustering within a 40 to 120 meter diameter polygon along the east stream-side bank area of the site with perhaps a weak peak within a 55 meter zone.

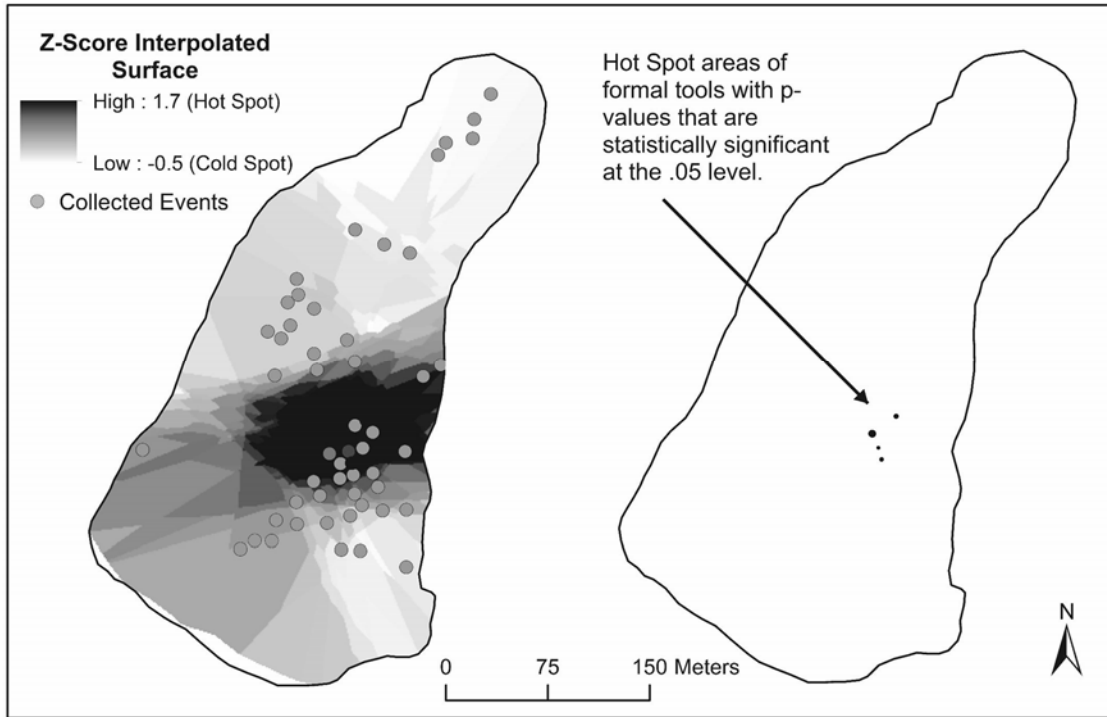


Figure 5.5. Hot Spot Analysis of 5JA421 Formal Tools.

Figure 5.5 (above) shows the result of our Hot/Cold spot analysis of formal tools, including projectile points. The map on the left shows an interpolated surface that uses Z-scores from the hot/spot analysis output. A one-tailed test of z-scores indicates that interpolated areas with a Z-score greater than 1.64 are statistically significant hot spots for formal tools. Alternatively, statistically significant cold spots should have a z-score lower than -1.64. There are no statistically significant

cold spots of formal tools. The map on the right in Figure 5.5 shows only the formal tool hot spot areas which are statistically significant at the .05 level (z-scores greater than 1.64). This is a very limited area which *closely conforms to our GIS map informed placement of 5JA421 excavation units* (see earlier Figure 5.4).

Table 5.3. Average Nearest Neighbor Summary of Formal Tool data for site 5JA421. n = 90.

Observed Mean Distance	8.639m
Expected Mean Distance	18.062
Nearest Neighbor Ratio	0.478
Z-Score	-9.468
p-value	0.00000

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Table 5.4. Average Nearest Neighbor Summary of debitage data for site 5JA421

Observed Mean Distance	1.994m
Expected Mean Distance	4.875m
Nearest Neighbor Ratio	0.409
Z-Score	38.472
p-value	0.00000

**Assorted, Less Frequent Artifact Types Analysis Results**

Surface surveys of 5JA421 yielded small numbers of associated bone, informal tools, ceramics, and ground stone, but bone was only recorded if it could reasonably be attributed as archaeological in origin, not from modern or recent historic sources. Archaeological versus non-archaeological bone determinations were field-based using such criteria as observations of bone emerging onto the surface through erosion and consisting of faunal material clearly not of recent origin, such as bison bone, a species eradicated from the region a century and a half earlier. The fully involved hot spot analysis process, described above, was not conducted on

these latter artifact subsets due to their small sample sizes. However, most secondary cultural material categories exhibited significant statistical clustering, although it was not possible to accurately assess their spatial intensity.

**Debitage Analysis Results**

As described earlier, the single largest amount of artifact material documented in 5JA421 surface surveys as well as in excavations was lithic tool manufacturing and refurbishment waste (debitage). As shown in the earlier Figure 5.4, there is apparent clustering of debitage throughout the site's 43 acres, but we also needed to determine if the GIS-visualized distribution pattern was

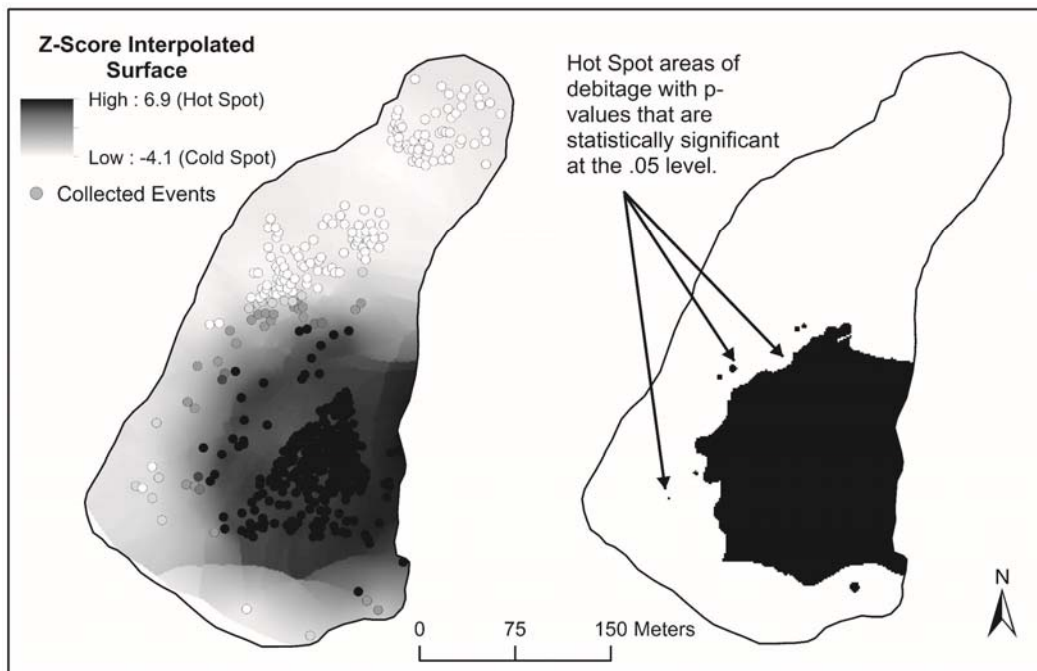


Figure 5.6. Cold (lighter shaded areas) and Hot (darker shaded areas) Spot Analysis results for 5JA421 debitage.

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statistically significant. We conducted Average Nearest neighbor Analysis on debitage points to assess overall clustering. Our analysis results (see Table 5.4) indicated a mean cluster distance of 2 meters between debitage points, showing statistically significant clustering of debitage. A random distribution would have returned an expected mean distance of 4.9 meters. These results confirmed our visual impression that the overall distribution of debitage was clustered. Multi-Distance Spatial Cluster analysis (Ripleys K Function) showed debitage most strongly clustered around 60 meters, with overall clustering terminating at ~170 meters.

The left-side map in Figure 5.6 shows an interpolated plot of debitage hot spots. Darker shaded areas represent areas of statistically significant intense lithic debitage. The lightest shaded areas represent cold spots which, if even appearing somewhat clustered, have statistically less significant intense debitage concentrations. Both the light and darkest points have

significantly low or high Z-scores of less than a .01 chance of being random. The right-side map on in Figure 5.6 focuses only on statistically significant (.05) debitage hot spots (clustering). Hot spot analysis clearly shows intense debitage clustering coinciding with earlier described formal tool hot spots and in the same general locations as the 2007-2010 excavation blocks.

### Fire Cracked Rock Analysis Results

We also analyzed fire cracked rock (FCR) distributions for statistical significance. In Ballinger Draw, fire-cracked rock is visually recognizable as fire-reddened and heat-fractured rock lying on the surface, normally consisting of cobbles and cobble fragments of quartzite and quartz and inferred as representing former hearth or roasting pit locations. Our FCR data set consisted of a 257 individual FCR rocks, or if they were a closely spaced (within .5 m) FCR cluster they were recorded as a single GPS point.

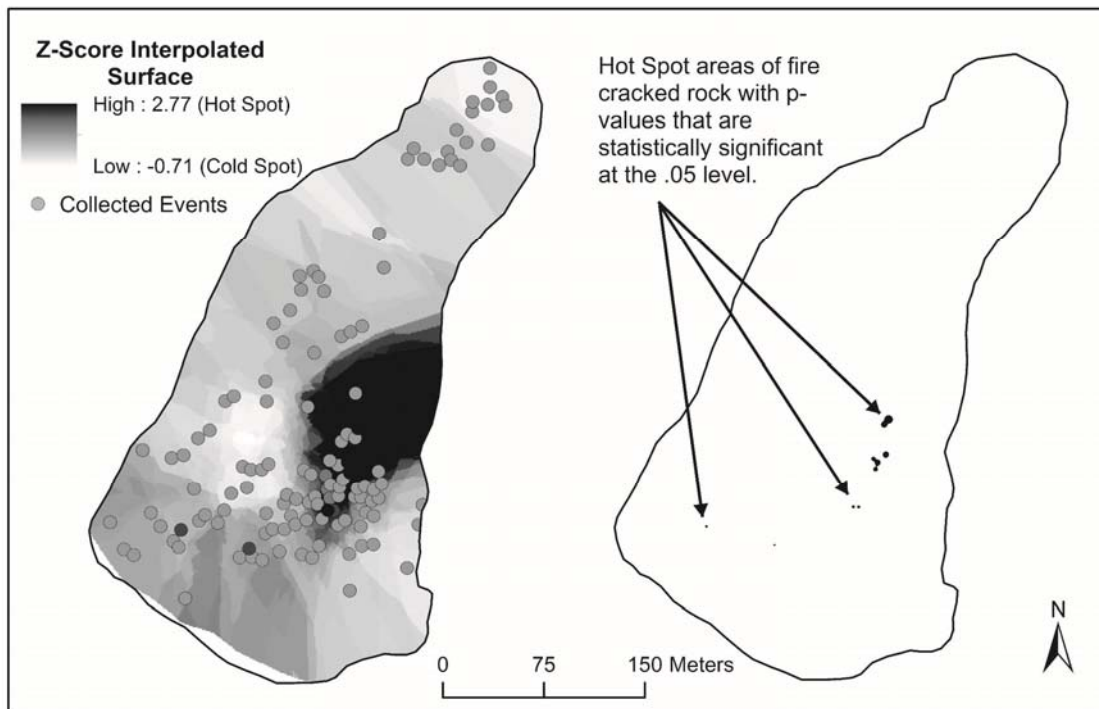


Figure 5.7. Cold (lighter shades) and Hot (darkest shades) Spot Analysis of 5JA421 FCR.



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While GIS-mapped patterns of FCR distributions appeared well-clustered to the naked eye (see Figure 5.4 above), we needed to substantiate that observation through statistical analysis. We found results of average nearest neighbor analysis (Table 5.5) and the Multi-Distance Spatial Clustering (Ripleys K function) analysis showed fire-cracked rock was strongly clustered at a peak of about 70 meters. Hot spot analysis, however, showed that areas of statistically significant clustering were very small and focused at only few locations within the site (Figure 5.7).

Our interpolated map (using kriging) of FCR clustering (Figure 5.7, left map) suggests intense clustering in the east central portion of the site, but this is misleading. The statistically accurate situation (Figure 5.7, right hand map) shows the interpolated surface (again using kriging) of p-values for 5JA421; with those darkest areas with .05 or lower values (statistically significant) while the bulk of the site has less significant p-values greater than .05. Interpretation of FCR analysis results confirm the probable significance of surface FCR density as an indicator of concentrated *subsurface* deposits. The majority of FCR hot spots occur within the general areas of formal tool and debitage hot spots and excavation blocks. However, a few FCR hot spots in the site's south and southwest quadrant suggest the presence of other camp or specialized activity (camp hearths, roasting pits...) areas. These areas should be targeted if excavations are resumed at the site in the future.

## CONCLUSIONS

The merging of theory, method, and practice in archaeology is a long and productive tradition. What is revolutionary since the advent of the New Archaeology Paradigm a half century ago is that our tools for acquiring and analyzing ever more accurate and detailed archaeological data in the field and laboratory continue to advance at an ever-accelerating pace. Among the most useful tools for archaeology today are Global Positioning System (GPS) and Geographic Information System (GIS) technologies. Merged with careful, traditional field survey and excavation methodologies, they allow us to accurately document three-dimensional imagery of modern residues of ancient technological remains on the landscape and better conceptualize and test hypothetical scenarios of past human cultural behavior.

In the preceding chapter, we have described a system of archaeological data collection that fuses traditional field methods with 21<sup>st</sup> century technology, both contributing to reconstructing and modeling prehistoric cultural systems at multiple scales of inquiry, from the individual site to localized geographic areas with shared geologic and natural conditions to geographic sub-regions and regions. Like the prehistoric peoples who once lived on the landscapes we study, we ourselves are changing and evolving in how we extract usable information from the archaeological record and apply new and old theory, method, and practice and emerging and future technologies in the quest for their better understanding and appreciation.

**Table 5.5. Average Nearest Neighbor Summary of Fire Cracked Rock data for site JA421. n = 257**

<b>Observed Mean Distance</b>	<b>4.442m</b>
<b>Expected Mean Distance</b>	<b>1.689 m</b>
<b>Nearest Neighbor Ratio</b>	<b>0.416</b>
<b>Z-Score</b>	<b>-17.92</b>
<b>p-value</b>	<b>0.00000</b>

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## CHAPTER 6

# THROUGH A GLASS, DARKLY: PATTERNS OF OBSIDIAN AND FINE GRAINED VOLCANIC TOOLSTONE ACQUISITION ON THE SOUTHERN PLATEAU

BY KENNETH C. REID

### ABSTRACT

*Early 19<sup>th</sup> century explorers, fur traders, and missionaries sometimes made passing reference to the toolstones used by Southern Plateau natives. Although some travelers compiled lexicons of native words, their own English and French vocabularies for the rich diversity of regional lithics ranged from impoverished to eccentric. As a result, many native terms for lithic categories have been simultaneously recorded and lost: we know how to say them but we don't know what they mean. Nevertheless, to cite one example, a slowly-dawning awareness of the place of regional obsidians in native industries can be traced from a neglected William Clark map of 1806 to the first appearance of the word itself in Irving's *The Adventures of Captain Bonneville in 1837*. This paper reviews how the "flints," black Bottle Glass," "crystalised carbonated Bitunem," and cailloux of early 19<sup>th</sup> century journal entries, word lists, and maps became recognized as obsidians in the 1870s and andesites and dacites by the 1980s. Some potential social boundary implications for late prehistoric western Idaho and eastern Oregon that emerge from these data are mentioned in conclusion.*

### INTRODUCTION

Our understanding of the distribution and identity of igneous toolstones along the boundary zone between the Columbia Plateau and Great Basin culture areas has increased markedly in recent years. Contract reports,

theses, and journal articles routinely report the sources and the distances represented by obsidian artifacts. The fine-grained volcanic suite of basaltic andesites, andesites, and dacites is beginning to receive comparable attention using x-ray fluorescence and petrographic analyses. However, less effort has been devoted to the outcrops, quarries, source areas, and workshops where these toolstones began their journeys. This paper highlights what we've learned – and still haven't learned – about these places after two centuries of intermittent inquiry. Toolstone data gaps noted for the Great Basin more than a decade ago still need to be addressed on the Southern Plateau: source area distributions, comparative ease of extraction, workability, and package size (Jones and Beck 1999:91-92).

No attempt will be made here to separate toolstones identified in the literature as obsidians (Hughes 2007), vitrophyres (Sappington 1981a), vitreous tuffs (Bailey 1992), and ignimbrites (Jaehnig 1992). For present purposes, all are grouped as "obsidian." Similarly, cherts, chalcedonies, flints, agates, jaspers, petrified woods, silicified argillites, and other microcrystalline silicates will be lumped under "chert." Finally, the umbrella term "fine-grained volcanic" (FGV) includes rocks informally known as "basalts" (Bryan and Tuohy 1960), "fine grained basalts" (Jaehnig 1991; Womack 1977), and "glassy basalts" (Nisbet and Drake 1982) in the regional literature. When these are geochemically and petrographically analyzed, depending largely on their silica content, they group as basaltic andesites, andesites, dacites, and trachydacites (Bakewell 1991). Nevertheless, it is still a good practice to distinguish these toolstones from basalt proper. For example, among middle Holocene industries reported along the lower Snake River it can be difficult for the reader to tell whether "basalt" means locally available subconchoidally-fracturing basalt river or talus cobbles, or conchoidally-fracturing, siliceous, fine-grained volcanic toolstones imported from a distant upland source, or some combination of the two (Muto 1976).



## HISTORY OF INVESTIGATIONS

Early 19<sup>th</sup> century explorers, fur traders, and missionaries sometimes made passing reference to the toolstones used by Southern Plateau natives, including the Shoshone (Tyrrell 1916:329) and Nez Perce (Baird 2000). Although a few visitors compiled lexicons of native words, their own English and French vocabularies for the rich diversity of regional raw materials ranged from impoverished to eccentric. As a result, native discriminations among lithic categories have been simultaneously recorded and lost: we sometimes know how to say them but we don't always know what they mean. Nevertheless, a dawning awareness of the distinctive qualities and limited distribution of obsidian flickers through the early literature. Sorting out the basalt problem got off to a much later start (Bakewell 1991, 1993, Bakewell and Irving 1994, Reid et al. 1993, Reid 1997).

The word obsidian does not appear in the journals or correspondence of the Lewis and Clark expedition, the Astorians, or the North West or Hudson's Bay Company clerks who left the first written records of the region, although they sometimes noted the distinctive properties of volcanic glass and sometimes attempted to describe it. For example, Samuel Black's response to a Hudson's Bay Company questionnaire in 1829 says that the Nez Perce

*"...point their arrows with Flint & a kind of crystal stone near resembling the color of Black Bottle looks like crystalised carbonated Bitunem, its found in the mountains but I believe a Secondary production Rock Crystals may be found but do not know whether in the primitive or Secondary productions.—I have seen the carbonated Bitunem like crystal hanging about them as ornaments it appears to brake in Thin bits like Flint Pebbles &c This is all the minerals I have seen among the Indians"* (Baird 2000:50).

Unknown to the undictionaried Black, obsidian had long been recognized as a "stone reckoned among glass, sometimes green, sometimes black and clear and bright" (Simpson and Weiner 1989:665). However, at least for

this study area, the term languished in obscurity until Washington Irving resurrected it in 1837, where arrows "tipped with obsidian" are mentioned for the first time among natives in the Browns Bench area south of Twin Falls (Irving 1961:221).

Irving's widely read books seem to have popularized the term, for it appears with increasing frequency after 1837. The following year a missionary mentioned obsidian outcrops in the upper Henry's Fork (Parker 1990:99), and in 1839 an itinerant naturalist recalled his thirsty companions sucking on "bullets, pebbles of chalcedony, and pieces of smooth obsidian" near Lost River (Townsend 1999:80). These may be the first references to the nearby Big Table Mountain and Big Southern Butte sources. Russell's memoir of trapping the same area covers the years 1834-1843, although it was not readied for publication until 1848. His mention of Snake arrows "pointed with quartz or obsideon" (sic) probably postdates a reading of Irving's *Bonneville* (Russell 1965:144).

The new word spread quickly. Within ten years, obsidian had been recognized in an archaeological context in Hopewell mounds in Ohio (Squier and Davis 1848). By 1876, the term was familiar enough for Powell to elicit different Numa terms for "arrowhead," *Wu-nap'*, and "black obsidian arrowhead" *Ta-sip'* (Fowler and Fowler 1971:131, 251). Two years later the pioneering lithic technologist William Henry Holmes visited the Obsidian Cliff source area at Yellowstone National Park and published a detailed description (Holmes 1879).

Ethnographers soon took note of the stone as well. Robert H. Lowie discovered obsidian (*du'p'*) was widely available and used for knives and arrowpoints among the Northern Shoshone at the Lemhi Agency (1909:173). By the following year, when Herbert J. Spinden summered among the Nez Perce gathering thesis data, the word appeared regularly in scholarly monographs. He identified obsidian as the preferred stone for chipped implements among the Nez Perce, with pieces collected in the John Day valley to the west and from Yellowstone to the east (Spinden 1908:184).

## LITHICS IN THE WEST

Spinden was unfamiliar with the earlier work of Alice Fletcher in the Nez Perce country. Had he reviewed her notes, he might have assigned shorter distance-to-source estimates for Nez Perce obsidians. Fifteen years earlier, Fletcher had reported that

*“In southern Idaho, in the Snake country, were two buttes, and parties went there for flint at the risk of their lives. They would quarry the stone and put the rough pieces of flint in a deerskin bag, and start home. In safe places they would stop and rest, and while resting would work out arrowheads. (I have found many work-shops at resting places on the trail leading from the Nez Perce land to the southern country)”* (Sappington and Carley 1995:22).

While it is arguable whether “Snake country” refers to the land of the Snakes (Numa) or the Snake River Plain, I suspect the two southern buttes were sources of obsidian rather than flint. The term appears nowhere in Fletcher’s notes on the Nez Perce, but she described a “black stone (ops) from which arrow points were chipped” and that sometimes figured in men’s names (Sappington and Carley 1995:25). The *Nez Perce Dictionary* gives two terms, *?aps* and *suxs*, for flint or obsidian (Aoki 1994:1158). Presumably *ops* and *?aps* are the same stone. The black color and use for arrow points suggests the material is obsidian, while use of the term in male names is confirmed by *Apash Wyakaikt*, “Flint Necklace,” the Nez Perce chief who hosted Lewis and Clark in 1806 (Moulton 1991:204). Again, *ops*, *?aps*, and *apash*, all seem to be the same term.

Fletcher’s notes bring us back to the records and maps of Lewis and Clark. Although the word does not appear in any of the expedition’s journals, a few entries describe a toolstone that is certainly obsidian, though always called “flint.” Thus, in camp with the Shoshones on the Lemhi River, Lewis recorded “...some of this flint was as transparent as the common black glass and much of the same color easily broken, and flaked off much like glass leaving a very sharp edge” (Moulton 1988:143).

Less widely appreciated is the probability that William Clark, the expedition’s cartographer, pinpointed the location of the most important obsidian source in western Idaho. He labeled a Nez Perce map with translated place names, including a “Flint Rock” in the lower reach of a stream now known as the Payette River (Moulton 1983:100). “Flint Rock” matches the location of the obsidian source at Timber Butte (Figure 6.1).

The early conflation of obsidian and flint may not have ended there. Eight years later, the first published version of Clark’s map of the Snake River country shows the modern Burnt River as “Flint River” (Moulton 1983:126), with the name placed in the lower valley at the approximate location of the Dooley Mountain obsidian sources. If Clark’s Nez Perce informants used the same name for the rock and the river, it was probably *ops*, and Fletcher’s two buttes probably correspond to the first two obsidian sources met by south-bound Nez Perce: Timber Butte and Dooley Mountain. As noted by Fletcher, both might have been risky places for Nez Perce knappers early in the 19<sup>th</sup> century. However, in the more distant past Timber Butte and Dooley Mountain fell within, rather than at the contested edge, of the ancestral Nez Perce territory.

If Clark unknowingly recorded the location of Timber Butte, and Fletcher unknowingly described direct procurement of Timber Butte obsidian by Nez Perce knappers, the source did not become known to archaeologists and geologists until 1963. While searching for an historic Shoshone grave, Idaho’s state historian stumbled onto an obsidian outcrop “more than 20 feet wide, and extending at least 60 feet along a fracture” near the crest of Timber Butte (Wells 1980:3). The source area had been overlooked by geologists, and was not professionally mapped and recorded until a decade later (Clemens 1990:8).

LITHICS IN THE WEST

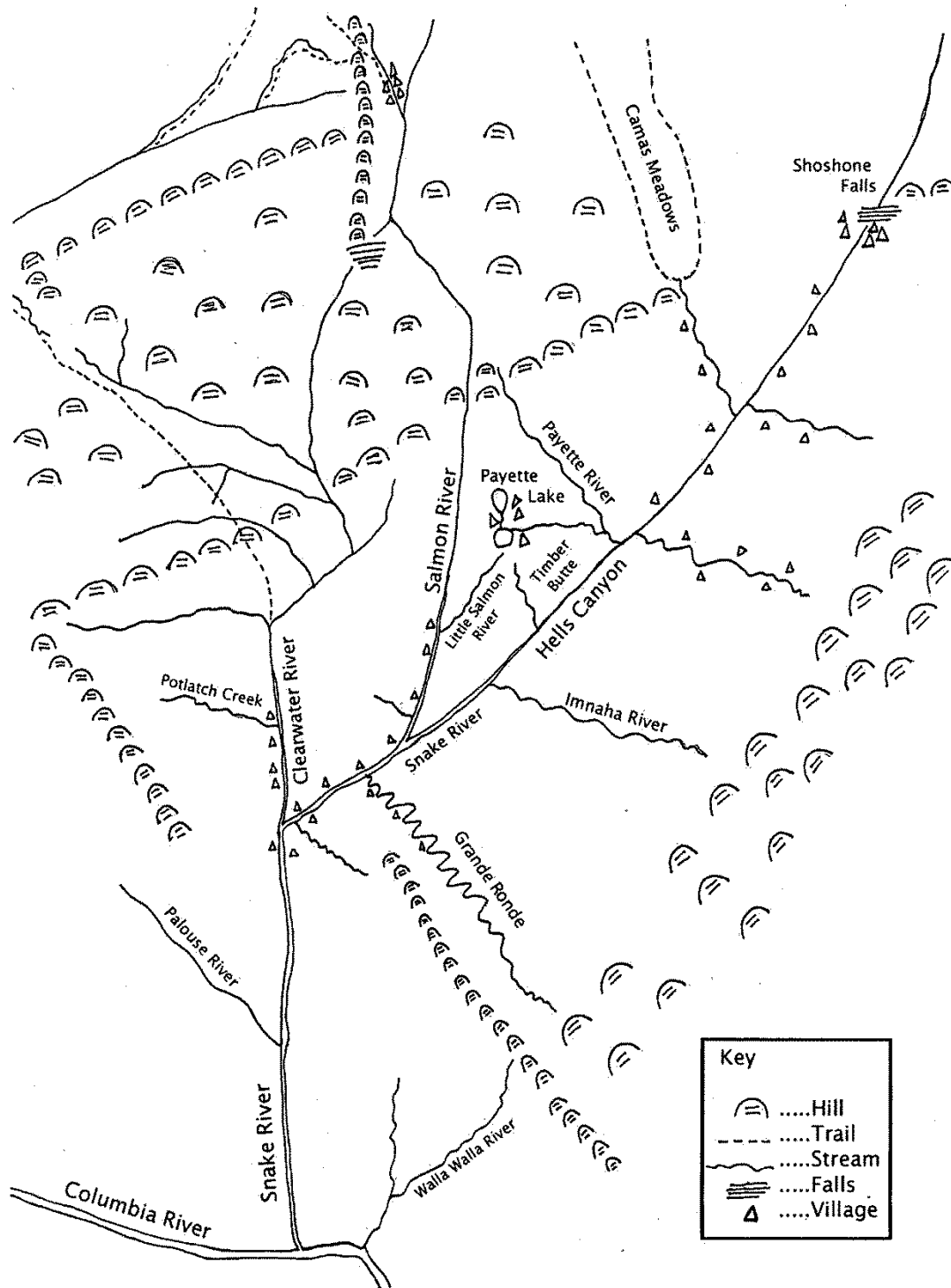


Figure 6.1. Nez Perce map of 1806 showing the location of Timber Butte ("Flint Rock"). Redrawn and relabeled from Moulton (1983: Map 100).

Following Wells's brief report of the Timber Butte source, and excepting a single early attempt to chemically source samples from Veratic Rockshelter in southeastern Idaho (Wright et al. 1969; Hughes 2007) obsidian studies in the Snake River basin blossomed (Sappington 1981a, b, c, 1984; McDonald 1985, 1986; Reed 1985; Bailey 1992, 2006; Willingham 1995; Holmer 1997; Plager 2001; Thompson 2004; Corn 2006; McAlister and Henrikson 2007; Willson 2007; Armstrong 2009; Lee and Metcalf 2011). However, with the exception of McDonald's work at Dooley Mountain, these studies focused on the identification and sourcing of artifacts using x-ray fluorescence analysis of their geochemistry. Studies of trade and travel trumped any pursuit of procurement, processing, and production, and little effort went into characterizing source areas as workshop or quarry sites.

Studies of the fine-grained volcanic (FGV) toolstones in the region had an earlier start with Bryan and Tuohy's (1960) Stockhoff monograph, and gained momentum when obsidian sourcing accelerated. However, in contrast with the obsidian studies, the FGV focus remained on quarries, workshops, and reduction technologies, rather than on tracing artifacts to outcrops within regional frameworks of mobility and exchange (Warren et al. 1971; Ruebelmann 1973; Bucy 1971, 1974; Womack 1977; McPherson et al. 1981; Nisbet and Drake 1982; Jaehrig 1991, 1992; Dickerson 1998; Reid and Root 1998). Recent success with FGV sourcing using x-ray fluorescence and petrographic thin sections (Bakewell 1991, 1993, 2002, 2005; Dickerson 1998) promises that establishing artifact-to-outcrop distances and directions will soon become routine. However, the continuing tendency to characterize outcrops and workshops as "quarries" still leaves the earlier phases of production dynamics largely unexamined.

#### **WORKSHOP ECONOMICS**

The appraisal of toolstone quality by archaeologists has taken several directions, ranging from symbolic to kinetic to mechanical. Apart from package size, accessibility, and workability, the emic role of such

qualities as color, luminosity, radiance, brilliance, and "strength" are appropriate to acknowledge in some contexts. For example, a term for "powerful or strong" among the Lemhi Shoshone distinguished obsidian from iron (Lowie 1909:173). As noted earlier, Samuel Black's reference to the ornamental use of obsidian may be echoed in the name of Flint Necklace for a Nez Perce chief (Baird 2000:50; Moulton 1991:204). The power of obsidian may also have been related to its use for war points in recent times (Tyrrell 1916:329). While there is surely more to toolstone selection than geographic proximity and mechanical properties, here we shall only acknowledge the semiotics while we focus on the economics.

Economic geologists distinguish between the place value and the unit value of rocks and minerals. High place value characterizes a rock when it is used at or near the place where it occurs naturally. High unit value characterizes a rock with properties that make it unique or valuable within a certain context, and worth transporting over long distances (Bates 1960:7-8). The distinction may have more general applicability. But what are the time and labor costs involved in finding, testing, trimming, and transporting stone-age lithics?

Cost/utility indices offer a more quantitative approach to measuring the place and unit values of toolstones. Cost/utility indices gauge search and processing time, as well as the workability, size and form, and durability of the material (Elston 1990:154-159). Search time includes extraction and assaying pieces of toolstone. Processing time includes primary and secondary reduction, and the production staging sequence for bifaces. In the Snake River basin, all of these activities unfold in a context partly determined by elevation, snow cover, and vertical exposure.

The size and form of desired tools constrain decisions about the appropriate clast or nodule shape and weight. Size varies widely among different raw materials and obviously constrains the initial dimensions of cores and flake blanks. Small nodules or clasts can only make small stone tools, and may require distinctive reduction methods such as block-on-block or bipolar flaking to do so (Andrefsky 1994:384-386). Raw materials that allow

large cores, blanks, or early-stage production bifaces to be made at the source for transport elsewhere may be favored over smaller pebble or cobble sources. For example, the dacite at Craig Mountain outcrops in blocks more than 1 m in diameter near the summit (Womack 1977: Fig. 3) and as tabular and subrounded boulders strewn down the southern slope (Figure 6.2). At the other extreme, regular exploitation of small cobble source areas may be masked by the export of cobbles



**Figure 6.2. Dacite boulder at the Stockhoff workshop (author photograph).**

and their subsequent reduction at camps distant from the source (McDonald 1985).

Workability is a measure that combines toughness and soundness. Knapping experiments show that highly variable soundness or resistance to freeze-thaw cycles typifies the basaltic andesites from Elk Mountain and Starvation Spring (Nisbet and Drake 1882:18-20; Jaehnig 1991:41). This factor must have compromised any advantage promised by the large size of toolstone clasts at Starvation Spring. The soundness of surficial obsidian deposits is also often problematic. Bailey's (1992)

inspection of more than seventy surface exposures around the Snake River Plain noted how little of the material was suited for controlled flaking because of devitrification. Presumably, smaller clasts dry out more quickly and completely than larger ones. Other factors affecting obsidian soundness include spherulitic inclusions and phenocrystic impurities (Bailey 1992).

Toolstone toughness refers to the effort required to sustain a controlled fracture, and corresponds to what

Elston (1990:156) terms plasticity.

Toughness has often been appraised kinetically through replicative knapping. Numb-wristed veterans of these experiments agree that fine-grained volcanic toolstones are hard to work (Bucy 1971:98-101; Jaehnig 1991:40-45; Root 1998:7.1-7.13). FGV toolstones in the Great Basin are similarly intractable, with higher fracture toughness than cherts (Jones and Beck 1999:90). However, not much has been done to actually measure the differences, or explore varying workability within individual toolstones.

Taking a page from the fracture mechanics literature, MacDonald (1995:348) used a textbook abrasion test as a toolstone quality index to rank toughness for andesites, cherts, opalites, and obsidians recovered from a seasonal

camp near Starvation Spring. Andesites ranked almost twice as tough as chert and opalite, and obsidians, as expected, were the easiest material to biface. However, the referenced toughness values include the caution that they "do not represent the range of variability that occurs within these groupings" (Cottrell and Kamminga 1990:129).

**Table 6.1. Comparative Fracture Toughness Values<sup>1</sup> for Regional Fine Grained Volcanics compared to Obsidians and Unheated and Heated Chert, Flint, Agate, and Jasper (data from Domanski and Webb 1992, 1998).**

Obsidians	FGV	"Chert" -	"Chert"- 300°C	"Chert" - 400°C
24.01 <sup>a</sup>	73.50 <sup>1</sup>	48.54 (chert)	49.13	36.75
26.30 <sup>a</sup>	70.86 <sup>2</sup>	65.85 (flint)	38.84	37.12
27.42 <sup>a</sup>	55.67 <sup>3</sup>	51.52 (flint)	37.31	34.88
25.82 <sup>b</sup>	77.16 <sup>4</sup>	81.96 (agate)	64.92	31.72
	89.51 <sup>5</sup>	72.41 (jasper)	56.04	47.41

<sup>1</sup> Cylinders approximately 22 mm in length and 15 mm in diameter were mechanically impacted by forces ranging between 21-56 lbs, yielding fracture toughness values expressed as megapascals (MPa.mm<sup>0.5</sup>).

<sup>a</sup> Papua New Guinea; <sup>b</sup> Glass Butte, Oregon; <sup>1,2</sup> Midvale Hill basaltic andesite; <sup>3</sup> Stockhoff dacite; <sup>4,5</sup> Pataha Canyon basaltic andesite

The Pataha Canyon lithic analysis used a controlled mechanical fracture toughness test to evaluate workability of the local basaltic andesite (Domanski and Webb 1998). Testing followed procedures described in Domanski et al. (1994:186-188) and Whittaker et al. (1992:262-267). Cylinders approximately 22 mm in length and 15 mm in diameter were mechanically impacted by forces ranging between 21-56 lbs, yielding fracture toughness values expressed as megapascals (MPa.mm<sup>0.5</sup>). Although the sample sizes may be too small to be more than suggestive, they show the difference between two cobbles of Pataha Canyon basaltic andesite is as great as the difference between unheated and successfully heated chert (Table 6.1). The good workability knappers report for Stockhoff dacite (Womack 1977:76-83; Root 1998:7.3) is reflected in its low fracture toughness.

As expected, the data indicate that obsidians have the lowest fracture toughness and are the easiest toolstone to biface. However, given the notoriety that fine-grained volcanics have for relative intractability, it is surprising to find that at least three of the FGV toolstones are comparable to unheated cherts, flints, agates, and jaspers in their fracture toughness. Significant differences among them do not appear until the cherts are heat treated to 400°C. The siliceous dacite from Stockhoff is actually easier to work than the unheated chert, jasper, agate, and one of the flint controls, and not much more difficult than the successfully heated jasper.

#### TOOLSTONE TERRANES OF THE BASIN-PLATEAU BOUNDARY

With these considerations on package size and workability in hand, we can turn to the toolstone geography of the study area.

The southern Snake River basin alternately divides and integrates the Basin and Plateau culture areas. It includes two partially overlapping toolstone provinces or "terranes" (Elston 1990:155) where igneous lithologies rival cherts in abundance, distribution, size, and workability. The middle and upper Snake River and lower reaches of several tributaries are rimmed by more than 70 reported obsidian sources. Nearly half have been chemically fingerprinted through continually refined x-ray fluorescence studies.

Unlike the garland of obsidian sources draped around the Snake River Plain, FGV toolstones cluster within the Columbia River Basalt Group (CRBG) of northeastern Oregon, southeastern Washington, and adjacent western Idaho. Three bedrock peninsulas of this CRBG Terrane jut eastward into Idaho (Figure 6.3): from south to north, the Weiser, Clearwater, and St. Maries (or Benewah) embayments (Camp et al. 1982).

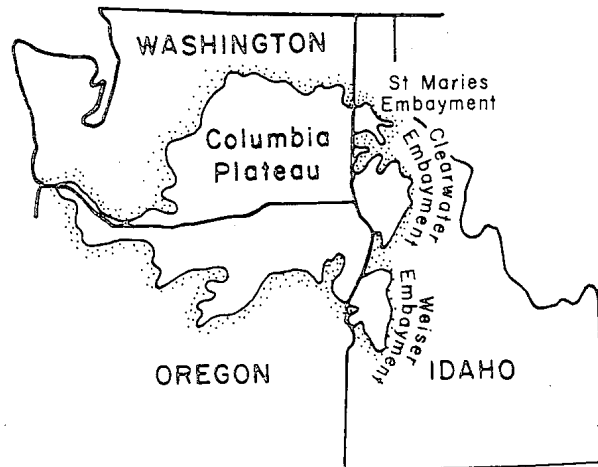
The Weiser and Clearwater embayments host extensive toolstone exposures and workshops, including the Midvale Hill and Mesa Hill sites in the Weiser basin, and High Breaks Ridge on the Joseph Plain (Fig. 5). Similar sources may outcrop on the St. Maries embayment, but have not yet been documented.

### Snake River Plain Terrane

The locations, identities, and synonymies of Snake River Plain (SNP) Terrane sources have been summarized by Holmer (1997). Working with a database of 1,200 sourced specimens from southeastern Idaho, he offered several distributional generalizations for the eastern Snake River Plain: obsidian seemed to move in directions parallel rather than perpendicular to the Snake River; greater distances between artifacts and sources were noted among late Paleoindian and late prehistoric assemblages than during the middle and late Holocene; projectile points were found on average 43 km further from the source than debitage; sources had a catchment radius of about 250-300 km; and five of the sources accounted for 82% of the sample. He did not attempt to distinguish source areas, workshops, or quarries from one another, and based his findings exclusively on artifact-to-source distances and bearings.

Building on Holmer's start, Plager (2001) developed a database for all of southern Idaho, and calculated distance algorithms for each obsidian source. She found that prehistoric hunter-gatherers hiked along procurement paths 20% longer than Holmer's Euclidian distances (Plager 2001:57). Her data confirmed east-west traffic patterns along the Snake River Plain, and found a regular distance-decay relationship for the six most represented obsidians: Big Table Mountain (Bear Gulch), Big Southern Butte, Browns Bench, Malad, Owyhee, and Timber Butte.

Holmer and Plager limited themselves to distributional studies of chemically fingerprinted obsidian artifacts. Neither examined source areas or workshops in any detail. Although 31 chemically distinguishable outcrops have been mapped and sampled, only a handful account for most of the sourcing data reported in Holmer (1997), Plager (2001), and Willson (2007). Five sources made up 80% of the 1,200 artifacts in Holmer's (1997) data base: Malad, Timber Butte, Big Southern Butte, Browns Bench, and Big Table Mountain (Bear Gulch).



**Figure 6.3. The Columbia River Basalt Group (CRBG) and its eastern embayments (reproduced from Camp et al. 1982:57).**

Working with an enlarged data base of 2,607 artifacts, Plager (2001:35-36) found that 85% of the southern Idaho specimens came from the same five sources, plus Owyhee. Willson (2007:22) summarized findings for 2,033 obsidian artifacts from 96 sites. Again, five sources accounted for 85% of the sample, except that here the Owyhee source outranked Big Table Mountain.

The distribution of the most represented sources is shown in Figure 6.4. The prominence of the subsample summarized in Table 6.2 is reinforced by individual site studies. For example, at deeply stratified Wilson Butte Cave, the Browns Bench and Big Southern Butte sources accounted for two thirds of the 17 SNP obsidians identified (Bailey 2006:126).

Bailey (1992:31-32) visited 76 ignimbrite/obsidian exposures around the Snake River plain and found none exposed in bedrock. All sources comprised cobble exposures on hillslopes or stream gravels. At most localities, much of the exposed material was too weathered for successful knapping. The average lower elevation of the most widely trafficked obsidians is about 500 m higher than the same contour for the FGV workshops, a potential constraint on seasonal accessibility.

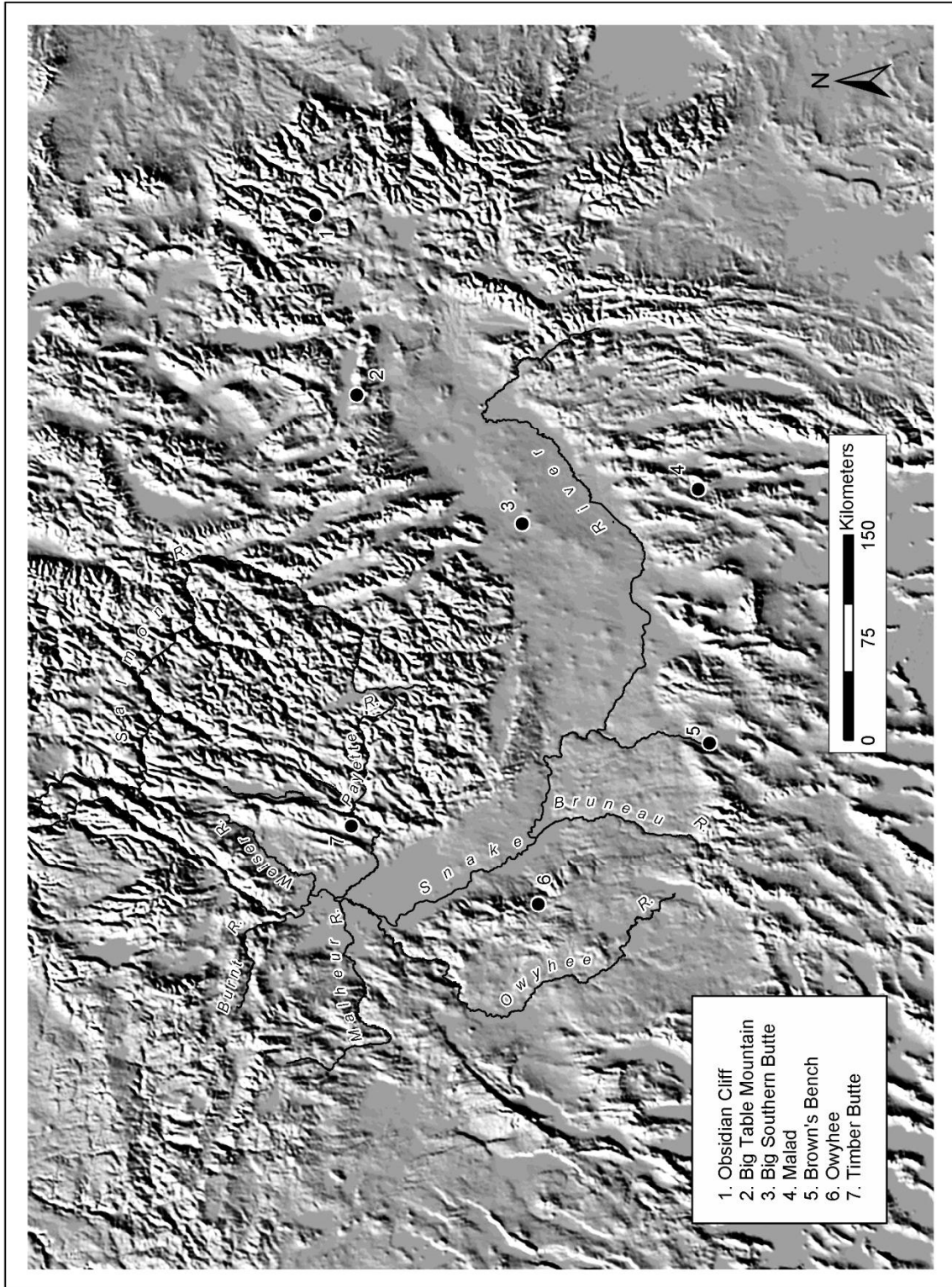


Figure 6.4. Source areas for the most widely distributed obsidians of the Southern Plateau.



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Table 6.2. Summary Data for the Most Widely Distributed Obsidian Sources in the Snake River Plain Terrane.

Source	Area	Elevation	Clast	Workshop/Quarry	Earliest
Timber Butte <sup>1</sup>	16 km <sup>2</sup>	1341-1426	25 cm	Workshop	Clovis
Big Southern Butte <sup>2</sup>	.17 km <sup>2</sup>	1585-2231	60 cm	Workshop	Clovis
Owyhee <sup>3</sup>	~ 4 km <sup>2</sup>	1219	20 cm	Workshop	Haskett
Browns Bench <sup>4</sup>	2,000 km <sup>2</sup>	2237	30 cm	Workshop	Clovis
Malad <sup>5</sup>	~ 3 km <sup>2</sup>	1768	15 cm	Workshop	Folsom
Big Table Mountain <sup>6</sup>	.51 km <sup>2</sup>	2193-2713	20 cm	Quarry	Folsom
Dooley Mountain <sup>7</sup>	~ 10 km <sup>2</sup>	1341-1829	25 cm	Workshop	Windust

<sup>1</sup>Wells 1980; Sappington 1981 a, b; Clemens 1990; Corn 2006; Michels 1988

<sup>2</sup>Sappington 1881a; Bailey 1992; Hughes 2008, 2010, 2011a,b

<sup>3</sup>Sappington 1981c; Bailey 1992; Plew and Willson 2005; Gallagher 1982; Willson 2007

<sup>4</sup>Bailey 1992; Hughes 2006, 2011a,b

<sup>5</sup>Bailey 1992; Thompson 2004; Davis and Root 2005

<sup>6</sup>McDonald 1985, 1986; Brauner 1985

Clast sizes for the obsidians are comparable to the basaltic andesites, but considerably smaller than the dacites (Table 6.3). Obsidian nodules in the study area typically range between 15-30 cm in their long axis. Measurements from nearby biface caches sourced to these exposures are consistently less than 20 cm (Kohntopp 2006; Lohse et al. 2010; Pavesic 1966; Hughes and Pavesic 2005).

By comparison, the package size of regolithic or interflow outcrops of microcrystalline toolstone in the region is poorly documented. However, alluvial cherts in the Snake River basin typically occur as small cobbles or pebbles. Chert gravels exceeding 13 cm in diameter are mentioned in geological sources (Reid 1997:75), but siliceous cobbles on gravel bars examined below Hells Canyon Dam are smaller. Size ranges have not been reported for the chert component of the Crowsnest Gravel, exposed along the Snake River for 160 km below Kanaka Rapids. Chert clasts make up a “sizeable proportion” of the unit and presumably decrease in caliber in a downstream direction (Malde and Powers 1962:1215).

Among the six highest ranked obsidian sources reviewed here, quarry pits have been identified only at 10CL627 (Table 6.2), one of eight recorded workshops that make up the Big Table Mountain (Bear Gulch) complex in the Centennial Mountains. Information available for the other sources in Table 6.2 supports the

general applicability of Sappington’s (1984) “procurement without quarry production” hypothesis.

These exposures were probably visited by individuals or families during the seasonal round, with cobble harvests embedded in other activities. Grubbing with stone or antler picks or digging sticks for shallowly buried unweathered nodules would have been no more difficult than harvesting potatoes for today’s gardener. On-site testing for cobble soundness would involve little effort. Procurement costs included seasonally-timed uphill hikes, harvesting and assaying of nodules, and downhill treks with suitable pieces of toolstone or early-stage production bifaces.

The vast area reported for the Browns Bench exposure (Table 6.2) is probably underestimated and certainly includes many unrecorded workshops of variable size. Similarly, the Timber Butte source area is based on the Timber Butte Rhyolite Formation, which presumably includes several unrecorded workings. The property is on private land and has not yet been systematically surveyed. The figure for the Dooley Mountain sources includes 12 sampled and mapped areas on the summit and north and south slopes of Dooley Mountain (McDonald 1985:66). Among the eight sites at Big Table Mountain, 10CL267 is the largest, at .51 km<sup>2</sup>, and the only one with quarry pits. The others range in size from 114 m<sup>2</sup> up to >2 ha. Halford (2008:49) suggests that the bedrock quarrying of Bodie Hills obsidian in California between about 3500-1350 B.P. was

stimulated by the continuous depletion of larger surface cobbles beginning in the early Holocene. A similar dynamic may account for the shift from surface collection to excavation apparent at Big Table Mountain.

However, the obsidian sources as a group do not display the intensive nearby workshop activity reported for the FGV sources. This picture stands in still sharper contrast with procurement evidence recently reported for the Obsidian Cliffs source area on the Yellowstone Plateau. Here recent post-fire surveys have identified scores of quarry/workshop clusters, each comprising groups of depressions, pits, and trenches associated with abundant workshop debris: blocks of obsidian, cores, production bifaces, and debitage. Clast sizes are not reported, but it appears that pieces collected at or near the surface were smaller than mined or quarried pieces. The depressions and pits ranged up to 2.5 m in depth, and the trenches up to 35 m in length (Johnson et al. 1995; Davis et al. 1995: Appendix A). Hundreds of these quarry features clustered in 59 discernible loci, a pattern arguably consistent with direct procurement by task groups moving large amounts of material in single episodes.

#### **Columbia River Basalt Group (CRBG) Terrane**

An array of fine-grained volcanic sources mapped as the Powder River Volcanic Field (Bailey 1990) in eastern Oregon includes the high-silica dacite at Craig Mountain, where the Stockhoff, Marshmeadow, Ladd Canyon and nearby Pilcher Creek workshops cluster. The dacite originates in the Saddle Mountain Basalt Flow. Another cluster of basaltic andesite workshops occurs on the Joseph Upland, where the Grand Ronde Basalt Flow laps around the Wallawas on the north and east, and juts eastward across the Snake River in three Idaho embayments. The Grande Ronde is the most widely distributed flow in this toolstone province.

Table 6.3 summarizes extant data on nine FGV workshops of the CRBG Terrane. Their locations are shown in Figure 6.5. The level of investigation varies across the sample. A gridded surface collection of 5,860 m<sup>2</sup> at 10WN10 on Midvale Hill recovered 320 nodules, 165 cores, and 37 bifacial and unifacial blanks (Bucy

1974:16-17), while at nearby Mesa Hill, also within the Weiser embayment, a 68 m<sup>2</sup> block excavation of a shallowly sealed single-component workshop floor piece-plotted a much higher density of bifaces, unifaces, cores, hammerstones, anvils, and finished tools (Ruebelmann 1973), revealing gaps and clusters that may mark working positions of individual knappers (Figure 6.6).

Block excavations at Pilcher Creek sampled superimposed Archaic (Cascade phase) and Paleoarchaic (Windust phase) components, but revealed no changes in production biface output over time (Brauner 1985). Smaller samples from blocks and test units at the other six workshops focused on working out the reduction sequences.

At Starvation Spring, workshop debris extended to bedrock at depths ranging to 140 cm. Lithics were concentrated on an eroded paleosol capped by redeposited Mazama tephra. A temporal trend was identified, with the initial occupants generating a complete biface reduction sequence, while the later knappers shifted to testing, trimming, and transporting the toolstone off-site for further reduction elsewhere. Projectile points from the seven test units indicated a Tucannon-early Harder phase temporal sequence between about 4000-2000 years ago (Jaehnig 1992:37).

A pattern of nearby off-site reduction was postulated at Midvale Hill (Dort 1964:19; Bucy 1974:16-17) and demonstrated at High Breaks Ridge (Dickerson 1998). At the latter workshop cluster a nearby upland camp relied almost entirely on the same chemically identified basaltic andesite, and displayed core and biface reduction stages successional to those represented at the workshops. The campsite dated to between 3500-3100 RCYBP and appears to date the workshop cluster as well.

Temporal control at most FGV workshops continues to rely on diagnostic projectile points. Paleoarchaic stemmed Windust and Haskett points were recovered in the Stockhoff (Womack 1977:Fig. 20j; McPherson et al. 1981:296-297), Marshmeadow (McPherson et al. 1981:359, Fig. 109), Ladd Canyon (McPherson et al. 1981:651-652, Fig. 204h), and Pilcher Creek (Brauner 1985:51-54) workshops. Paleoarchaic FGV points have been recovered in campsite settings elsewhere in the

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Table 6.3. Summary Data for Fine Grained Volcanic Workshops of the CRBG Terrane.

Source	Elevation	Site Area <sup>a</sup>	Toolstone	Clast Size	Fracture Toughness <sup>b</sup>	Production Peak RCYBP
Stockhoff <sup>1</sup>	1103-1335 m	186	dacite	>1 m	55.67	~6845-5800
Marshmeadow <sup>2</sup>	1122-1140 m	5.5	dacite	<1 m	--	~4000-700
Pilcher Creek <sup>3</sup>	1219 m	.75	dacite?	20 cm	--	~10,000
Midvale Hill <sup>4</sup>	1012 m	8.3	basaltic andesite	20 cm	70.86/73.50	~4500-2000
Mesa Hill <sup>5</sup>	890-902 m	--	andesite	--	--	~7000-5000
Elk Mountain <sup>6</sup>	1561 m	1.2	basaltic andesite	10 cm	--	~3000
Starvation Spring <sup>7</sup>	1310-1402 m	77	basaltic andesite	35 cm	--	~4000-2000
High Breaks Ridge <sup>8</sup>	1426-1487 m	1.1	basaltic andesite	14 cm	--	~3500-3000
Pataha Canyon <sup>9</sup>	1155 m	4.2	basaltic andesite	10 cm	77.16/89.51	~2500

<sup>a</sup> Surface area of one or more concentrations in hectares; <sup>b</sup> Domanski and Webb 1998; <sup>1</sup>Bryan and Tuohy 1960; Womack 1977; McPherson et al.1981; Reid et al. 1993 ; <sup>2</sup>McPherson et al.1981 ; <sup>3</sup>Brauner 1985; <sup>4</sup>Dort 1964; Bucy 1971, 1972; Warren et al. 1971; Bakewell 2002; <sup>5</sup>Ruebelmann 1973; <sup>6</sup>Nisbet and Drake 1982; <sup>7</sup>Jaehnig 1992; <sup>8</sup>Dickerson 1998; <sup>9</sup>Reid and Root 1998

region at Evans Creek (Nisbet 1983:Fig. 5d,e), Gould Gulch (Gallison and Reid 1995:56), and Hetrick (Rudolph 1995:Tables 6-40, 6-41). To date, although Paleoindian knappers made wide use of the obsidians, no fluted Clovis or Folsom points made from FGV toolstones have been reported in the region.

Exploitation of the tough basaltic andesites seems to intensify in the later Holocene. The emergent pattern hints that Paleoarchaic knappers favored more tractable but also more localized dacites over tougher, but more widely distributed, basaltic andesites. Thus, while middle and late Holocene knappers continued to exploit the Craig Mountain dacite source, they also brought into production several basaltic andesite outcrops of the widespread Grande Ronde Basalt Flow. These include Midvale Hill, Mesa Hill, Elk Mountain, High Breaks Ridge, and Pataha Canyon.

In common with the obsidian sources, the variability in FGV workshop area apparent in Table 3 reflects in part how (and when) the sites were recorded. For example, the site record for Stockhoff (35UN52) includes nine separate concentrations ranging in area from 4 to 121 ha. Similarly, the heavily forested condition of Starvation Spring obscures any internal variability at this large site. The scale challenge typical of source-area sprawl suggests that these workshops would profit from a noninvasive remote sensing approach such as LiDar light ranging and mapping. Subtle traces of pits and other features now obscured by vegetation and field conditions might be captured in comprehensive site overviews linking surface debris to underlying rock structure.

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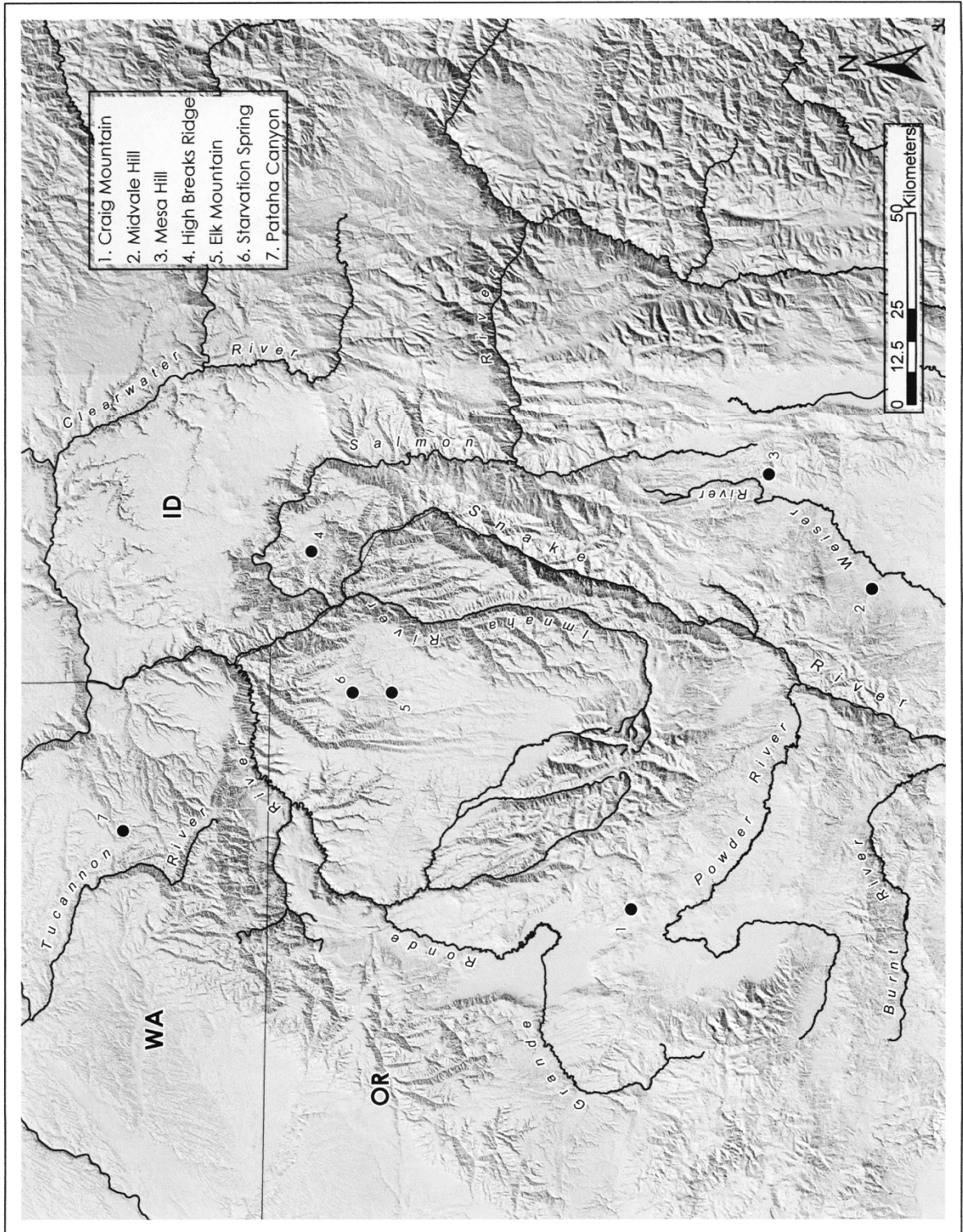


Figure 6.5. Source areas for selected fine-rained volcanics of the Southern Plateau.

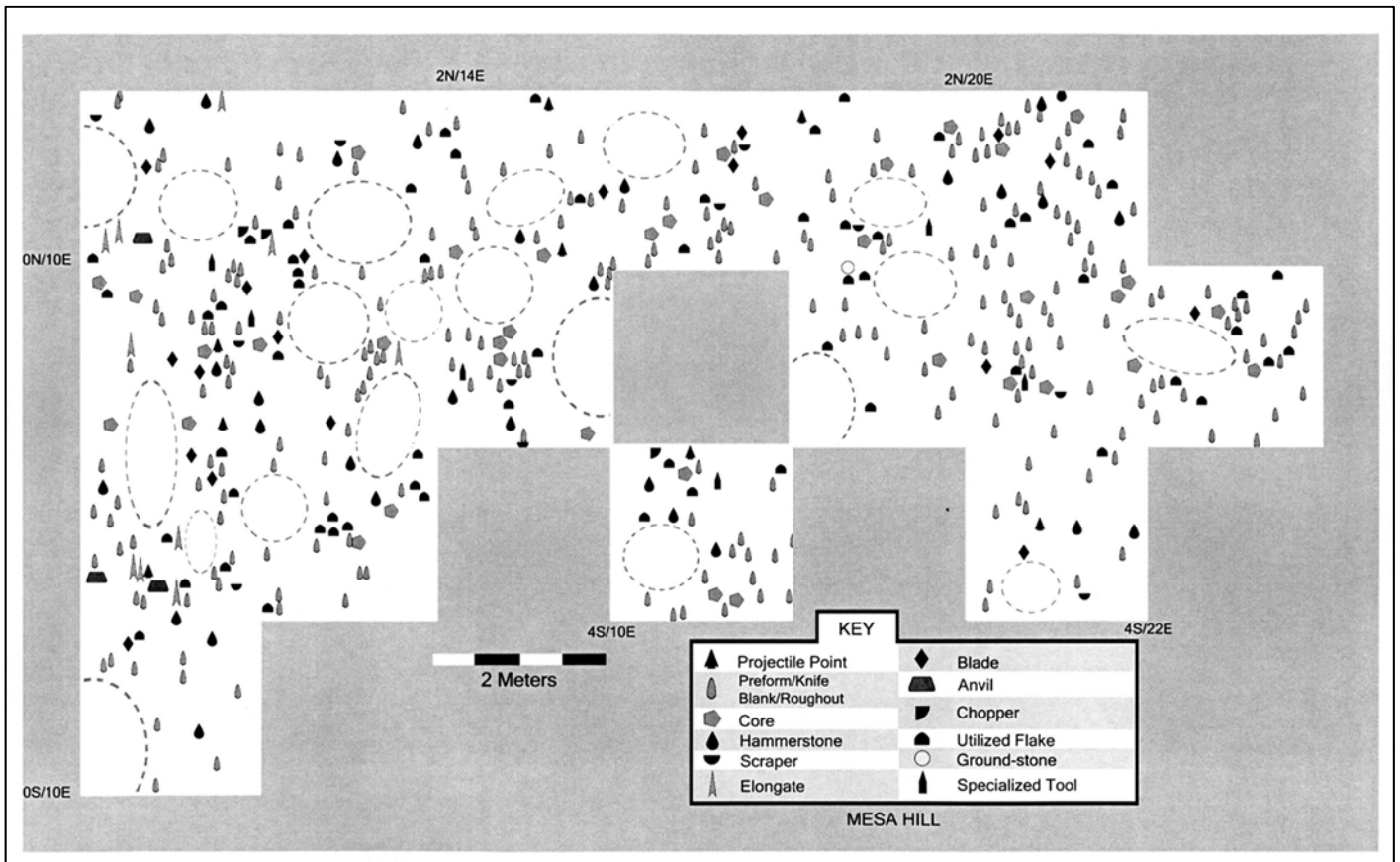


Figure 6.6. Mesa Hill workshop floor debris, with postulated knappers' positions (redrafted from Ruebelmann 1973: Fig. 5)

Gauging changes in output volume at these workshops has been most seriously pursued at Pataha Canyon (Root 1998). Here four analytic units were defined in a small 15 m<sup>2</sup> block. Workshop output consisted of flake cores and bifacial preforms in all analytic units, although early-stage bifacial reduction was emphasized in the earlier units. When the occupation span was broken down into three units of 2500 years each, the biface output estimate, derived from replication and size-grading of bifacial debitage, was about seven bifaces/year for the Harder/Piqunin interval (2500-200 BP). For the Cascade/Tucannon interval (5000-2500 BP), it dropped to 4.5 bifaces/year. During the early-middle Holocene (7500-5000), production achieved about one biface every two years.

By 2500 years ago, a discernible increase in skill level was reflected in fewer bifacial miscarriages. The same

notoriously difficult stone seems to have been used throughout the workshop's time span, but later knappers had learned to make better use of it (Root 1998). This shift may reflect the appearance of craft specialization in the lower Snake basin. It is also accompanied by a much wider range of raw materials among discarded projectile points, perhaps reflecting increased exchange among craft specialists (Cross 1993). These small, unprepossessing workshops of tough and grubby toolstones clearly have the potential to deepen our understanding of social dynamics now known mainly from ethnography (e.g. Thomson 1949:63-81).

Root's analysis at Pataha Canyon focused on tracking how many bifaces left the workshop over time, while the data in the Stockhoff and Marshmeadow reports tell us only how much debris was left behind at the workshops. Still, a peak in production appears to follow the Mazama

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eruption at Stockhoff (Table 6.4), while production at nearby Marshmeadow did not accelerate until after 4000 years ago (Table 6.5).

How this variability patterns over a larger region is far from clear at this point. However, the recently proposed hypotheses that Craig Mountain dacite occurs in significant quantities at sites along the lower Snake River are plausible and geochemically testable. The numerous FGV production bifaces noted at Swift Bar (Andrefsky 1995) and Castle Rock (Morrison 1996) date to the same interval as the production surge at Stockhoff. Qualities that might have made Craig Mountain dacite worth the trip include large package size, low fracture toughness, and workshop proximity to abundant salmon, camas, and game resources. To the extent that the Grand Ronde River served as a dugout canoe transportation corridor feeding into navigable waters below Hells Canyon, biface-ballasted canoes could deliver bulky cargoes to distant downstream destinations. This scenario might also explain the scarcity of the same material at

contemporaneous sites in Hells Canyon (Randolph and Dahlstrom 1977; Reid and Gallison 1994; Reid and Chatters 1997), where all FGV toolstone had to have been packed in by pedestrians.

### SUMMARY AND CONCLUSIONS

After a halting, haphazard start early in the 19<sup>th</sup> century, the search for igneous toolstones in the Snake River basin flagged for nearly a century and a half before finding direction and scientific footing in geochemical and petrographic analyses and geologic mapping. Steady improvements in fingerprinting through x-ray fluorescence have corrected earlier misidentifications (Hughes 2007; Hughes and Pavesic 2005) and refined the scale of resolution: seed-sized pressure flakes from a Nez Perce lodge floor in Hells Canyon have been traced upstream to Timber Butte and Dooley Mountain (Hughes 2012).

However, much still remains to be learned about

**Table 6.4. Workshop accumulation rates for debitage and bifacial/unifacial blanks at Stockhoff (compiled from McPherson et al. 1981).**

Stratigraphic Unit(s)	Age (RCYBP)	Debitage	Workshop Blank
1	7600 - 6845	11/year	1/20 years
<b>Mazama Tephra<sup>1</sup></b>			
3, A, B, 6, 7a	6845 - 5800	61/year	1/2.4 years
7b, c, 8, C	5700 - 1700	11/year	1/24 years
9, 11	1500 - 150	07/year	1/20 years

<sup>1</sup>Age of the Mazama Set O tephra as reported in McPherson et al. (1981) has been adjusted.

**Table 6.5. Workshop accumulation rates for debitage and bifacial/unifacial blanks at Marshmeadow (compiled from McPherson et al. 1981).**

Stratigraphic Unit(s)	Age (RCYBP)	Debitage Accumulation	Workshop Blank
2	6700 - 6100	5/year	1/23 years
4	4000 - 3410	21/year	1/8 years
5	3410 - 2260	19/year	1/10 years
6	2260 - 690	21/year	1/5 years

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workshop activity at Timber Butte, Dooley Mountain, and the other sources touched upon here. Evidence suggests that no more than six of the scores of obsidian sources in the SNP Terrane contributed the bulk of material that went into regional circulation along the boundary zone between the Basin and Plateau. Regional patterning is consistent with an embedded cobble harvesting pattern and core and biface reduction by individual knappers at off-site workshops (Sappington 1984; McDonald 1985). The labor investment involved uphill climbs and downhill loads rather than regolithic trenching or hammering adits into cirque headwalls (c.f. Choquette 1981).

A cluster of debris-clogged pits littered with quartzite hammerstones at Big Table Mountain is the only true quarry discovered in this review. Its proximity to the Obsidian Cliff quarries on the Yellowstone Plateau, and the fact that both of these obsidians were conveyed to consumers as far east as the Scioto Hopewell (DeBoer 2004) hints at two procurement patterns in the study area: embedded cobble harvesting by tool-depleted resident populations, and direct procurement and surplus production by trade specialists.

Accessibility, portability, and workability gave obsidians a unit value recognized as far away as Ohio during the Middle Woodland period. In contrast, the suite of FGV toolstones outcropping in flows of the CRBG Terrane exhibit more localized distributions suggestive of place value. The durable working edges on these tough toolstones may have anchored activity hubs where other tool materials were bulk processed. Thus, the hardness of FGV toolstones is sometimes cited to support the idea that source areas doubled as industrial loci where tool-quality wooden, bone, and antler raw materials were brought for shaping and scraping into digging sticks and other implements (Bucy 1971:42; Jenkins and Connolly 1990:144-145). Several of the FGV source areas discussed above occur near root meadows, fisheries, and hunting grounds, with seasonal camps clustered in their immediate vicinity. To these potential advantages should be added the generally lower elevations and longer seasonal availability of the FGV sources.

The basaltic andesite workshops reported here cluster along outcrops of the Grande Ronde Basalt Flow.

The single confirmed dacite source occurs in the Saddle Mountain Basalt Flow. To date, Grande Ronde toolstones separated by hundreds of kilometers have not been geochemically distinguished from one another. However, they are chemically distinct from the dacite exposed in the Saddle Mountain Basalt Flow at Craig Mountain. The latter toolstone had the added advantages of large package size and low fracture toughness, with local workshops turning out production bifaces longer than 35 cm and standardized unifaces only slightly shorter.

I'll close with a comment offered from a wider perspective. Thus, nowhere in the study area reviewed here have true quarries been recorded that are comparable to the Obsidian Cliff source on the Yellowstone Plateau (Johnson et al. 1995), the Cashman dacite quarry in southwestern Montana (Baumler et al. 2001), or the more distant Spanish Diggings quartzite quarries in eastern Wyoming (Reher 1990). These are true quarries with numerous pits, ditches, trenches, adits, extensive debris aprons and tailings, and a range of associated features such as caches, cairns, and habitation structures. The absence of such sites has organizational implications at the regional level. For example, the scale of works on the Hartville Uplift has been interpreted to reflect the task-specific, direct-procurement of toolstone, planned and scheduled in concert with communal bison drives and mass processing of kills (Reher 1990:276-279). A similar explanation has not been offered for the extensive quarrying at Cashman, but may be appropriate given the site's proximity to prime bison habitat.

Whether the apparent absence of these sites in our study area marks a true negative or a sampling or visibility bias should be addressed in future research. Thus, the scale of toolstone quarrying at the Obsidian Cliff National Historic Landmark (Johnson et al. 1995) did not become fully apparent until the catastrophic forest fires of 1988 and a post-fire survey the following year. Similar fires can be expected to increase in frequency in coming years, but it is unlikely that they will be followed by similarly intensive ground surveys. Remote sensing survey and mapping appears to be the logical next step

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to understanding the size and internal complexity of these sites.

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## CHAPTER 7

### ALM ROCKSHELTER LITHIC DEBITAGE ANALYSIS: IMPLICATIONS FOR HUNTER-GATHERER MOBILITY STRATEGIES IN THE BIG HORN MOUNTAINS, WYOMING

BY BRIAN E. OSTAHOWSKI AND ROBERT L. KELLY

#### ABSTRACT

*Alm rockshelter is a prehistoric site located at the mouth of Paintrock Canyon, on the western side of the Big Horn Mountains. The site contains a well-stratified record of occupation from late Paleoindian to late Prehistoric times. This study analyzed lithic debitage excavated at Alm rockshelter's three test units to test implications of the hypothesis that the Big Horn Basin region experienced population growth and decline during certain time intervals which correlate with decreasing and increasing aridity (Kelly et al 2013). Debitage analysis tests the hypotheses that (a) when the region experienced an increased population (associated with cooler/wetter climate), the prehistoric population used Alm rockshelter through residential mobility; and (b) at times of decreased population (drier/warmer climate), people used the shelter through logistical mobility.*

This much we know: mobility is a key attribute of the foraging adaptation. All foragers use a mix of residential mobility to bring consumers to resources, and logistical mobility to bring resources to consumers. Different mobility strategies among foraging societies result from a heavier reliance on one of these over the other. In this paper, we are concerned with detecting changes in mobility from lithic assemblages, specifically from debitage, and with how mobility is linked to climatically-

induced resource changes and human population density.

Our case study comes from the site of Alm Shelter, located on the western edge of the Big Horn Mountains, in northwestern Wyoming. Diachronic changes in hunter-gatherer mobility are reconstructed through an attribute analysis of the site's debitage assemblage. This focuses on patterns of core reduction, stone tool production and curation, the ratio of local to nonlocal toolstone, debitage density, and formal chipped and groundstone tools. We conclude that changes in prehistoric population density combined with climate changes helped govern settlement organization for hunter-gatherers who used Alm Shelter.

#### POTENTIAL PITFALLS OF DEBITAGE ANALYSIS

Inferring types of mobility rests on the assumption that debitage types and attributes are indicative of the types of tools produced and reduction strategies used at a location (Andrefsky 1998; Sullivan 2001). This seems a safe assumption since debitage tends to remain where it was produced; some flakes may be scavenged by a site's later occupants and flakes may be swept up and discarded away from where they were produced, but by and large evidence of tool production and maintenance remains where it was produced. Unlike retouched stone tools, debitage is also generally abundant in even small samples of a site, such as are obtained through test excavations (which is the case here), and hence amenable to statistical analysis.

Residential sites typically have high tool diversity and consequently should contain debitage associated with both formal and informal tool production (Andrefsky 1998; Chatters 1987). Accordingly, debitage associated with the initial stages of tool manufacture, such as core reduction, would be commonly expected. Likewise, we would also expect to find a high frequency of local lithic materials engaged in initial core reduction because local toolstone transport costs would be minimal (Beck 2008; Metcalf and Barlow 1992).

Logistical sites should exhibit debitage suggestive of low tool diversity. Multifunctional tools, such as a biface,

are often used on logistical forays because they are portable and can perform different roles depending on the conditions imposed by the length and purpose of the foray as well as by raw-material distributions (Andrefsky 1998; Kelly 1988; Kuhn 1994). In general, the debitage generated on a logistical foray should reflect the rejuvenation and maintenance of multifunctional tools rather than their production (Andrefsky 1998). This means that we should expect to find a higher ratio of nonlocal toolstone in assemblages generated by logistical movements (Kuhn 1994; Surovell 2009), and evidence of biface reduction. Local toolstone reduction should be confined to early stages of reduction and expedient flake tool production.

Unfortunately, debitage can be quite frustrating to analyze. This is largely a product of the fact that debitage has no “natural” categories other than raw material (and heterogeneity in sources can make source assignments difficult). Zooarchaeologists can divide bone into species and elements, and be fairly confident in their assignments because species and skeletal elements do not grade into one another; there is no gray area between a bison and a mouse, or between a femur and a rib. There are unidentifiable bones, but by and large analysts can agree on species and element of those that are identifiable. However, many debitage characteristics, e.g., platform type, dorsal scar count, or even termination type are not measured or categorized in the same fashion by different analysts, even highly experienced ones (Dukeman 2002). And the more fine-grained the categories (e.g., measuring cortex in bins that increase by 10%), the more likely analysts are to disagree. In this paper we use debitage attributes that we think are the most reliably recorded and hence the most replicable among analysts. This limits us to fairly coarse categories.

#### **MOBILITY, RESOURCE DEPRESSION AND POPULATION**

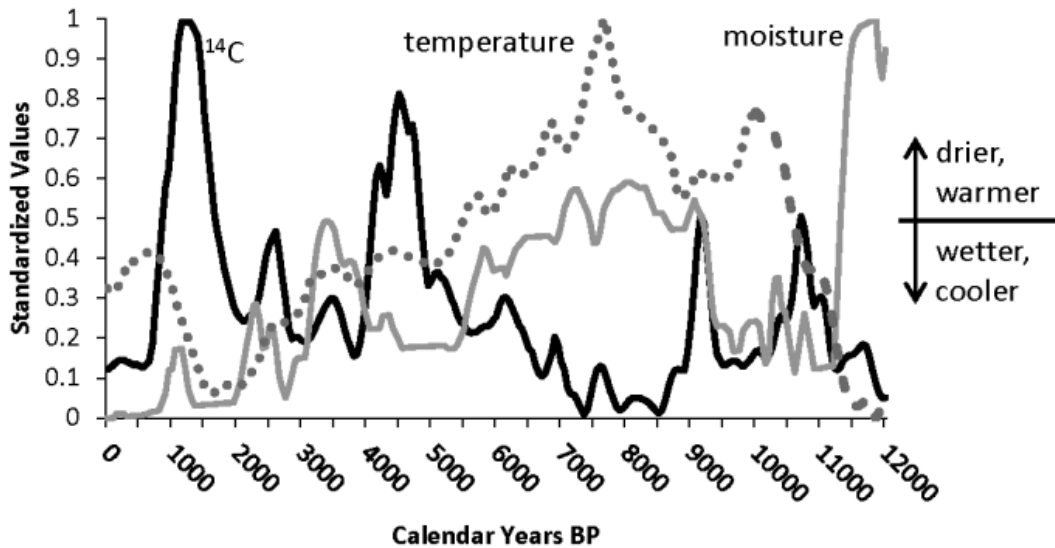
Changes in the form of mobility practiced should reflect the combined effect of human population density, climatically-induced changes in food density, and the distribution of key non-food resources such as shelter,

water, and firewood (Kelly 2013). Larger human populations and/or climate changes can lead to resource depression of high-ranked food resources, especially large game (Wolverton 2001; Bryan 2006). In general, a reduction in high-ranked resources will lead to greater residential mobility. High-ranked resources are high-ranked precisely because they provide high post-encounter return rates. Resources that provide high post-encounter return rates can be exploited at greater distances from a camp, hence encouraging logistical acquisition of those resources. If high-ranked resources become less common, optimal foraging theory leads us to expect diet to expand, and include more low-ranked (i.e., low return-rate) foods (Kelly 2013). Low ranked foods cannot be acquired at an energetic gain very far from camp, requiring that people use residential mobility to move consumers closer to food.

In an arid environment, we expect drier conditions to reduce the availability of food on the landscape through a reduction in primary production. Although all food types could be depressed, a reduction in the abundance of large game should result in a dietary expansion under dry conditions. This will be exacerbated under conditions of high population density. Under moister conditions, we expect diet to contract, focusing more on large game. Accordingly, residential mobility should decrease and logistical mobility increase among pedestrian foragers.

However, arid conditions will also limit the availability of water, and that fact could counteract a desire to move residentially. We return to this fact below. We use the summed probability of calibrated and radiocarbon dates (see Kelly et al 2013) as a proxy measure of population. These dates come from a database of 158 dates from closed sites (caves and rockshelters, including Alm Shelter), and 421 dates from open-air sites in the Bighorn Basin and surrounding mountains. Summed probabilities were generated using CALPAL (Hulu 2007) separately for open-air and closed sites. The open-air site distribution was taphonomically-corrected (see Surovell et al 2009) and averaged with the closed site distribution.





**Figure 7.1. Relative human population size ( $^{14}\text{C}$  summed probability values) plotted against moisture deficit and temperature trends.**

Figure 7.1 shows the changes that have occurred since human populations entered the region about 13,000 years ago (all ages in calibrated years BP). Population grew to a peak at about 10,700 BP, then declined before it grew again, reaching a second peak about 9000 BP before declining dramatically. This 9000 BP peak, however, only appears in the closed site distribution; the open site distribution alone (not shown) declines continuously from 10,700 BP.

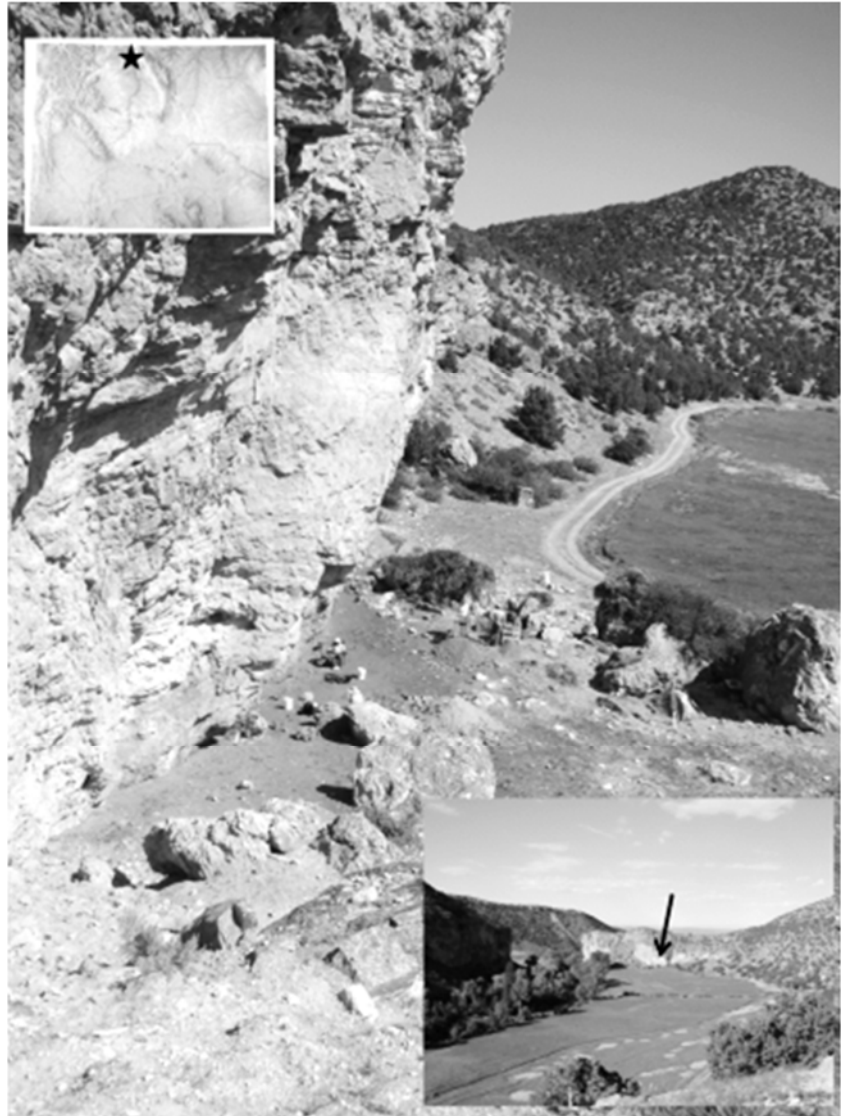
Population remains low throughout the early Holocene before it begins to grow ~7000 BP, reaching a peak ~4400 BP. Population then again declines rapidly, rises and falls, and then grows rapidly ~2000 BP, reaching a peak ~1100 BP. Population then again declines. We suspect that this final decline only partially reflects a decline in human population; it could also reflect a bias against dating the latest archaeological manifestation in a site (e.g., the uppermost hearth in a profile) and/or, for the very final portion of the sequence, the use of European artifacts to date contact-era sites and strata. (It may also reflect a decline in population, but one produced by introduced disease, rather than climate-linked declines in foraging.)

These periods of population growth and decline are closely tied to regional changes in temperature and moisture. Moisture is reconstructed from dated changes in elevations of Lake of the Woods, a high elevation lake in the northern Wind River Mountains (Shuman et al 2009); temperature is reconstructed from pollen spectra from cores taken from bogs in Yellowstone Park and the Bighorn Mountains (Shuman 2012); these data are portrayed in Figure 7.1. There is a tight and expectable relationship between the summed probability distribution and temperature and moisture: as climate becomes cooler and wetter, population grows, and as climate becomes warmer and drier, population declines (Kelly et al 2013). Moisture appears to be a stronger immediate factor in population change (expected in an arid environment) while temperature produces a consistent ~300 year lag in human population growth response. In addition, the human growth rate implied by the radiocarbon data is only 0.3%, lower than measured rates among ethnographically known foragers (Kelly 2013). This chapter investigates the relationship between mobility as measured by debitage attributes, human population and climate change.

**ALM SHELTER**

Alm rockshelter (48BH3457) is a well-stratified rockshelter located at 5150 ft asl (1570 m) at the mouth of Paint Rock Canyon in the foothills on the west side of the Big Horn Mountains (Figure 7.2). The site lies at the base of a predominantly limestone south-facing cliff and overlooks Paint Rock Creek less than 100 m to the south. The site area is defined by a cluster of large boulders to the east and a large talus cone to the south; the dripline encompasses an area up to 60 m but only about 5 m deep at most (Figure 7.3). Although many shelters are too small to be used by a large logistical party, let alone a

**Figure 7.2. Map of Wyoming showing location of Alm Shelter with overview of site in Paintrock Canyon.**

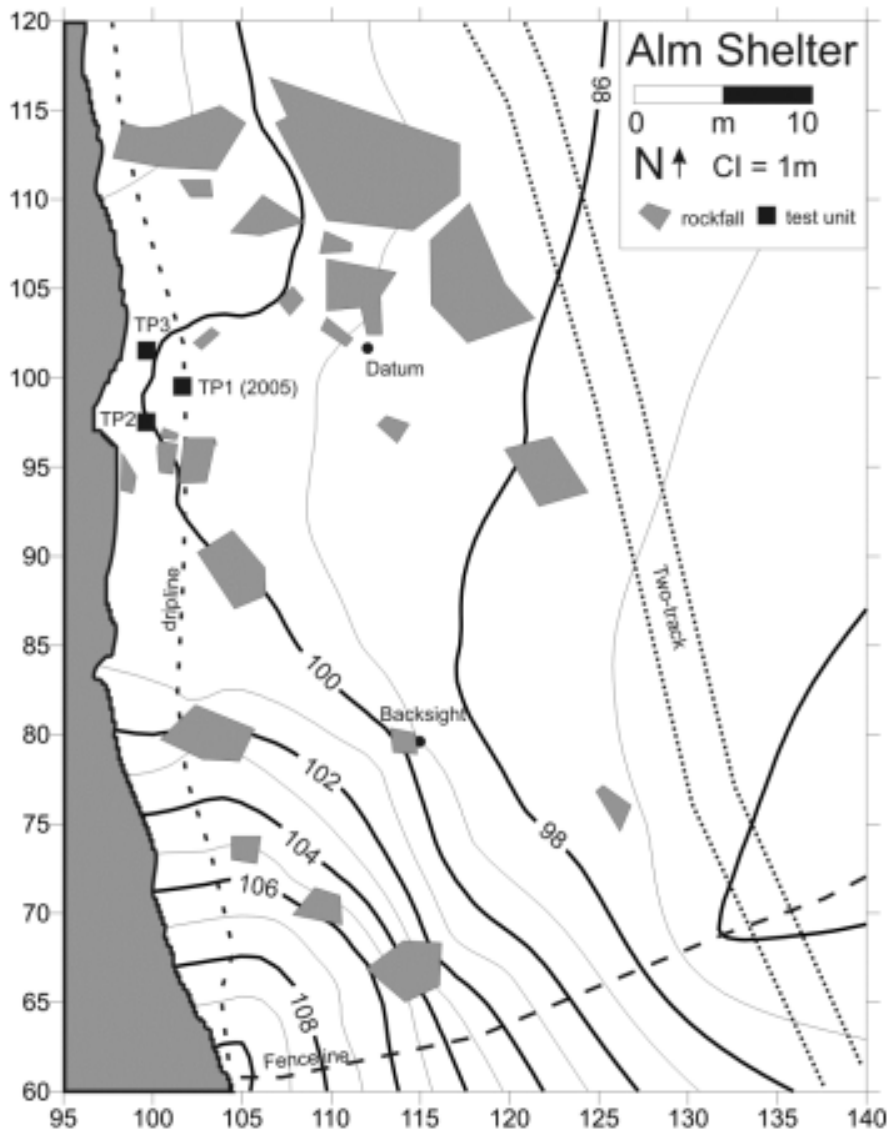


residential group (even a single family), Alm is large enough to have easily accommodated the 18-28 people who commonly form a co-residing foraging group (Kelly 2013).

Kelly excavated a total of three 1 x 1 m test units during 2005 and 2009 field seasons. The site's excavated deposits are over 2 m deep (bedrock was not reached), cover the past 13,000 calendar years, are remarkably free of rodent disturbance, and are well-stratified and well-dated. Alm also contains a high density of archaeological materials. A total of 18,289 artifacts were recovered during excavations; this included 18,108 pieces of debitage, 45 projectile points/knives, 43 other bifaces, 61 retouched flakes, 20 scrapers and 12 manos. The sediments in the three test units are dated by 25 radiocarbon dates (Table 7.1). There were two minor reversals in test unit 1, and one major reversal at the base of test unit 3; the last of these was redated and all

three reversals are ignored here. Levels without dates were assigned ages by interpolating from bracketing dates.

The Big Horn Basin is an arid intermontane basin of sparse grassland flanked to the east by the Big Horn Mountains (Francis 1997; Frison 2007a) which range from 4150 – 13,200 ft asl (1267-4018 m) (Francis 1997). Higher elevations become incrementally colder and wetter as the altitude increases while the basin floors are generally hot and dry (Young et al. 2000: 10). Alm



Herbivore populations in the Big Horn Mountains typically follow flora seasons and move from low-elevation summer to high-elevation winter feeding areas (Frison 1978; Hughes

**Figure 7.3. Alm Shelter site topographic map showing location of three test units.**

2003). On the basin floors, archaeological evidence suggests that bison (*Bison sp.*) were supported on the open plains valley floors at different times (Frison 1992:331).

In general, the artifact assemblages recovered from rockshelters in the Bighorn Mountains suggest that the shelters were largely used as short term waystations for logistical hunting forays (Freeland 2012). These shelters typically contain very low densities of archaeological material, few hearths containing very little evidence of the use of economically-significant plants, very few groundstone artifacts, and numbers of projectile points (unpublished data). Alm shelter is somewhat different from other shelters investigated in the Bighorn Mountains, having a low lithic assemblage diversity, suggesting

rockshelter is located at the confluence of desert-basin, grassland, and foothill-scrub zones as well as stream bank plant communities. Sitting on Paint Rock Creek, the site has a source of water that runs in even the driest of recent years; and the canyon it runs through provides access to the highest reaches of the mountains.

Prehistorically, the Big Horn Mountains supported significant animal populations, including Bighorn sheep, mule deer, white-tail deer, Rocky Mountain elk, antelope and bear (Frison 1978; Larson 1990; Walker 2007).

redundant use over time, a higher frequency of shatter and cortical flakes, suggesting early stage lithic processing, and yet a higher frequency of flakes with >3 scars on the dorsal surface (suggesting later stage reduction). Its hearths also contain a higher ratio of economic to fuel wood in the hearths, suggesting plant collection (Freeland 2012). Alm Shelter is therefore not typical of Bighorn shelters, but its location (at the mouth of a well-watered canyon) and size (large) means that it

## LITHICS IN THE WEST

**Table 7.1. Radiocarbon dates from Alm Shelter.**

Lab Number	Material	14C Age	Calibrated	Comment
AA-68840	Carbon, hearth ( <i>Juniperus</i> )	1178±36	1110±60	Test 1, level 2
AA-68637	Carbon, hearth ( <i>Populus</i> )	1610±42	1500±60	Test 1, level 3, profile
AA-72381	Carbon	1380±40	1320±30	Test 1, level 4, profile, processed by J. Finley
AA-72380	Carbon	2900±60	3060±90	Test 1, level 5, profile, processed by J. Finley
AA-68641	Carbon, hearth ( <i>Populus</i> )	4768±71	5480±100	Test 1, level 6/7
AA-68642	Carbon ( <i>Populus</i> )	6746±46	7610±40	Test 1, level 9, profile
AA-72379	Carbon	6700±50	7570±50	Test 1, level 10, profile, processed by J. Finley
AA-72377	Carbon	8240±60	9220±90	Test 1, level 13, profile, processed by J. Finley
AA-72378	Carbon	8260±50	9260±100	Test 1, level 13, profile, processed by J. Finley
AA-68639	Carbon, hearth ( <i>Populus</i> )	8160±50	9130±90	Test 1, level 14
AA-72376	Carbon, hearth ( <i>Populus</i> )	9590±60	10950±140	Test 1, level 16, processed by J. Finley
AA-68643	Carbon ( <i>Populus</i> )	11084±71	12970±80	Test 1, level 17, profile
PRI-09-158-BH3457-709	uncharred twig ( <i>Poaceae</i> )	935±20	870±50	Test 2, level 3, profile
PRI-09-158-BH3457-713	Carbon ( <i>Salicaceae</i> )	3985±20	4470±40	Test 2, level 6, profile
PRI-09-158-BH3457-692	Carbon ( <i>Picea</i> )	5680±20	6460±30	Test 2, level 9, profile
PRI-09-158-BH3457-712	Carbon ( <i>Salicaceae</i> )	9500±25	10860±150	Test 2, level 14, profile
PRI-09-158-BH3457-711	Carbon ( <i>Salicaceae</i> )	10105±30	11720±110	Test 2, level 18, profile
PRI-09-158-BH3457-664	Carbon ( <i>Salicaceae</i> )	10980±30	12870±60	Test 2, level 19
PRI-10-149-688	Carbon ( <i>Salicaceae</i> )	1605±15	1490±50	Test 3, level 2, profile
PRI-10-52-670	uncharred twig ( <i>Poaceae</i> )	2425±15	2430±40	Test 3, level 3, profile
PRI-10-149-673	carbon ( <i>betula</i> )	4405±15	4980±50	Test 3, level 7, profile
PRI-10-52-672	Carbon ( <i>Salicaceae</i> )	5700±15	6480±20	Test 3, level 9, profile
PRI-10-149-686	Carbon ( <i>Salicaceae</i> )	8710±25	9660±60	Test 3, level 13, profile
PRI-09-158-BH3457-714	carbon ( <i>betula</i> )	6245±20	7210±40	Test 3, level 20, excavated; out of sequence
PRI-10-52-682	Carbon ( <i>Salicaceae</i> )	10975±25	12860±60	Test 3, level 20, profile

could have seen more use as a residential location than could other, smaller shelters located in less well-traveled corridors.

### ENVIRONMENTAL CHANGE AND PREHISTORIC POPULATION EXPECTATIONS

The Holocene marks a transition to a post-glacial epoch in which warming climatic conditions caused adjustments in plant and animal distributions across North America. In the Big Horn Mountains paleoecological responses to aridity, temperature, moisture and summer/winter insolation changes moved coniferous taxa up and down in elevation along moisture

gradients. This caused a dynamic resource distribution throughout the Holocene which affected prehistoric subsistence strategies and forced hunter-gatherers to carefully monitor plant and animal resources.

In the Big Horn basin, the early Holocene transition, around 12,000 BP, exhibited a continually warming climate (Brooks 1995; Frison 1992). Mesic habitats in the basin were stressed by increased seasonal extremes (Larson 1990:26). Nonetheless, bison, which feed on mesic grasses and sagebrush biomass, proliferated in the region until about 9,000 BP, at which point they decrease in frequency in the archaeological record (Hughes 2003; Larson 1990). Frison (1992; 2007a) argues that during the earliest Holocene, evidence of meat caches and

## LITHICS IN THE WEST

structures on the valley floor suggests that the foothill-mountain margins were used by the people living on the valley floor, such as Clovis or Folsom groups, through logistical foraging and lithic procurement. By about 12,000 BP, a separate Paleoindian occupation of the Big Horn Mountains occurred, the Foothill/Mountain Complex (Frison 1992; Kornfeld et al 2010). It is evidenced at several closed sites such as Mummy Cave, Medicine Lodge Creek, Two Moon Shelter, and Little Canyon Creek Cave. Researchers believe that this complex represents a parallel but different settlement and subsistence system from that of the open plains and valleys (Kornfeld et al 2010:95).

The continuing warm and dry climate of the early Holocene, between 10,000 and 6000 BP restricted the forests to higher elevations, and people shifted their subsistence emphasis toward seasonally migratory big-game species in the mountains (Hughes 2003:280). As a result, closed sites along the western foothills of the Big Horn Mountains experienced increased use (Frison 1978); this is seen in the 9000 BP peak in the closed site radiocarbon date distribution mentioned above. The 9000 BP peak, however, was short-lived and suggests that people may have retreated to the mountains as climate became more arid, but that eventually the human population of the mountains declined as well.

The climate data suggest a gradual return to mesic conditions during the mid-Holocene, from 7000 to 4000 BP; human population grew at this time. Bison reappeared in the High Plains as evidenced by the return of communal bison hunting (Hughes 2003). However, aridity returned soon after 4200 BP, and may have been presaged by extremely severe droughts about 4200 BP that were felt across the northern hemisphere (Booth et al 2005; Frison 1978; Reeves 1973). By about 3000 BP the climate in the Rocky Mountain region exhibited climate conditions similar to today (Shuman et al. 2009:1861).

Wetter conditions returned by 2000 BP, and forest zones slowly descended downslope and the mountains' carrying capacity increased. The prehistoric human population grew, reaching a peak around 1100 BP. This

peak was short-lived as climate returned to more xeric conditions during the Medieval Climate Warming.

### PREDICTIONS

As outlined above, under dry conditions we expect human populations to use the better-watered portions of the landscape, and to increase residential mobility in response to lower overall return rates. This could produce two conflicting demands: water, which might restrict people, and low return rates, which would encourage moving consumers to resources. Water, in fact, dictates mobility under extremely arid conditions. The Ju/'hoansi, for example, limit residential mobility during the dry season, preferring to place themselves on water pans and forage further afield. The neighboring G/wi, on the other hand, lack such pans of water and so increase their residential mobility during the summer, acquiring water from melons and the body cavities of hunted game. Likewise, in Australia's western desert and in Baja California, foragers generally remain on a waterhole until it has completely dried, accepting low daily return rates produced by longer forays for low return rate foods (Kelly 2013). Where the regional landscape is dry but where water sources are available as linear streams, we might expect people to move more frequently, albeit constrained along streams.

At the same time, high population density will reduce the availability of high-ranked resources, resulting in an expansion of diet, the need to move more frequently, but also in constraints on a group's ability to move (Kelly 2013). Thus, high human population densities could have the same effect as an arid climate. Such changes could result in technological innovations (e.g., plant-processing technologies) that then permanently alter the perceived return rates of available foods. We use Alm Shelter to explore the contributions of climate and human population size on mobility in northwestern Wyoming.

## LITHICS IN THE WEST

**Table 7.2. Debitage Attribute Table.**

Ratio Scale	Ordinal Scale	Non-Metric/Nominal Scale
Length (nearest .01 mm)	Dorsal Flake Scar (>3)	Raw Material Type
Width (nearest .01 mm)	Flake Striking Platform Count (>3)	Flake Portion and Artifact Type
Thickness (nearest .01 mm)	--	Presence of Cortex
Weight (g)	--	Presence of Thermal Alteration
Interior Platform Angle (°)	--	Presence of Feather Termination
--	<b>Platform Characteristics (Presence/Absence)</b>	--
Whole Platform	Cortical Platform	Lipped Platform
Split Platform	Platform Plain	Platform Abrasion
Crushed Platform	Dihedral Platform	Sheared Bulb of Percussion

### METHODS AND ASSUMPTIONS

The debitage analysis was conducted within the 10 cm arbitrary levels used in excavation. Analysis was restricted to those specimens that did not pass through a ¼" screen. In total, 5216 pieces of debitage were analyzed (28.8% sample); 92% of this assemblage is one form of chert or another. A suite of metric and non-metric traits were recorded on each specimen (Table 7.2). The recording of certain lithic debitage attributes reflects the results of replicability studies of lithic attributes. For example, Dukeman (2002) showed that two measurements in particular, dorsal flake scar count and platform facet count, are not counted similarly by analysts. Consequently, these attributes were recorded in broad ordinal categories. Similarly, dorsal cortex is recorded simply as present/absent.

### LITHIC RESOURCE DISTRIBUTION

The Permian age Phosphoria Formation is the dominant toolstone in the Alm assemblage (n=2359, 45%) and is a high quality chert exposed widely along the slopes of the foothills (Frison 2007b). Phosphoria veins are exposed at various thicknesses which often exhibit a variety of colors within exposures (Campbell 1956).

Phosphoria is similar to the high-quality Pennsylvanian age Amsden Formation (n=8; 0.15%), which is exposed at a slightly higher elevation.

At the lowest elevations in the Big Horn Mountains, along the basin margin, runs a band of Upper Jurassic Morrison formation which produces high quality fine-grained quartzites and cherts (Frison 2007b). Morrison outcrops are typically exposed as veins in and around highly eroded gullies which are littered with Cloverly Formation boulders (Jennings 2005:52). Morrison debitage is considered to be procured locally (~10 km) and is the second most abundant material at Alm (n=279, 5.3%).

The Mississippian age Madison Formation produces an exceptionally high-quality chert (Francis 1997:219). Madison cherts are heterogeneous but have a few distinctive colors. Madison cherts are rare (n= 140, 1.9%) and represent a high elevation, nonlocal prehistoric toolstone identified at Alm rockshelter. As with Medicine Lodge Creek, the source of Madison toolstone is likely the Spanish Point Quarry, located some 20 km from Alm Rockshelter (Frison 2007b:30) and about 1200 m higher in elevation (Ostahowski 2011).

Quartzite occurs as secondary gravel deposits along the interior of the basin (Francis 1997) and is rare at Alm

(n=188, 3.6%). Exotic materials such as basalt (n=11, 0.2%), obsidian (n=11, 0.2%) and clear quartz (n=22, 0.4%) are nonlocal and extremely rare at Alm. Shale (n=1, 0.01%), silicified shale (n=42, 0.8%), and silicified siltstone (n=2, 0.01%) appear in low frequencies and are considered local, due to the variety of lithologies in the Phosphoria formation (Campbell 1956).

Noting that 20 km (one-way) foraging trips are rarely documented in the ethnographic literature, Surovell (2009:78) defines local raw material as anything within a 20 km radius of a site, and non-local material as anything found further away. This definition means that all Phosphoria and Morrison quartzite is considered local toolstone. Since there is variation within Phosphoria, we considered all cherts to be locally procured unless identified to a type found more than 20 kms from the site (i.e., Madison).

## RESULTS

The simplest attribute of a debitage assemblage is abundance. We measure abundance here in terms of density within 10 cm excavation levels as:

$$\text{Debitage density} = \frac{\text{Level's debitage count}}{\text{Total weight of sediment excavated in level—weight after screening}}$$

This measure controls for differences in the actual thicknesses of levels and for that portion of a level's volume which is rock. Since debitage cannot occur inside rock (that enters the site as roof fall or colluvium), this method measures debitage density relative to the portion of the level's volume that could contain debitage. We then created a concordance of levels for all three units using radiocarbon and interpolated dates (Table 7.3), assigned a mean date to each set of levels, and calculated the mean debitage density by level. To check ourselves, we calculated debitage density in several other ways, including looking at cumulative weight, with similar results.

We initially expected debitage density to parallel the <sup>14</sup>C frequencies that monitor regional population density. However, we found the opposite pattern (Figure

7.4A): although population density is low in the early Holocene, and high in the late Holocene, debitage density is highest at Alm in the early Holocene and lowest in the late Holocene. This does not appear to be an artifact of changes in sedimentation rates, which remain relatively constant. Assuming that debitage density measures the intensity of shelter use, then Alm is used more intensively at times of low as opposed to high population density. Since population density responds to climate (Kelly et al 2013), we can go further and state that Alm is used when population density is low and the regional climate is more arid. In fact, debitage density is correlated with temperature and moisture (from Kelly et al 2013;  $r=0.70$ ,  $n=20$  pairs,  $p=0.003$ ; Figure 7.4B). It makes sense that the regional population might decline as climate becomes more arid (and foraging return rates decline). It also makes sense that during arid times well-watered places, such as Paint Rock Canyon, might see more use. While 25 dates are not sufficient to create a radiocarbon frequency comparable to the regional one, Alm does contain spikes of summed probability values in the early Holocene (at 9700, 9000, 7600, and 6500 BP), when the regional record suggests depopulation (other dateable hearths lie stratigraphically between those which produced these spikes so these dates are not isolated occurrences).

### Attribute Trends across Lithic Materials

The distribution of debitage attributes are compared among Phosphoria toolstone, Madison toolstone and Morrison toolstone to ascertain if raw materials were preferentially used for certain reduction activities. A series of chi-square tests (from Ostahowski 2011) found significant differences in the distributions of cortex ( $\chi^2=16.59$ ,  $df=2$ ,  $p<0.001$ ), lipped platforms ( $\chi^2=6.89$ ,  $df=2$ ,  $p=0.031$ ), platform abrasion ( $\chi^2=8.16$ ,  $df=2$ ,  $p=0.016$ ), thermal alteration ( $\chi^2=15.41$ ,  $df=2$ ,  $p<0.001$ ), whole platforms ( $\chi^2=6.45$ ,  $df=2$ ,  $p=0.039$ ), platform cortex ( $\chi^2=12.14$ ,  $df=2$ ,  $p=0.002$ ) and split platforms ( $\chi^2=9.31$ ,  $df=2$ ,  $p=0.009$ ) across raw material types. However, there are no significant differences among the three raw material types in the presence of >3 dorsal scars on whole flakes ( $\chi^2=2.23$ ,  $df=2$ ,  $p=0.32$ ), platforms

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**Table 7.3. Excavation Level Concordance derived from 14C dates (uncalibrated)**

TU1	TU 2	TU 3
--	Lvl 1	--
Lvl 1	Lvl 2	Lvl 1
--	Lvl 3 (935 ± 20)	--
Lvl 2 (1178 ± 36)	Lvl 4 (app. 1951)	Lvl 2 (1605 ± 15)
Lvl 4 (1380 ± 40, or app. 2255)	--	Lvl 3 (2425 ± 15)
Lvl 5 (2900 ± 60)	Lvl 5 (app. 2967)	Lvl 4 (app. 2920)
Lvl 6 (app. 3834)	Lvl 6 (3985 ± 20)	Lvl 5 (app. 3415)
Lvl 7 (4768 ± 71)	Lvl 7 (app. 4550)	Lvl 7 (4405 ± 15)
-	Lvl 8 (app. 5115)	Lvl 8 (app. 5052)
Lvl 8 (app. 5757)	Lvl 9 (5680 ± 20)	Lvl 9 (5700 ± 15)
Lvl 9(6746 ± 46)	Lvl 10 (app. 6444)	Lvl 10 (app. 6452)
Lvl 11 (app. 7216)	Lvl 11 (app. 7208)	Lvl 11 (app. 7204)
Lvl 12 (app. 7732)	Lvl 12 (app. 7972)	Lvl 12 (app. 7956)
Lvl 13 (8260 ± 50, 8240 ± 50)	-	-
Lvl 14 (8160 ± 50, or app. 8696)	Lvl 13 (app. 8736)	Lvl 13 (8710 ± 25)
Lvl 15 (app. 8875)	-	Lvl 14 (app. 9033)
Lvl 16(9590 ± 60)	Lvl 14 (9500 ± 25)	Lvl 15 (app. 9356)
--	Lvl 15 (app. 9651)	Lvl 16 (app. 9679)
--	Lvl 16 (app. 9802)	-
--	Lvl 17 (app. 9953)	Lvl 17 (app. 10002)
--	Lvl 18 (10, 105 ± 30)	Lvl 18 (app. 10325)
Lvl 17 (11,084 ± 71)	Lvl 19 (10,980 ± 30)	Lvl 19 (app. 10648)
Lvl 18	Lvl 20	--
Lvl 19	Lvl 21	--
Lvl 20	Lvl 22	--
Lvl 21	--	--

bearing >3 facets ( $\chi^2=1.19$ ,  $df=2$ ,  $p=0.55$ ) and crushed platforms ( $\chi^2=1.26$ ,  $df=2$ ,  $p=0.53$ ). There is also no difference in mean whole flake weight between raw materials ( $F=1.006$ ,  $p=0.36$ ).

The adjusted standardized residuals indicate that higher than expected frequencies of cortex, platform cortex, and thermal alteration, coupled with a lower than expected distribution of whole platforms suggests a general pattern of initial core reduction for Phosphoria at Alm throughout time (Table 7.4). Split platforms tend to be produced in high frequencies during core reduction and drive down the frequency of whole platforms (Prentiss 2001). Given Alm’s short toolstone transport distance to Phosphoria formation quarries (some stone is available within a kilometer of the site) it is not surprising that early stage Phosphoria reduction occurred at Alm.

The Madison formation debitage exhibited higher than expected frequencies of lipped and whole platforms. Lipped platforms are produced by bending fractures often associated with soft hammer percussion during later stage bifacial thinning and tool production (Andrefsky 1998; Cotterell and Kamminga 1987). Flakes removed during later bifacial reduction stages are expected to have obtuse interior platform angles (Sullivan and Rozen 1985:758). However, the mean Madison lipped platform angle ( $n=14$ ) of  $125^\circ$  is no higher than the mean Phosphoria ( $125^\circ$ ,  $n=145$ ) or the mean Morrison ( $125^\circ$ ,  $n=25$ ). Nonetheless, other attributes of Madison debitage are not suggestive of initial core reduction. Morrison debitage attribute trends also indicate later stage reduction.



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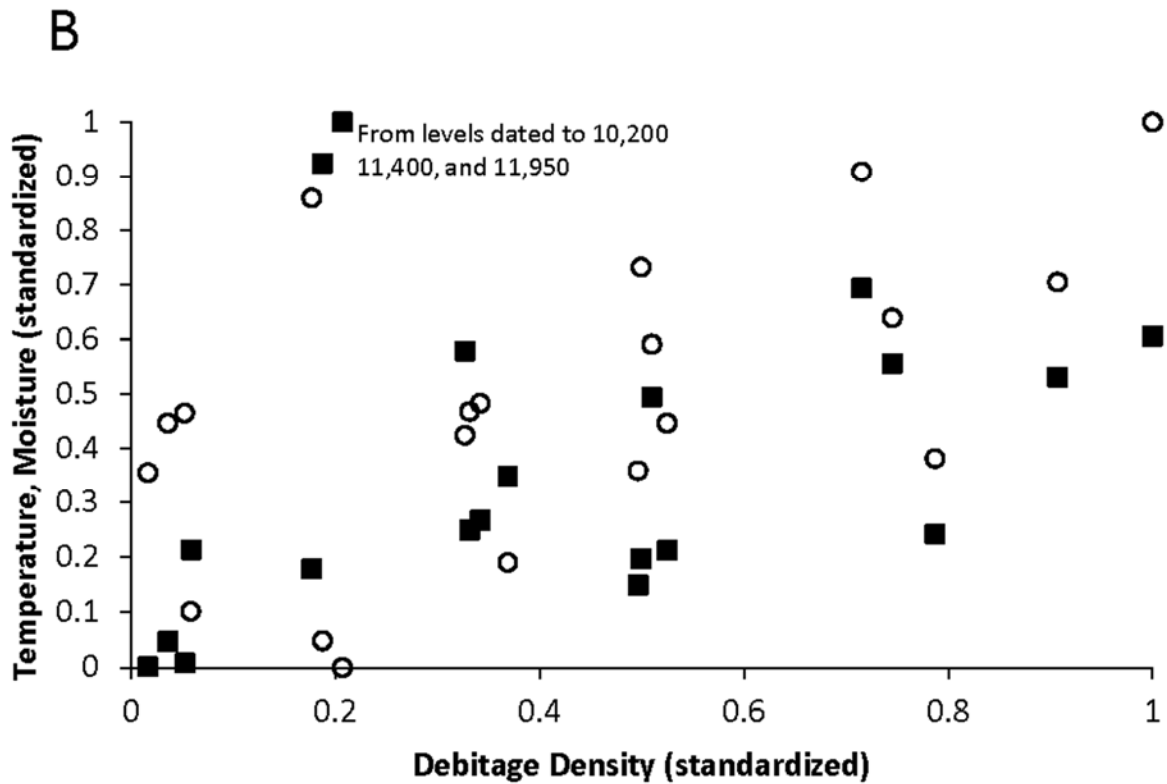
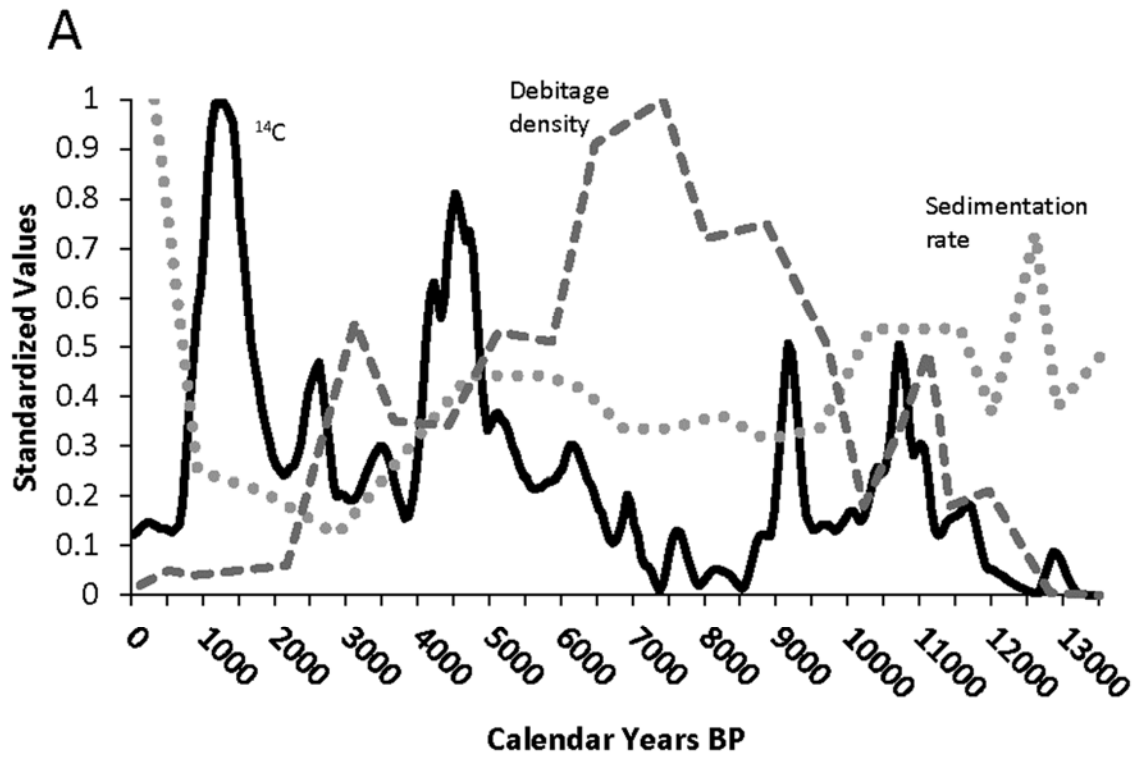


Figure 7.4. A. Relative human population size (<sup>14</sup>C summed probability values) plotted against debitage density at Alm Shelter and estimated sedimentation rate. B. Relationship between Alm Shelter debitage densities by chronological unit plotted against temperature and moisture estimates.

**Table 7.4. Adjusted Standardized Residuals across Significant Attribute Distributions**

Attribute	Phosphoria	Madison	Morrison
Cortex*	Higher (3.91)	--	Lower (-3.89)
Lipped Platforms	--	Higher (3.11)	--
Platform Abrasions	--	--	Lower (-3.81)
Thermal Alteration*	Higher (2.22)	Lower (-2.19)	Lower (-3.66)
Platform Cortex	Higher (2.29)	--	Lower (-4.04)
Platform Split	Higher (2.65)	--	Lower (-5.24)
Platform Whole	Lower (-2.50)	Higher (3.40)	Higher (3.37)

\*Included all flake portions in analysis

The most telling of the attributes is the low frequency of cortex, on both the dorsal surface and platforms. The higher than expected frequencies of complete flakes with whole platforms could be the result of edge shaping and platform preparation (Prentiss 2001). Thus, a pattern emerges which associates Phosphoria cherts with early stage reduction and Morrison and Madison with later stage reduction, although it is clear that no raw material was left at the site solely through only one portion of the reduction sequence.

#### DIACHRONIC CHANGES IN ATTRIBUTES

The earliest definitive evidence of a human use of Alm Shelter comes from a hearth near the base of unit 2 dated to 11,720 BP; another hearth in unit 1 dates to 10,950 BP. Still older dates (approximately 12,900 BP) lie deeper in all three units, but the associated archaeological material is sparse and small, and could be a result of downward movement of the later archaeological material. In fact, assemblages are very small at both the very early and the very late ends of the sequence at Alm; these small samples affect some of the data patterns and are generally ignored in analysis.

A number of the recorded debitage variables show no significant changes or trends over time. This suggests that the shelter was generally used redundantly through time. However, some debitage variables do show significant changes over time, and the debitage density data suggest that the shelter's use may have changed during the early Holocene when regional population was

low and climate was quite arid, and during the latest Holocene, when regional population was at a peak, and climate was cooler and wetter (with the exception of the Medieval warming).

#### Toolstone Source and Local Source Flake Size

During the earliest period of the Holocene at Alm, local toolstone dominates the debitage assemblages (Figure 7.5A). This trend reverses ~10,000 BP, coincident with the beginnings of extreme aridity. Local toolstone again becomes increasingly important from ~7500 to 6000 BP, coinciding with population growth as climate ameliorates. The ratio of local to nonlocal toolstone declines again just before population peaks about 4500 BP, and remains low throughout the remainder of the sequence. Mean Phosphoria flake size is largely inversely related to the local:nonlocal ratio, although not significantly so (Figure 7.5A, B). Where non-local materials dominate, Phosphoria may occasionally be reduced expediently for flake tools, resulting in larger flakes. Where local materials dominate, Phosphoria could be reduced for flake tools, but also to manufacture and resharpen implements, resulting in greater variability in flake size (Figure 7.5B). The pattern that emerges is that prior to 10,000 BP, debitage assemblages are frequently dominated by local toolstone, represented by small flakes. Many of the later assemblages have high frequencies of nonlocal toolstone, with local sources more often represented by large flakes, but in lower frequencies.

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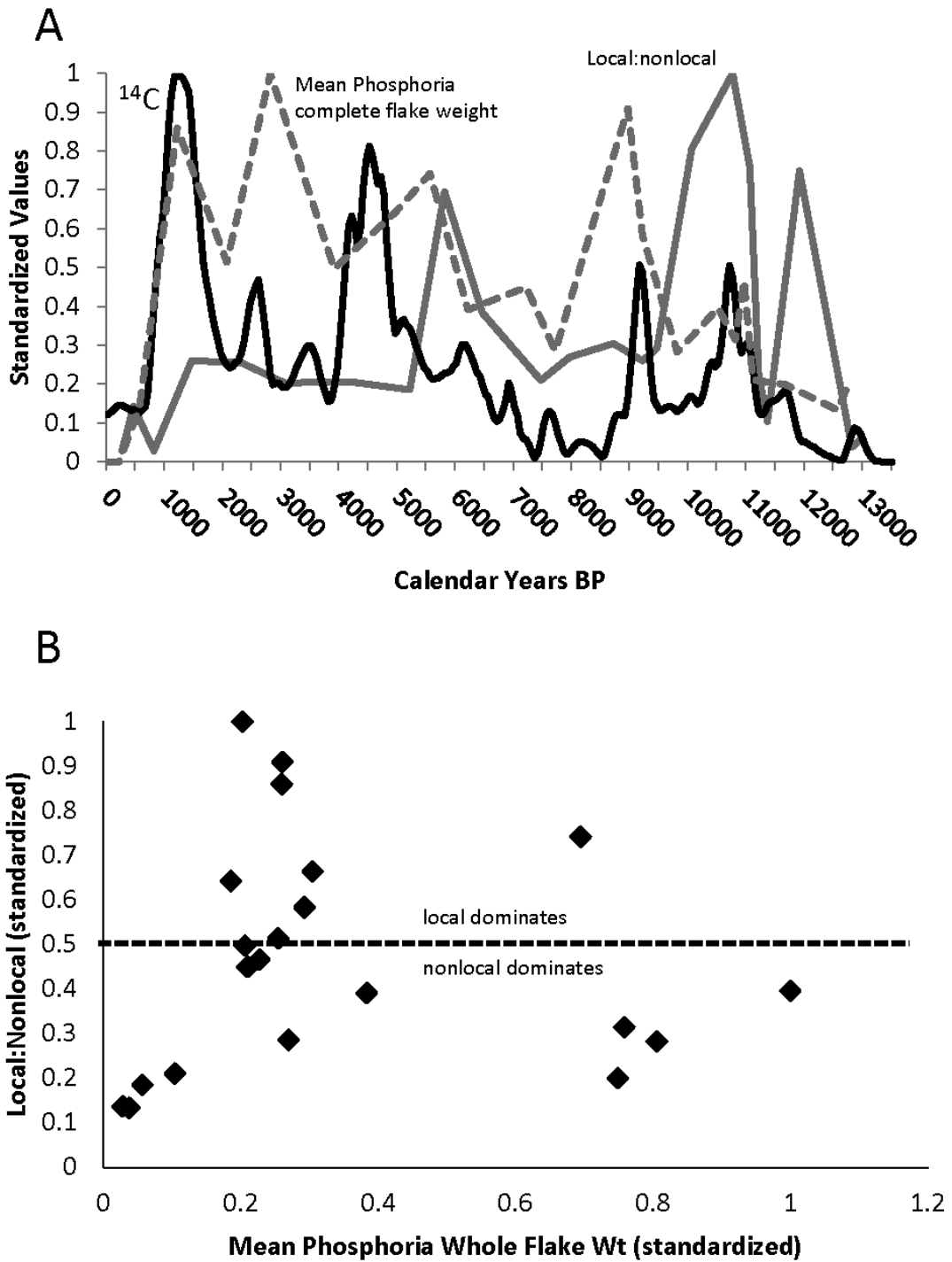


Figure 7.5. A. Relative human population size (14C summed probability values) plotted against average Complete Flake size of Phosphoria and the ratio of local to nonlocal debitage trends over time at Alm Shelter. B. The relationship between mean Phosphoria flake size and the local:nonlocal ratio of debitage.

**Relative Thickness (RT)**

High relative thickness (RT) values indicate a relatively thin flake produced by later stages in the reduction of bifaces (or resharpening) and low RT values indicate a relatively thick flake, produced early in the reduction sequence (Prasciunas 2007:343; Sullivan and Rozen 1985; Sullivan 2001). Figure 7.6 illustrates changes in RT values on complete flakes of high-altitude Madison toolstone, basin-floor Morrison toolstone, and local Phosphoria.

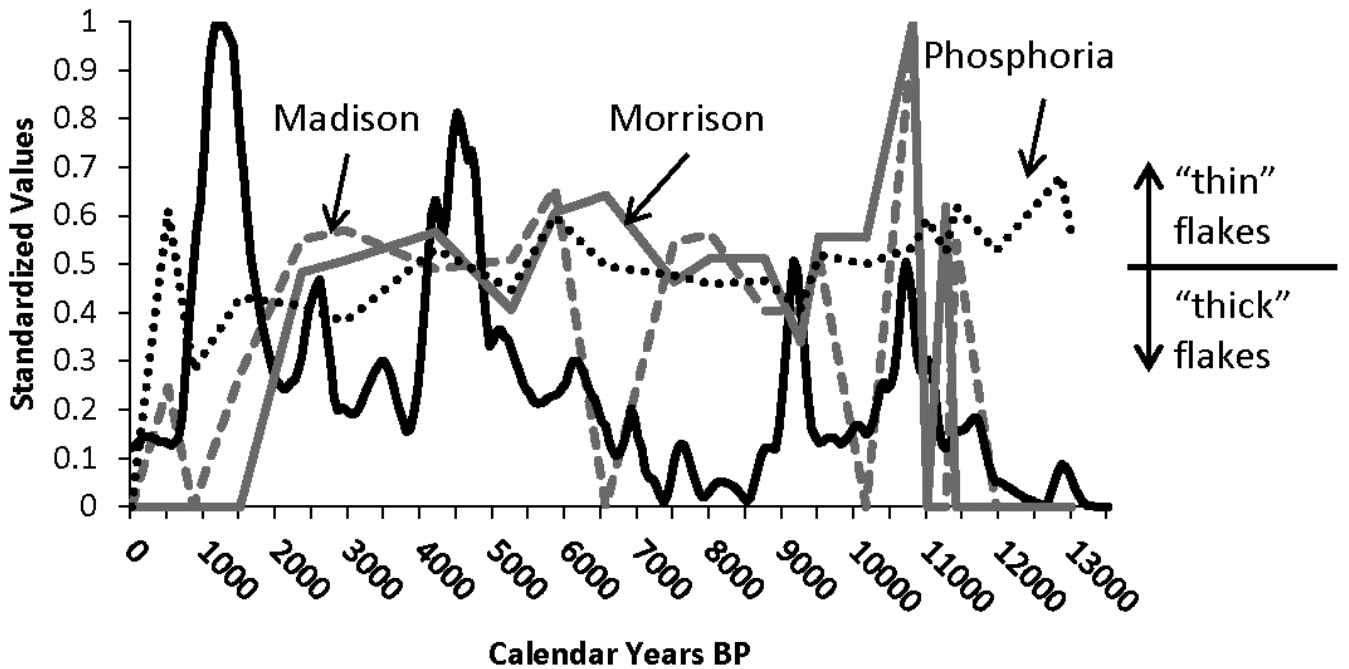
Although Phosphoria values change little over time, those for both Madison and Morrison toolstone exhibit a peak value ~10,800 BP. This indicates that on average, thin flakes from bifacial cores were discarded from nonlocal toolstone during the initial early Holocene. After this time, RT values decrease and, in general, maintain moderate values throughout the Holocene until around 1,200 BP, when frequencies of both nonlocal toolstone types decrease. At the same time peak RT values occur,

there is a prevalence of flakes with >3 dorsal scars and flakes with >3 platform facets, both of which point to later stages in stone reduction. We associate these data with the transport of bifacial cores, of possibly all raw materials, to Alm. These data most likely point to logistical use of the shelter prior to 10,000 or 10,800 BP.

**Local Toolstone Shatter and Crushed Platforms**

As pieces of shatter are unlikely to be culled as usable tool blanks, it represents a variable that can monitor coarse-grained patterns of reduction. Low shatter weight points to the importing of local toolstone in complete or nearly complete form and is thus evidence of later tool production or resharpening. Crushed platforms can result from hard-hammer percussion early in the reduction sequence (Prentiss 2001), but also in later stages of reduction, e.g., during biface thinning, as a function of soft hammer destruction of the platform on

**Figure 7.6. Relative human population size (14C summed probability values) plotted against changes in relative thickness values over time at Alm Shelter for Phosphoria, Madison and Morrison toolstone.**



## LITHICS IN THE WEST

thin, fragile flakes. As Figure 7.7A illustrates, Phosphoria flakes exhibit high frequencies of crushed platforms ~9000-10,800 BP, low levels from 7500-9000 BP, and then high levels until ~1500 BP. Prior to 10,000 BP, high frequencies of crushed platforms are associated with small Phosphoria flakes and low shatter weight (Figure 7.7B), pointing to late stage reduction. By 9000 BP, Phosphoria shatter weight declines but is still high, and flake size is large, suggesting early core reduction. The frequency of crushed platforms, flake and shatter weight then all decline until ~7500-8000 BP. These data are difficult to interpret, but probably indicate a return to late stage reduction. From 8000 to 6000 BP, crushed platforms increase in frequency, and flake and shatter size both increase. These all suggest a return to early stage reduction.

In general, we associate low flake density and indicators of late stage reduction of toolstone (the prevalence of “thin” flakes of nonlocal toolstone, low flake and shatter weight) with logistical use of the site. Likewise, we associate high debitage density and indicators of early stage reduction of toolstone (“thick” flakes of nonlocal toolstone, high flake and shatter weight) with more residential use of the site.

### Lithic Tools

The retouched and groundstone tool assemblage is small (Table 7.5), as expected from a test of only three 1x1 m units; consequently, any interpretations are tentative. Because of the small sample size we collapse various tool categories: hunting equipment includes whole projectile points, fragments of points (bases, midsections and tips) and preforms. Bifaces include any other whole or broken bifacial implement that does not appear to be a projectile point. Scrapers and retouched flakes, which co-occur ( $r = 0.68$ ,  $n = 21$ ,  $p = 0.0007$ ), are combined as implements to work organic components of the technology. The category of manos includes broken and complete specimens.

Hunting equipment is positively associated with bifaces ( $r = 0.67$ ,  $n = 21$ ,  $p = 0.0008$ , but not with scrapers/retouched flakes ( $r = 0.23$ ,  $n = 21$ ,  $p = 0.30$ ; Figure 7.8A and B). Manos appear ~7500 BP, and from

that point on are correlated with hunting equipment ( $r = .56$ ,  $n = 11$ ,  $p = 0.07$ ; Figure 7.8A). The correlation of these two suggests that both hunting and plant processing were occurring at the same time whenever the shelter was used for the last 7500 years. This, in turn, suggests the presence of both men and women and thus residential use of the site.

The sample sizes here are so small that it is imprudent to draw detailed conclusions from artifact frequencies. Assuming that manos = plant collection/processing, then prior to 7500 BP the main subsistence task at the shelter was hunting, as evidenced by projectile points, though this probably came in spurts; points then decline in importance after 9000 BP. There is an increase in hunting about 6000 BP, and then not again, until ~850 BP. Scrapers appear to be inversely related to projectile points, and high frequencies could signal use of the shelter as a residence, where we might expect the manufacture of organic components of the technology to take place (along with hide-working, which the scrapers could also signal).

### DISCUSSION

The debitage and tool patterns, along with the changes in demography and climate are summarized in Table 7.6. The shelter first appears to be used as a hunting camp for logistical parties, operating from residential bases elsewhere, given the evidence for biface maintenance and resharpening. The presence of Morrison and Madison toolstone shows a use of both lower and higher elevation locations, but with local material dominant, the base camp was not far away. Climate is cool and wet, and human population density low. If the economy was heavily dependent on hunting, then logistical hunting in the mountains is expected. Given its location at the mouth of a well-watered canyon, Alm occupies prime foraging real estate, and could have been the site of residential occupations, but the lithic assemblage suggests otherwise.

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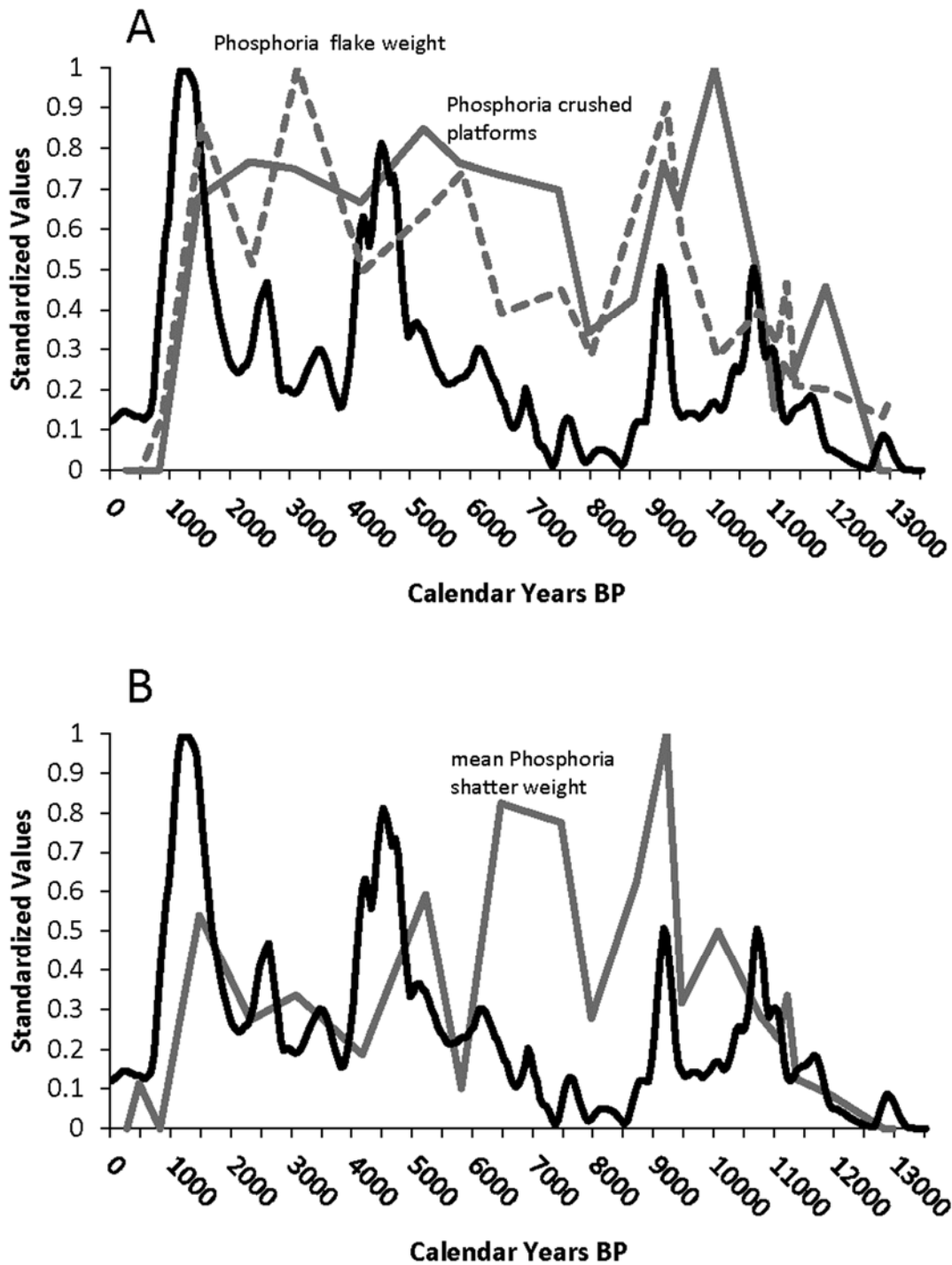


Figure 7.7. A. Relative human population size (14C summed probability values) plotted against changes in Phosphoria mean complete flake size and the frequency of Phosphoria crushed platforms over time at Alm Shelter. B. Relative human population size (14C summed probability values) plotted against changes in mean Phosphoria shatter weight over time at Alm Shelter.

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Table 7.5. Stone tools from Alm Shelter, by actual or interpolated age of level.

Calibrated Age	Hunting Equip.	Bifaces	Scrapers	Retouched Flakes	Cores	Manos	Total
300	0	0	0	0	1	0	1
500	0	0	0	0	0	0	0
850	3	0	0	1	0	2	6
1500	2	0	0	0	1	2	5
2350	4	10	0	9	0	1	24
3100	1	0	1	2	0	1	5
4200	2	4	2	6	1	1	16
5250	3	3	1	5	0	0	12
5850	11	8	0	3	1	2	25
6500	3	5	4	7	0	1	20
7500	4	3	3	12	5	2	29
8000	1	3	2	1	2	0	9
8750	1	2	3	10	1	0	17
9250	2	3	0	0	1	0	6
9500	0	0	1	1	0	0	2
10100	0	1	1	1	0	0	3
10800	5	1	1	1	0	0	8
11100	0	0	1	1	0	0	2
11250	2	0	0	0	1	0	3
11400	1	0	0	1	0	0	2
11950	0	0	0	0	1	0	1
Total	45	43	20	61	15	12	196

*Note: Bifaces does not include projectile points; hunting equipment includes whole and broken projectile points (bases, midsections, tips), as well as performs.*

This use of the site may have continued until ~9000 BP, when retouched flakes and scrapers become common at the expense of hunting equipment, and nonlocal raw material becomes more common. The site's use may have shifted back and forth between logistical and residential use: residential use at 9000 BP (although with a hunting focus) as regional population declined, but as people aggregated in the mountains and hence used the well-watered Paint Rock Canyon more intensively. With a further deterioration of climate and a concomitant reduction in people after 9000 BP, the site may have been used logistically until 8000 BP, but then returned to

residential use about 7500 BP, this time with a growing focus on plants. This shift in economy and settlement pattern was not driven by population – as it appears to decline regionally and in the mountains – but by climate which became quite arid. As expected, hunting of high-ranked prey appears to decline in favor of lower-ranked plant collecting.

As climate become less arid, the human population grew from about 7000 to 4500 BP. Hunting equipment sees a brief resurgence about 6000 BP, but otherwise the site's assemblage remains dominated by scrapers and retouched flakes, suggestive of residential use.

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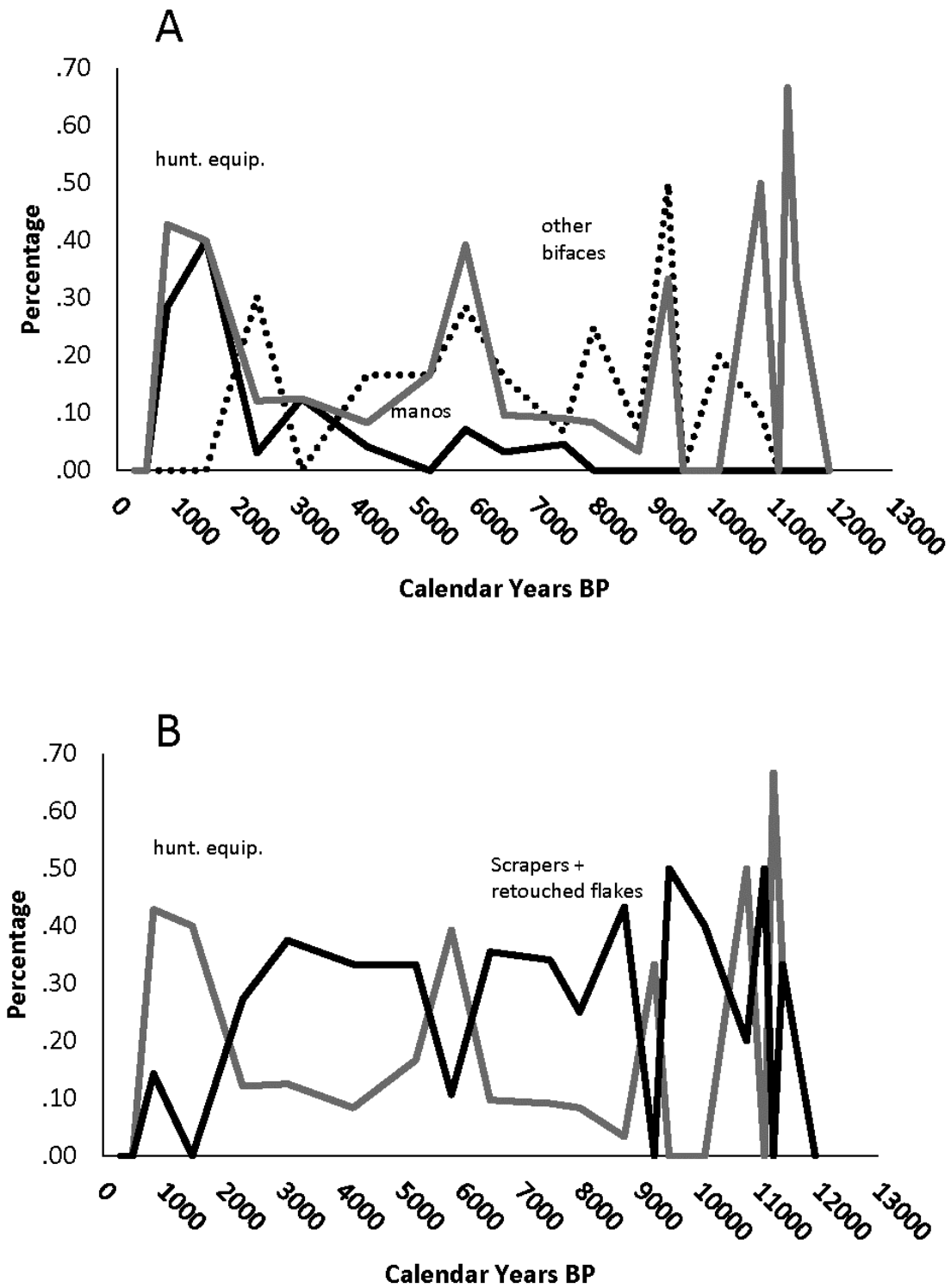


Figure 7.8. A. Relative frequency of hunting equipment, bifaces, and manos over time at Alm Shelter. B. Relative frequency of hunting equipment and scrapers/retouched flakes over time at Alm Shelter.



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Table 7.6. Summary of Trends.

Period	Debitage	Tools	Population	Climate	Interpretation
Pre-10,000 BP	<ul style="list-style-type: none"> <li>• Debitage density low</li> <li>• Local material dominant</li> <li>• Morrison/Madison: “thin” flakes; crushed platform % high, flakes small, shatter small: Suggests late stage reduction/tool rejuvenation</li> </ul>	<ul style="list-style-type: none"> <li>• Milling equip. nonexistent</li> <li>• Scrapers most common, pre-9000</li> <li>• Hunting equip most common, pre-10,000</li> </ul>	<ul style="list-style-type: none"> <li>• Very low, growing until 10,800 BP, then declines</li> </ul>	<ul style="list-style-type: none"> <li>• Initially wet and cool, but becoming warmer</li> </ul>	<ul style="list-style-type: none"> <li>• Logistical mobility, probably focused on large game hunting</li> </ul>
5000-10,000 BP	<ul style="list-style-type: none"> <li>• Debitage density high</li> <li>• Nonlocal material dominant</li> <li>• Initially late stage reduction of Phosphoria, but short-lived shift to early stage about 9000 BP, return to late stage 9000 - 8000 BP, and then early stage 8000 – 5000 BP</li> </ul>	<ul style="list-style-type: none"> <li>• Retouched flakes/scrapers replace hunting equipment</li> <li>• Milling equipment appears about 7500 BP</li> </ul>	<ul style="list-style-type: none"> <li>• Initially low, but then grows, but only in mountains (shift from valley floor to foothills/mountains?), then declines rapidly, regionally very low, growth begins again about 7500 BP</li> </ul>	<ul style="list-style-type: none"> <li>• Climate initially very warm and dry; cool, wet climate returns slowly beginning about 7500 BP</li> </ul>	<ul style="list-style-type: none"> <li>• Initially logistical use; residential use ~9000 BP but with hunting focus</li> <li>• return to logistical use, 9000-8000 BP</li> <li>• then residential, with focus on plants (hunting camp interlude ~5500)</li> </ul>
0-5000 BP	<ul style="list-style-type: none"> <li>• Phosphoria flakes large</li> <li>• Debitage density declines, esp. after 3000 BP</li> <li>• Madison/Morrison: “thick” flakes (after 2000 BP)</li> </ul>	<ul style="list-style-type: none"> <li>• Milling equipment becomes more common (~1500 BP)</li> <li>• Hunting equipment becomes more common</li> <li>• Scrapers are nonexistent</li> <li>• Retouched flakes and bifaces uncommon after ~2000</li> </ul>	<ul style="list-style-type: none"> <li>• Regional population reaches peak 4500 BP, declines rapidly ~4200 BP</li> <li>• Population remains low, 4000-2000 BP, then begins to grow</li> <li>• Reaches peak at ~1100 BP, then declines rapidly</li> </ul>	<ul style="list-style-type: none"> <li>• Climate becomes progressively cooler and wetter</li> <li>• Until, about 1000 BP with return to warmer, drier conditions (Medieval warming)</li> </ul>	<ul style="list-style-type: none"> <li>• Use of site declines, especially after 3000 BP; Site rarely used after 2000 BP</li> <li>• Mixture of residential use (plants) and logistical use (game)</li> <li>•</li> </ul>

That interpretation is supported by evidence of early stage tool production (an increase in mean local toolstone flake size, shatter size and the incidence of crushed platforms).

Thedebitage density suggests that the site’s overall use declined beginning about 6500 years ago. Climate ameliorates and population grows at this time, so it is unclear whether this is a function of climate, population or both. Debitage density makes a brief resurgence about 3200 BP. As this occurs right after a population collapse and a return to more arid conditions, we expect

that it reflects the same phenomenon as the 9000 BP population peak and subsequent high levels ofdebitage density. The site’s use then continues its decline, as suggested by the decliningdebitage densities. The site sees little use after 2000 BP, when regional population is high; the prevalence of both hunting equipment and manos from 1500 to 850 BP may point to the site serving as a logistical hunting camp and/or as a residential camp with both hunting and plant collecting. This use of the site appears to correlate with a peak in prehistoric

human population, and hence may be driven more by population density than by climate.

## CONCLUSION

We do not wish to push these data too far, derived as they are from three test units and small sample sizes. It is difficult to sort out the effects of climate and demography on hunter-gatherer settlement systems of this region of the past 12,000 years since climate and demography themselves are linked (Kelly et al 2013), and since technological changes alter (more-or-less) forever the return rates of the available food resources.

Nonetheless, these data suggest that mobility strategies do indeed respond to the configurations of resources that change in response to climate and human demography (via humanly- or climatically-caused declines in the abundance of high-ranked resources). We can expect that a growing human population would have reduced the abundance of high-ranked game as climate returned to cool, moist conditions in the mid-Holocene. This, in turn, would have encouraged the greater use of plant foods, the development of grinding technology and use of Alm Shelter by residential groups who were moving consumers to resources. At the same time, we can see that under conditions of regionally low population densities in the early Holocene, an increase in aridity resulted in an aggregation of foragers in the mountains and an increased use of favored locales, such as Alm Shelter, and a shift from logistical to residential use of the site. This shift was driven more by climate than by human population density.

In conclusion, then, this analysis demonstrates that analyses of lithic assemblages can inform us about far more than reduction strategies. If we are able to link lithic reduction to the organization of foraging behavior, then lithic assemblages can help test hypotheses of how human foraging behavior changes in relation to population density and climate-induced changes in food resources.

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## CHAPTER 8

### DECIPHERING POINT-OF-ORIGIN FOR PREHISTORIC HUNTER-GATHERERS AT YELLOWSTONE LAKE, WYOMING: A CASE STUDY IN LITHIC TECHNOLOGY AND SETTLEMENT PATTERN STUDIES

By Douglas H. MacDonald

#### ABSTRACT

*Yellowstone Lake, Wyoming, is an excellent location to study hunter-gatherer lithic technological organization in prehistory. Well-defined lake-access routes, as well as a fairly well understood toolstone universe, facilitate an understanding of human settlement and land-use at the lake. The large size of the lake and its location at an apparent territorial nexus also leads to interesting lithic use and mobility patterns visible in archaeological refuse at prehistoric sites on the lake shores. Lithic data from archaeological excavations at sites on the northwest, northeast, southeast, and southwest shores of the lake reveal contrasting travel and lithic use patterns depending on individual point-of-entry to the lake shore. Ethnohistoric and archaeological data provide useful information in evaluating whether one or more ethnic groups from different regions utilized Yellowstone Lake in prehistory.*

#### INTRODUCTION

At an elevation of 2,360 m (7,750 ft.) amsl, Yellowstone Lake, Wyoming, is North America's largest high-elevation natural body of water (Figure 8.1; YNP 2010:20). In addition, the lake provides abundant natural resources to sustain human populations. For the last 12,000 years, hunter-gatherers from all over the northwestern Plains, northern Great Basin, and Rocky

Mountains ventured to the lake to exploit animal, plant, and fish resources. Because these hunter-gatherers transported stone with them, Yellowstone Lake provides an excellent location to study hunter-gatherer lithic technological organization in prehistory.

Due to numerous prior studies (Canon et al. 1993, 1996, and 1997; Davis et al. 1995; Hale 2003; Hale and Livers 2013; Johnson et al. 2004; MacDonald et al. 2012; MacDonald and Hale 2013; Park 2011), the lithic landscape is well-defined at Yellowstone Lake and the surrounding ecosystem. In addition, prior work has established that access routes to Yellowstone Lake were constrained within several stream and river valleys. As discussed elsewhere (MacDonald et al. 2012), the large size of the lake and its location at an apparent territorial nexus also leads to interesting lithic use and mobility patterns visible in archaeological refuse at prehistoric sites on the lake shores. This paper compares lithic data from archaeological sites on the northwest, northeast, southeast and southwest shores of the lake. The data reveal variable travel and lithic use patterns depending on individual point-of-entry to the lake shore.

Prior research has defined two general models of hunter-gatherer use of Yellowstone Lake, both well defined by Johnson et al. (2004: 142-144) in their report on the Osprey Beach site on the southern shore of the lake. The first model, identified here as the Single User Model (SUM), proposes that Yellowstone Lake was seasonally utilized as part of an annual round by one group. The SUM is most recently advocated by Scheiber and Finley (2011) who further suggest that the single group was the Shoshone, at least in recent prehistory. The second model, defined here as the Multi-User Model (MUM), posits that a variety of ethnic groups from multiple regions utilized Yellowstone Lake in prehistory. The MUM is supported by the ethnographic literature, as well as by archaeological data provided by Park (2010, 2011).

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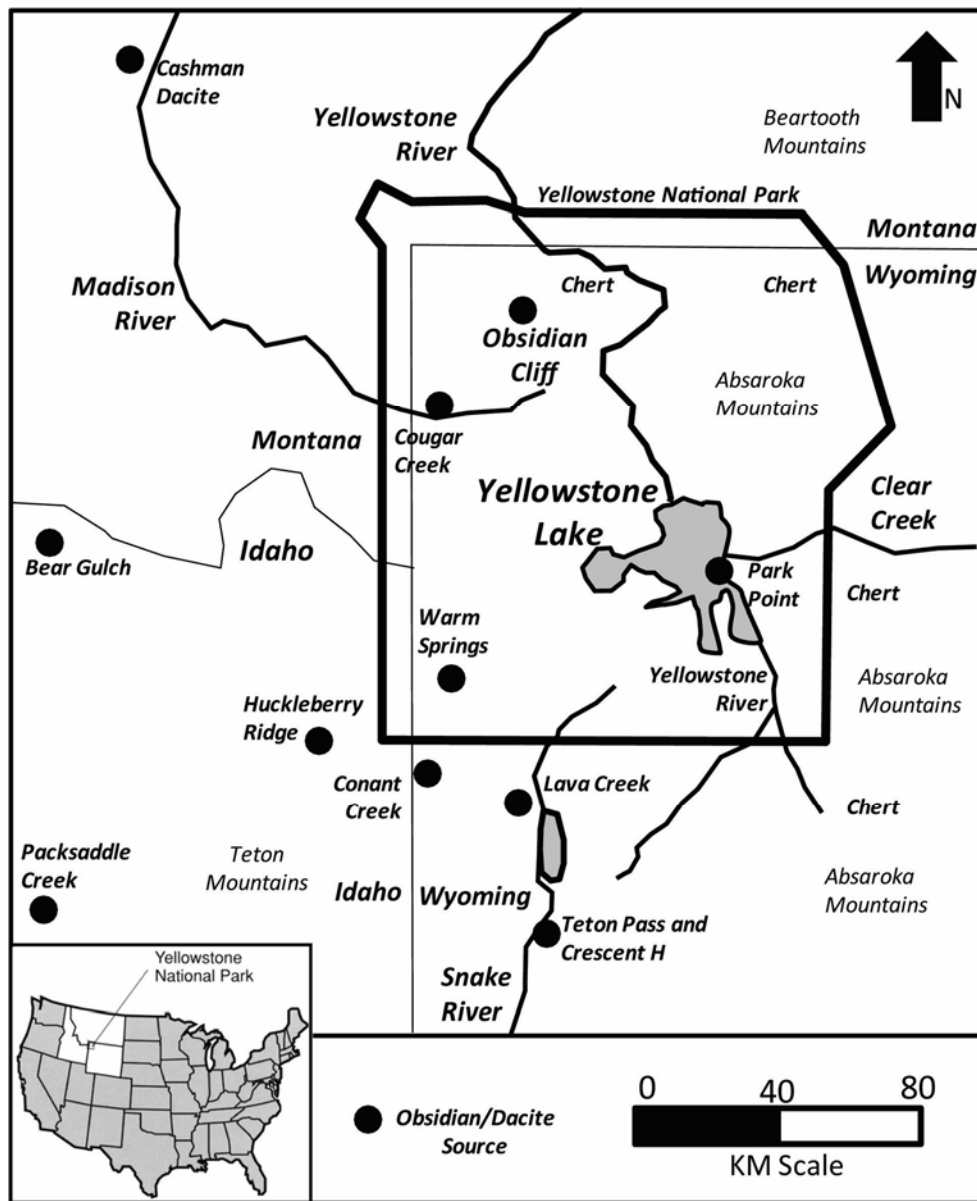
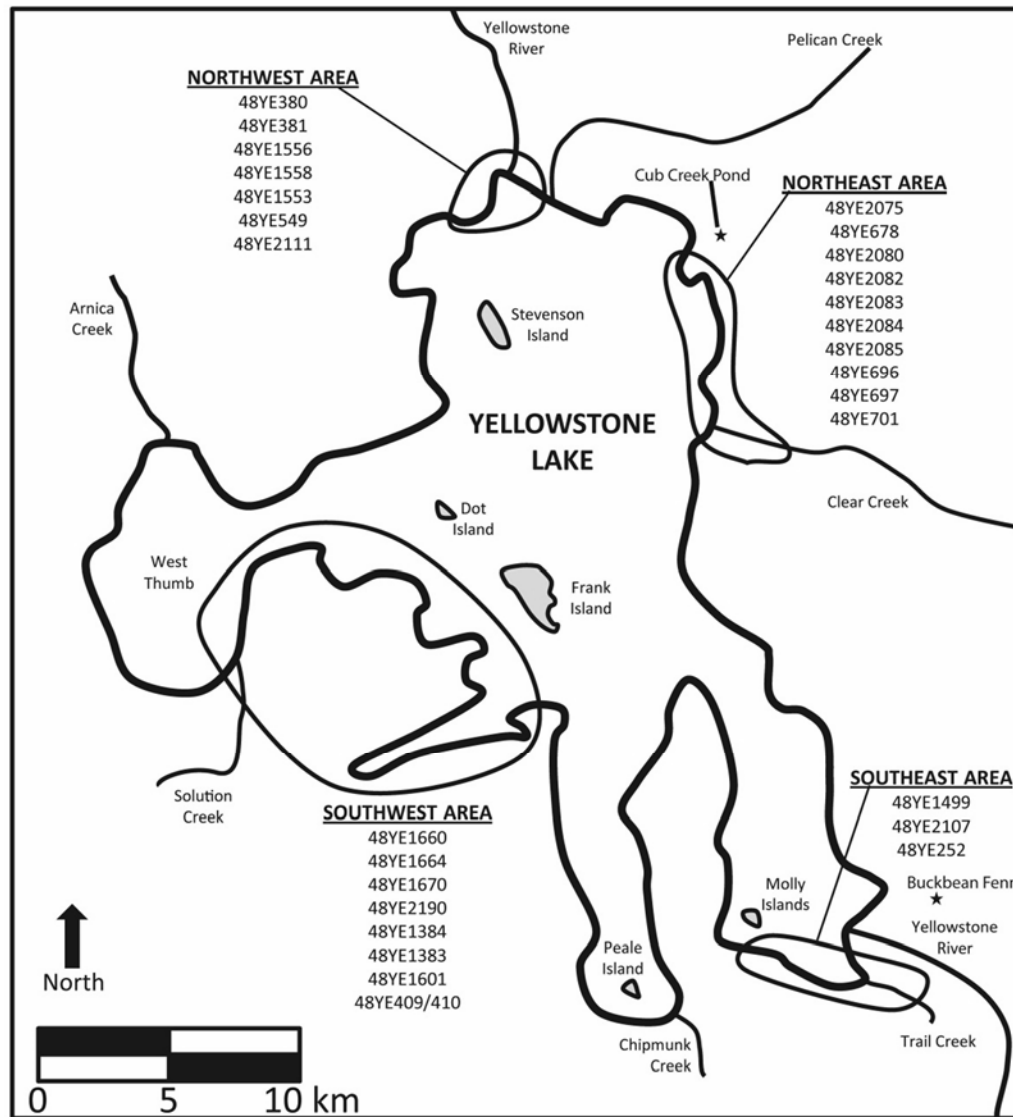


Figure 8.1. A Map of the Greater Yellowstone Ecosystem showing Yellowstone Lake and Regional Lithic Raw Material Sources.

The current paper evaluates the viability of each model — the SUM and the MUM — to determine if one ethnic group or multiple groups used Yellowstone Lake in the past. Ethnographic data are briefly summarized that largely support the MUM. More importantly for this paper, I utilize lithic data to evaluate the two models of lake use. In this regard, lithic raw material source data are presented for volcanic materials and, to a lesser extent, non-volcanic materials (e.g., chert,

orthoquartzite, petrified wood) that lend insight into hunter-gatherer mobility patterns. In this regard, the lithic data largely support the MUM in showing that multiple points of origin were utilized in the past, most likely by a variety of groups from at least three regions within the interior western United States.

## LITHICS IN THE WEST



**Figure 8.2. Map of Yellowstone Lake, including Key Archaeological Sites and Geographic Features Mentioned in Text.**

### BACKGROUND

Yellowstone Lake is the heart of the Greater Yellowstone Ecosystem (GYE) which encompasses nearly 80,000 sq. km. within northwest Wyoming, south-central Montana, and northeast Idaho (Figure 8.1). Measuring 32 km north-south and 22 km east-west with a shoreline measuring 225 km, Yellowstone Lake is bordered by the Absaroka Mountains to the east and the Teton Range to the south (YNP 2010:20). The Yellowstone River is the major tributary (Figure 8.2) and flows into the lake on its

southeast corner and out of it ca. 30 km to the northeast. Beyond the lake, the Yellowstone River flows 1,100 km across Montana and Wyoming as North America's largest free-flowing river. Among 60 or so other smaller streams that flow into the lake, Clear Creek arrives on its northeastern shore and has its headwaters in the Absaroka Range, nearly meeting the Shoshone River which flows eastward to the Big Horn Basin. Each of these three major waterways — the southern and northern Yellowstone Rivers and Clear Creek — were active travel routes in prehistory (MacDonald and Hale

## LITHICS IN THE WEST

2013; Park 2011:125-129). Other major lake-feeder streams include Pelican Creek on the north, Trail Creek on the southeast, Solution Creek on the southwest, and Arnica Creek on the west. The Madison River to the west of the lake was also a major regional route utilized in prehistory to gain access to the GYE (Johnson et al. 2004: 142-145).

Seasonality is important to understanding human use of the GYE. May through October are the only months with average temperatures around or above 10° centigrade (50° F). November through March puts the lake area in snowfall zones averaging ca. 50 cm or more per month with accumulation of a meter or more from November through April. Yellowstone Lake is frozen several feet thick between approximately early December and mid-late May.

Yellowstone Lake's shores contain several vegetative zones, including mesic subalpine fir, forested riparian, graminoid riparian, and sagebrush or shrub and grass habitats (Despain 1990). Interspersed among the extensive pine forests that enclose the lake, these open meadows and riparian areas are extremely diverse, containing as many as 400 plant species (Elliot and Hektner 2000). The University of Montana (UM) identified 52 different plant species within a 20-acre meadow on the northwest shore of the lake, of which 15 species were recognized as food sources, 17 species as medicinal, and eight species as spiritually important (Kershaw et al. 1998). Wright et al. (1980:183) conducted a plant-use study for the nearby Jackson Hole region to the south of the lake, with similar findings.

This diversity of plant resources supports more than 60 mammal species, including bison, elk, moose, big horn sheep, deer, antelope, grizzly and black bear, mountain lions, coyotes, and wolves. A vast majority of Yellowstone's bison and other medium and large ungulates are seasonally migratory, moving up in elevation in warm seasons and down in elevation in cold seasons (Cannon 2001). Another seasonally migratory subsistence resource in Yellowstone Lake is cutthroat trout (*Oncorhynchus clarki bouvieri*), one of only two surviving original native cutthroat trout species left in North America. Cutthroat trout are abundant at the lake

(and were in the past), especially in spring when they run up the lake's creeks to spawn.

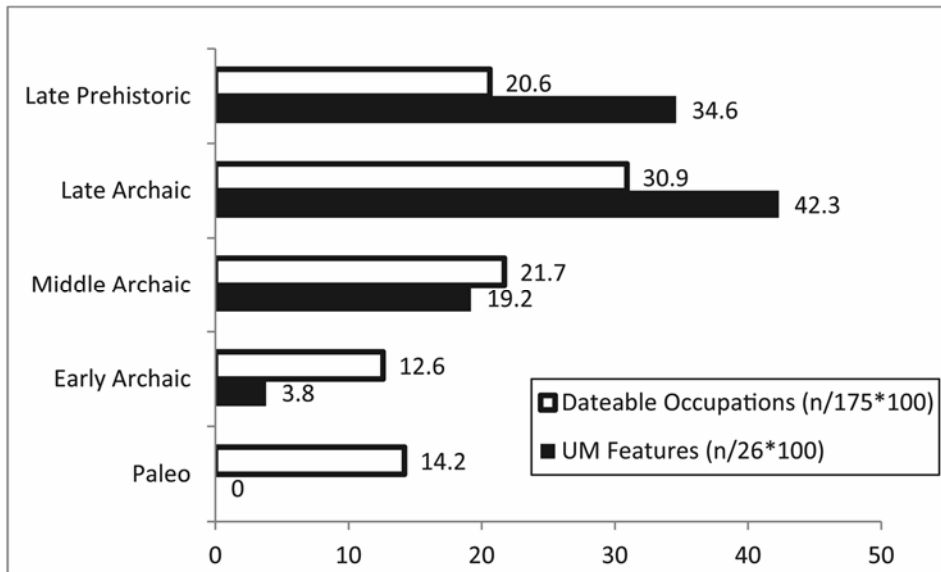
### **PRIOR ARCHAEOLOGICAL RESEARCH AT YELLOWSTONE LAKE**

This paper's evaluation of the SUM and MUM models of lake-use is influenced by various projects conducted during the last 50 years at Yellowstone Lake, Wyoming. Since the first archaeological inventories of Yellowstone Lake's West Thumb area during the late 1950s, many archaeological studies have been performed around Yellowstone Lake. These are detailed by Hale and Livers (2013) and I only briefly summarize them here. Figure 8.2 shows the locations of important lake-area sites discussed in the text. Montana State University, Missoula (now the University of Montana) was the first to survey Yellowstone National Park (Malouf 1958; Hoffman 1961; Taylor et al. 1964). Hoffman (1961: 16-18) subsequently recording a high density of sites at Yellowstone Lake. Taylor et al. (1964) performed the first excavations at Yellowstone Lake at the Fishing Bridge Site (48YE1) near the Yellowstone River outlet, with additional work there by Cannon et al. (1993) and UM (Livers and MacDonald 2011).

In the 1980s, more-focused academic research was conducted by a handful of researchers associated with the Midwest Archaeological Research Center (MWAC) on the southwestern shore of the lake, results of which are discussed more fully below (Reeve et al. 1981; Samuelson 1983; Wright et al. 1978, 1980). In the 1990s, Cannon et al. (1996, 1997) of the MWAC conducted excavations at several sites on the west and north shores of the lake. Finally, on the lake's south shore, Ann Johnson (Johnson et al. 2004; Shortt and Davis, 2002) led excavations at the Late Paleoindian Osprey Beach site (48YE409/410) with its extensive Cody Complex (ca. 9,300 B.P.) occupation. More recently, Yellowstone National Park provided funding to the University of Montana (UM) to complete survey and testing of archaeological sites on the northwest, eastern, and southern shores of Yellowstone Lake (MacDonald 2012; MacDonald and Hale 2013; Vivian et al. 2007, 2008).



## LITHICS IN THE WEST



**Figure 8.3. Prehistoric Use of Yellowstone Lake: Site & Feature Counts by Time Period.**

### YELLOWSTONE LAKE CULTURE HISTORY

These various studies have identified 285 archaeological sites along the shores of the lake, with 104 of those yielding 175 dateable occupations (Hale 2003; Hale and Livers 2013; McIntyre 2012). Recent excavations by UM at dozens of lake-area sites confirm active use of the lake since the Paleoindian period (Figure 8.3) (MacDonald and Livers 2011; Livers and MacDonald 2012; MacDonald et al. 2012). Of the 27 radiocarbon-dated features excavated by UM between 2009-2011 at 11 sites, only one (a ca. 6,800 B.P. hearth at 48YE381) predates 3,400 calibrated years ago (MacDonald et al. 2011), with Middle Archaic (n=5), Late Archaic (n=11), and Late Prehistoric (n=9) features dominating the feature assemblage. As of 2011, the various archaeological studies conducted at the lake have identified 25 Paleoindian, 22 Early Archaic, 38 Middle Archaic, 54 Late Archaic, and 36 Late Prehistoric occupations (McIntyre 2012). Based on research from other studies (MacDonald et al. 2012), lithic use is fairly consistent over time, with some exceptions (MacDonald et al. 2011, 2012). However, for the purposes of this paper, I hold time constant, instead preferring to focus

on geographic use of lithics in the various regions of the lake.

### METHOD AND THEORY

Understanding the lithic raw material use trends over time and space are the ultimate goals of UM's research at Yellowstone Lake (MacDonald 2009). While Binford's (1979, 1980) seminal works provide much of the basis for the current paper's theoretical perspective, I also rely extensively on Michael Schiffer's artifact life cycle models (1972) which fall

squarely in the organization of technology approach to lithic analysis (Andrefsky 1994). Margaret Nelson's

1991 paper on the organization of technology gives a small nod to Schiffer's work, discussing it in the contexts of artifact discard; however, Schiffer's life cycle model provides the first and still the most straightforward organizational model of human technological organization in the archaeological literature. By understanding the life cycle of artifacts, we can fully understand how those artifacts fit into the world of their users and understand a great deal about their lives, from material procurement, to tool manufacture, to tool use, recycling, and tool discard (MacDonald 2009).

Because of the variable life cycles of tools and the various life spans of those tools during their existence in the systemic context, we need to look at various assemblages of artifacts from the archaeological context to understand prehistoric hunter-gatherer culture. Every lithic assemblage from a site has multiple sub-assemblages that reflect different site-use behaviors. We need to look not just at the whole assemblage, but also at these sub-assemblages.

A problematic analytical trend in the regional work on settlement patterns in the "obsidian west" is the nearly exclusive sourcing of formal tools, as defined by Andrefsky (1994, 1998), rather than representative

samples of the entire lithic assemblages of sites. Projectile points are the most obvious kind of formal tool, those tools that remain in the tool kits of hunter-gatherers for a comparatively long time, take a longer time to make, are retouched for extensive use, and are generally cared for so they can be used over and over. Curated tools are important in understanding lithic technological organization, but they only represent a certain class of artifact, a sub-assemblage of a specific and perhaps even special kind of tool. But what about the other lithics we find at sites, the non-formal items, or even the debris from the production and maintenance of all tools?

Lithic sourcing of formal tools will inform us about two levels of movement that are important to hunter-gatherers, areas that I've referred to in the past as macro- and meso-movement areas, areas beyond the realm of daily travel (MacDonald 1999:148). Macro-movements consist of long-distance travel that might occur only a few times in a lifetime, while meso-movements consist of semi-regular travel to edges of defined territories. But what about the daily travel realm, the area of micromovement? This area reflects the daily world of hunter-gatherers, where they likely spent most of their time, likely to be revealed through debitage.

The presence of that formal item in the assemblage, however, only reflects the distance that tool traveled, not necessarily the distance its user traveled. But, flakes are going to more effectively tell us about the direct procurement of stone and the micro- and meso-movements of stone and people, especially if the debitage sample is selected from a range of flake types to reflect the entire tool production activities at the site.

Thus, by sourcing lithics used to produce debitage and a variety of tools, we can understand the entire universe of toolstone sources. At Yellowstone Lake, lithic materials occur in volcanic and non-volcanic form. Volcanics — including obsidians and dacites mostly — come from about 10 or so well-established and well-understood locations on the landscape (see Figure 8.1; MacDonald et al. 2012; Park 2011). At the lake, volcanic materials come from the north, south, and west, with one type (Park Point obsidian) also found to the east.

Sources for non-volcanics, including chert, chalcedony, petrified woods, and quartzites, are a bit more uncertain. We know that one group of cherts and chalcedonies has its origins north of Yellowstone Lake, from the Crescent Hill sources up along the Yellowstone river between Gardiner and Tower Junction. These cherts are well-described and defined by Adams et al. (2011) and MacDonald and Maas (2011). A large variety of chert, chalcedony and orthoquartzite also originates within Madison Limestone formations within the Absarokas and Wind River Mountains to the east and south of the lake. In addition, these cryptocrystalline lithics also occur in small nodules as secondary glacial gravels along the shore of Yellowstone Lake (Johnson et al. 2004; MacDonald et al. 2012).

At the very least, we can distinguish northern and eastern/southern cherts in terms of basic directionality. Yellowstone Lake's lithic landscape, thus, is composed of: 1) the sourceable-volcanics; 2) the northern cherts (represented by Crescent Hill chert); and 3) the eastern/southern cherts from the Absaroka Mountains and gravels of the lake itself. Our understanding of mobility of prehistoric hunter-gatherers thus is well-informed, but could be improved with accurate fingerprinting of the non-volcanic sources.

The current paper analyzes the various sub-assemblages of lithics from various site occupations along the lake shore. I look mostly at the flaking debris data associated with well-dated site components, with analysis of tools a lesser focus. As noted above, research indicates that the two assemblages tell different stories about the people that lived at Yellowstone Lake; formal tools telling us where the artifacts traveled and perhaps the people's meso and macromovements, while the flakes tell us more about the daily lives of the people and their local realm of micromovement and mesomovement.

#### EVALUATING THE SUM AND MUM

In conjunction with ethnohistoric data (Nabakov and Loendorf 2002, 2004), I provide archaeological data to evaluate these previously proposed ideas regarding use

of the lake. As reported herein and elsewhere (MacDonald et al. 2011; MacDonald and Hale 2013), I attempt to evaluate the two models of Yellowstone Lake use, including the Single-User Model (SUM) and the Multi-User Model (MUM), previously described by Johnson et al. (2004). I start this evaluation with a brief summary of the ethnographic literature, followed by a much more extensive overview of the Yellowstone Lake archaeological data.

#### **ETHNOHISTORIC AND ETHNOGRAPHIC DATA**

Our ethnohistoric and ethnographic data are largely, but not exclusively, compiled from Nabakov and Loendorf's (2002, 2004) seminal studies of contemporary Native American use of the GYE and Yellowstone Lake. While recent archaeological analysis by Scheiber and Finley (2011) largely focus on use of the GYE by the Shoshone, the ethnographic literature suggests that a diverse suite of ethnic groups utilized the region. Among these groups include the Shoshone, Bannock, Crow, Blackfeet, Salish, Kiowa, Nez Perce, among many others (Nabakov and Loendorf 2002, 2004).

In particular, the Blackfeet and Crow are known to have used the northern tier of the lake, while Nabakov and Loendorf suggest that the Wind River Shoshone were focused in the lake's southern tier. The Bannock and Nez Perce mostly used the northern tier of the lake as well, with the latter apparently focused in the Pelican Creek Valley as a main warm-season bison hunting area. It is simply not reasonable to think that the Shoshone were the exclusive users of the Greater Yellowstone Ecosystem, even in later prehistory, in light of extant ethnohistoric and archaeological data.

Ethnographic studies completed for Nabakov and Loendorf's work suggest that the various groups who used the lake incorporated a wide variety of subsistence strategies into their survival repertoire. Among the tribes, the Shoshone and Bannock are the only groups likely to have used the lake for fishing (Nabakov and Loendorf 2004:174). MacDonald et al. (2012) show that fishing likely was a minor component of the subsistence patterns for most people at Yellowstone Lake. In fact,

Nabakov and Loendorf do not provide specific ethnographic accounts of the Shoshone fishing at the lake, only noting that the Shoshone fished in the region and had origin stories for fish at Yellowstone Lake (Nabakov and Loendorf 2004: 174-176, 242-244). The ethnographic literature does not support any fishing by the Blackfeet or Crow at the lake (McAllester 1941). Thus, if the lake was used for fishing, it was likely by the Shoshone/Bannock in the spring, at least in recent history and prehistory.

Thus, while it may have occurred at Yellowstone Lake, fishing is not well-documented in the ethnographic literature. Nabakov and Loendorf (2004: 60-61, 93, 113, 139, 179) provide several descriptions of the hunting and gathering of land-based resources in Yellowstone, including the collection of a wide variety of plants, roots, seeds, and nuts. For the Shoshone, these account for 30-70 percent of their diet. Elliot and Hektner's (2000) study of riparian areas of Yellowstone identified more than 1,200 species of plants, many of which are edible and/or medicinal. Blue camas was especially attractive for the Bannock and Shoshone, one of the key edible plant species identified by the University of Montana within the lake's shoreline meadows. Wright et al. (1980) and Johnson et al. (2004: 139) also speculate that camas (*Camassia* sp.) was likely the most important spring root crop for Native Americans at Yellowstone Lake and vicinity. Mammal hunting was also vital to the lake-area subsistence regime during recent history. As noted above, more than 60 species of mammals inhabit the lake's environs, including elk, bison, deer, bear, rabbits and sheep, all of which were hunted.

The ethnohistoric, ethnographic, and ecological research summarized here explains why Native Americans were attracted to Yellowstone Lake. Following others (Johnson et al. 2004: 138-139; MacDonald et al. 2012), I propose that the lake served as a concentrated resource area in which a host of seasonally available resources were procured by mobile hunter-gatherer populations. In terms of seasonality, we propose that the use-cycle was initiated in early spring with snow still on the ground and ice still on the lake, thus explaining the presence of archaeological materials on the lake's five

islands. In terms of the two models of lake use, the ethnographic and ecological data summarized here support the multi-user model (MUM), with multiple Native American groups traveling to the lake from a variety of regions.

#### ARCHAEOLOGICAL DATA: METHODS

As with the ethnohistoric discussion above, this paper now presents archaeological data to evaluate the SUM and the MUM models of lake-area use. The ethnographic literature supports active use of the lake by the Shoshone; however, it is clear that many other ethnic groups used the lake as well. Figure 8.2 above shows the 28 key archaeological sites used in this study. These sites have yielded more than 24,000 lithic, faunal, and ethnobotanical artifacts from the excavation of more than 240 sq.m. around the entire circumference of the lake. As shown in Figure 8.2, this paper focuses on sites within four areas of the lake — northwest, northeast, southeast, and southwest — with excellent comparative data on lithic use.

As depicted in Figure 8.1 above, lithic source data are useful in determining the point of origin for hunter-gatherers who used the lake in prehistory. In this analysis, I focus on the overall lithic material trends on the respective shores of the lake, regardless of period of occupation (MacDonald et al. 2011; MacDonald et al. 2012). I use two sets of lithic material data in the current analysis. First, I compare the use of obsidian and chert at sites on the northwestern, northeastern, southeastern, and southwestern lake shores. To simplify comparison of the data, all volcanic materials are included within the obsidian category, including dacite, while in the chert category, I include all cryptocrystalline silica materials, including chert, chalcedony, silicified/petrified wood, and orthoquartzite. Sources for these various materials are identified in Figure 8.1.

Second, I use energy-dispersive x-ray fluorescence (EDXRF) analysis results of volcanic lithic artifacts at the lake, collected during our own and other's research, with all analyses completed by Richard Hughes (2010a, 2010b, 2011a, 2011b, 2012a, 2012b). The EDXRF data distinguish

four major volcanic-material source areas, including: 1) Obsidian Cliff, located 35 km (20 miles) northwest of the lake (Davis et al. 1995); 2) western sources, including Bear Gulch and Cougar Creek obsidians and southwest Montana dacites, located between 60-200 km (40-120 miles) west-northwest of the lake; 3) eastern sources, including only Park Point obsidian from the eastern shore of Yellowstone Lake (McIntyre et al. 2013); and 4) southern sources, including Teton Pass, Conant Creek, Packsaddle Creek, Crescent H, Warm Springs, Huckleberry Ridge, and Lava Creek, between 45-150 km (30-90 miles) (Park 2011: 125-126). Both of these sets of information — the obsidian vs. chert and the EDXRF data — help resolve the points of origin for Native Americans that used Yellowstone Lake.

In total, the lithic material study encompasses more than 24,000 artifacts from 28 well-studied sites at the lake (see Figure 8.2), including 23 by UM and five by others. On the northwest shore, I use data from seven sites near the Yellowstone River outlet (48YE380, 48YE381, 48YE1556, 48YE1558, 48YE1553, 48YE549 and 48YE2111; MacDonald and Livers 2011; Livers and MacDonald 2011). On the northeast shore, I combine our data from seven sites along Cub and Clear Creeks (48YE2075, 48YE678, 48YE2080, 48YE2082, 48YE2083, 48YE2084, and 48YE2085; Livers 2012) with those collected by Cannon et al. (1997) at three sites near Steamboat Point (48YE696, 48YE697, and 48YE701). On the southeast shore, I combine our data (Livers 2012) from sites 48YE1499 and 48YE2107 near the Yellowstone River inlet with those collected by Lifeways (Vivian 2009) at the nearby Donner Site (48YE252). On the south-central and southwest lake shore, I combine our data (MacDonald 2013) from seven excavated sites on the south-central lake shore (48YE1660, 48YE1664, 48YE1670, 48YE2190, 48YE1384, 48YE1383, and 48YE1601) with those collected by Lifeways (Johnson et al. 2004) at Osprey Beach (48YE409/410) on the southwest lake shore (West Thumb area). Numerous additional data are available from other studies and other areas of the lake, but for the purposes of this paper, these four areas — northwest, northeast, southeast, and southwest—provide adequate samples to

evaluate points of origin and the function of the lake in prehistory.

## ARCHAEOLOGICAL DATA: LITHIC MATERIAL RESULTS

### Northwest Shore

In the presentation of results, I present data in a clockwise fashion around the lake, starting on the northwest shore. Overall, obsidian accounts for 88 percent of all lithics at the northwest shore sites. Chert (8%) is a minority and largely derives from the Crescent Hill chert source to the north along the Yellowstone River. EDXRF data ( $n = 234$  total sourced lithics) suggest mobility to the west-northwest as well. As shown in Figure 8.4, sites on the northwest shore of the lake are heavily dominated by Obsidian Cliff obsidian (79.5% of XRF-sourced lithics) with sources 30 km (20 miles) northwest. In addition to the high percentage of Obsidian Cliff obsidian, southwest Montana dacites (largely Cashman dacite) and Bear Gulch obsidian account for 11.7 percent of sourced lithics, while the Park Point source on the eastern lake shore accounts for 6.8 percent of sourced lithics. EDXRF data do not support active travel or even trade to the south, with only one percent ( $n = 2/234$ ) of obsidians at northwest shore sites deriving from Jackson area obsidian sources.

The focus for north shore Native Americans was squarely to the north and northwest, with those areas comprising 91.2 percent of sourced EDXRF lithics. Together with the dominance of Crescent Hill chert among cryptocrystalline silica materials, these volcanic material data indicate that people living near the mouth of the Yellowstone River on the northwest shore likely originated from the north/northwest, likely using the Gardiner, Madison, and Yellowstone River Valleys as the main travel corridors to access the lake.

### Northeast Shore

There are significant differences in obsidian and chert use between northeastern and northwestern lake users ( $\chi^2 = 44.103$ ;  $df = 1$ ;  $p = .000$ ), with more obsidian on the northwest shore (88%) compared to the northeast shore (69%) due to the northwest shore's proximity to Obsidian Cliff. Increased chert on the northeast shore (31%)

compared to the northwest shore (8%) is due to the northeast shore's proximity to Absaroka cherts. Northeastern shore hunter-gatherers also used significant amounts of Park Point obsidian (30%) from the eastern lake shore. They also apparently targeted Obsidian Cliff, given that it represents nearly 67 percent of the obsidian at northeastern shore sites. Other sources represented in northeast lake shore EDXRF data include Teton Pass ( $n = 2$ ) and Conant Creek ( $n = 1$ ), indicating minimal use of southern sources.

As reflected in Figure 8.5, eastern-sourced materials — including Absaroka cherts and Park Point obsidian — account for 66 percent of the total lithic assemblage from UM's northeastern shore sites, with west-northwest sources constituting 34 percent. At northwest lake shore sites, eastern sources account for only 7 percent of lithics, with northern and western sources accounting for more than 91 percent. These differences in lithic raw material use are significant between the northwest and northeast lake shores and point in the direction of origin for people that used the respective areas of the lake ( $\chi^2 = 198.00$ ;  $df = 1$ ;  $p = .000$ ).

The differences in chert and obsidian use reflect different points of origin for people living on the respective lake shores, with northwestern lake users deriving from the north-northwest and northeastern lake users deriving from the east along the Clear Creek Valley and the Big Horn Basin. Considering that these lake shores are only seven miles apart, the variation in lithic raw material use between them is impressive. These data likely indicate segregation of populations that visited the lake based on their points of origin, with people arriving to the lake and not venturing much beyond. For example, people travelling from the east to the lake along the Clear Creek Valley apparently focused their time along the lake's east shore, with occasional travel to Obsidian Cliff to collect obsidian, which they curated with them as they traveled back eastward to their winter camps along the Shoshone River (e.g., Mummy Cave; Husted and Edgar 2002) and onward to the Big Horn Basin. As recorded by Hughes (2012), Obsidian Cliff obsidian was the main volcanic material procured by inhabitants of Mummy Cave.

LITHICS IN THE WEST

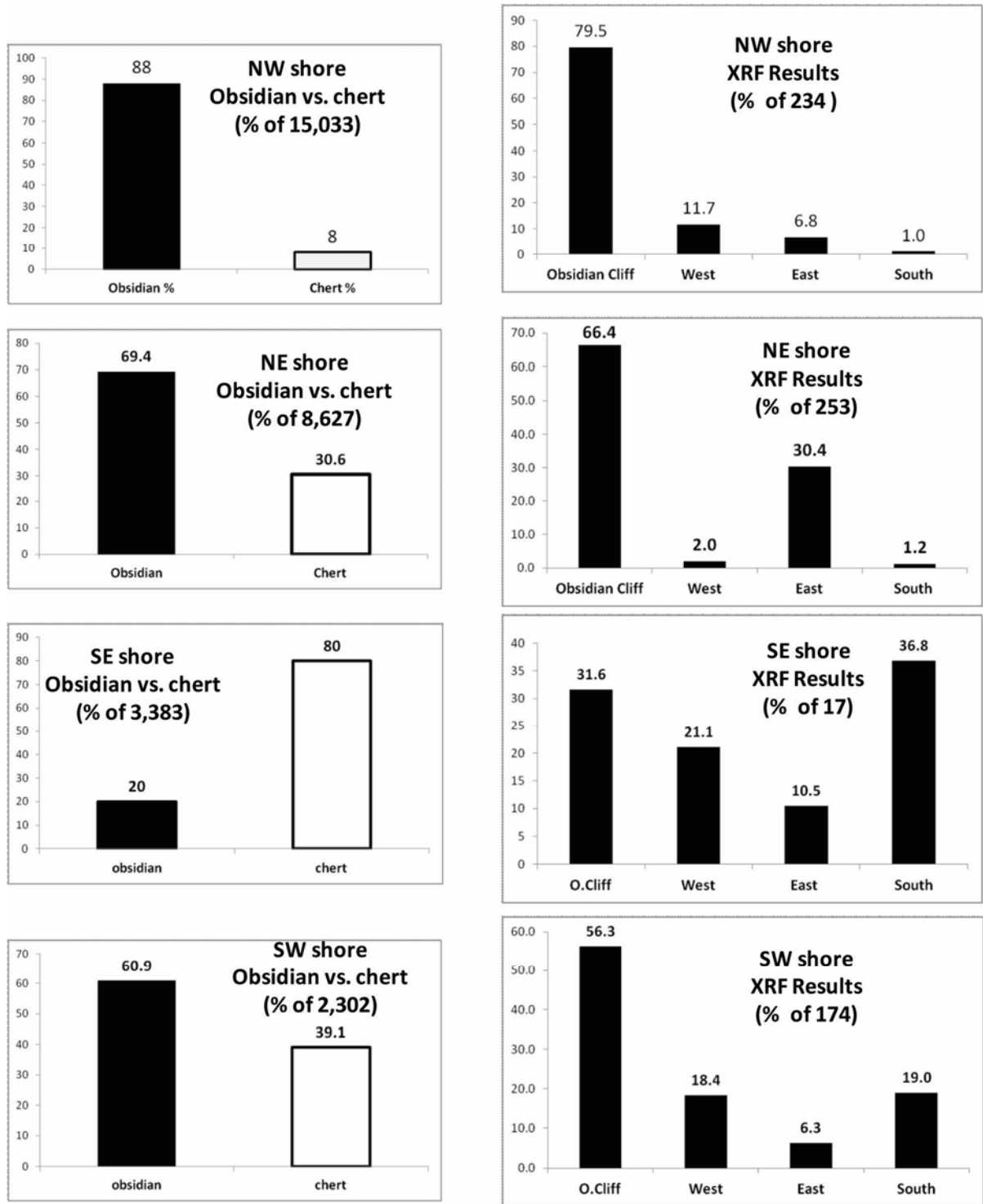


Figure 8.4. Comparison of Lithic Raw Material Use at Yellowstone Lake.

## LITHICS IN THE WEST

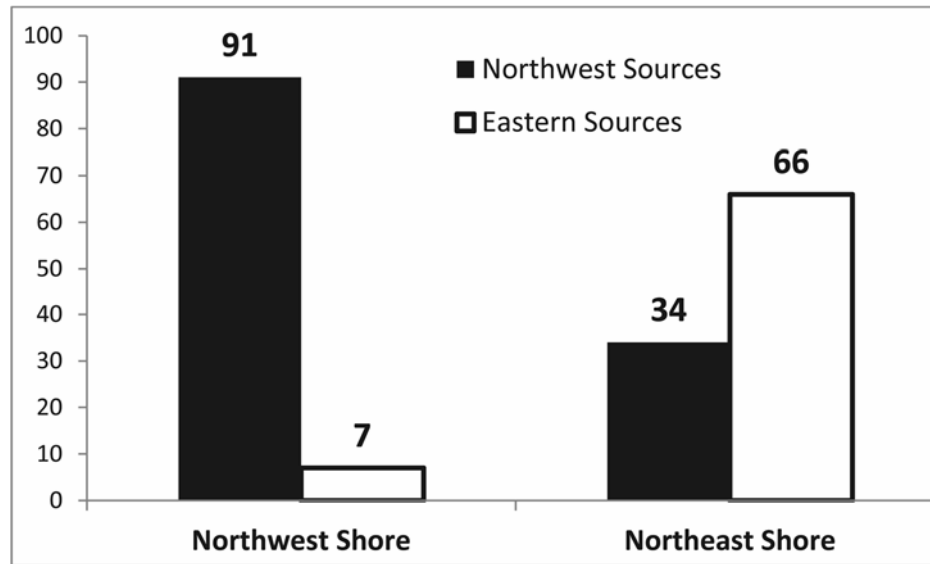


Figure 8.5. Comparison of Lithic Raw Material Use on the Northeast and Northwest Lake Shores.

### Southeast Shore

On the southeast shore of the lake, there is a much more diverse use of obsidians and cherts than on either the northwest or northeast shores. In contrast to the northern lake shore, the southeast shore yields predominantly materials with southern origins. It is important to note that the closest sources of materials to the southeast shore are Absaroka cherts, with sources along the lower (southern) Yellowstone River, ca. 15-30 km (10-20 miles) south. While these cherts are found occasionally as gravels on the lake shore, their small morphology and unpredictable distribution indicates that the primary sources were preferred locations of procurement. The most proximate obsidian sources are the southern (Jackson-area) sources at a distance of ca. 50 km. Obsidian Cliff would be directly accessed from the southeast lake shore only by walking around the entire lake perimeter (40 km) with another 35 km to the cliff.

As might be expected given their source-proximity, Absaroka cherts ( $n = 2,709$ ) comprise more than 80 percent of lithics at sites on the southeast lake shore ( $N = 3,383$ ), with obsidian ( $n = 675$ ) comprising the remainder of the southeast shore lithic assemblage. The lithic material data collected in the Southeast Arm by UM and Lifeways are not significantly different ( $\chi^2 = 0.466$ ;  $df = 2$ ;

$p = .495$ ), suggesting continuity in material use among the three different sites used in our studies.

Sourced obsidian artifacts from the southeastern lake shore sites ( $n = 17$ ) derive from five different sources, with 32 percent Obsidian Cliff and 37% southern sources. Western sources comprise 21 percent with eastern shore Park Point obsidian accounting for only 11 percent of southeast shore obsidian artifacts.

It is important to remember, however, that only approximately 20 percent of the entire lithic assemblages at southeastern lake shore sites are obsidian. Thus, in terms of the total lithic assemblage from the Donner Site ( $n = 3,329$ ), for example, Obsidian Cliff obsidian represents only ca. nine percent (ca. 300 lithics), compared to 89 percent (ca. 3,029 lithics) originating from southern/eastern sources (including Absaroka cherts and southern/eastern obsidians).

In order to more realistically compare Obsidian Cliff use between the four lake-shore areas, I calculated a relative percentage: (total obsidian artifacts x Obsidian Cliff %) ÷ total lithics. When this relative source percentage is calculated, Obsidian Cliff comprises only 6.3 percent of the southeastern shore sites' lithic assemblages, compared to 70 percent on the northwest shore (Figure 8.6). These data support a southern origin for southern lake shore users. The overall low densities

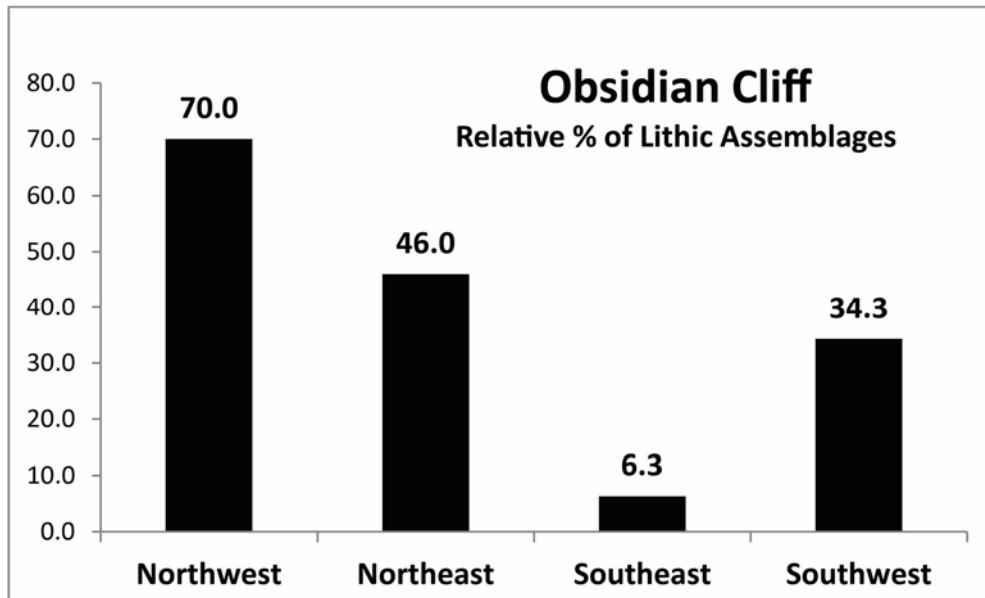


Figure 8.6. Relative Percentage of Obsidian Cliff Obsidian by Lake Area.

of Obsidian Cliff obsidian — in terms of the entire lithic assemblages at southeastern sites — likely indicates procurement via trade with other lake users to the north, rather than direct procurement. In other words, southeastern lake users traveled from the south northward up the Snake and Yellowstone Rivers to the mouth of the river on the southern lake shore. There, they hunted and gathered and occasionally socialized with other people visiting the lake, at which time they probably acquired Obsidian Cliff obsidian via trade.

#### Southwest Shore

Interestingly, lithic material trends on the southwest shore are not quite as clear as the other three areas discussed above. Here, at eight sites investigated by UM ( $n = 7$ ) and Lifeways ( $n = 1$ ), obsidian (61%;  $n = 1,401$ ) and chert (39%;  $n = 901$ ) percentages are nearly equally represented. These trends are distinct from both the northwest and southeast lake shores, the former of which had 90 percent obsidian and the latter only 20 percent.

In terms of the EDXRF data, the southwest shore generally appears to be a mix of northern, western, and southern sources. Fourteen different sources of obsidian

are present in the southwest shore site assemblages. However, given its closer proximity, Obsidian Cliff obsidian occurs in high percentages (56.3%;  $n = 98$ ). Bear Gulch obsidian was also popular (18%;  $n = 32$ ), perhaps indicating a western origin using the Madison River. Southern sources comprise 19 percent ( $n = 33$ ) of the southwest shore lithic assemblages. These data suggest use of southern, western, and northern sources by people living on the southwest shore, possibly indicating that these were mixing areas used by many different groups moving back and forth to the Yellowstone River and Obsidian Cliff.

#### LITHIC MATERIAL SUMMARY

The archaeological data collected by UM and others at these 28 lake-area sites support the hypothesis of use by multiple hunter-gatherer groups from multiple regions. On the northwest lake shore, individuals were oriented northward toward Obsidian Cliff and the Yellowstone, Madison, and Gardiner River Valleys. On the northeast shore, individuals were focused eastward up the Clear Creek and Shoshone River Valleys. On the southeast shore, the southern Yellowstone River was the likely origin route, while the southwestern shore appears



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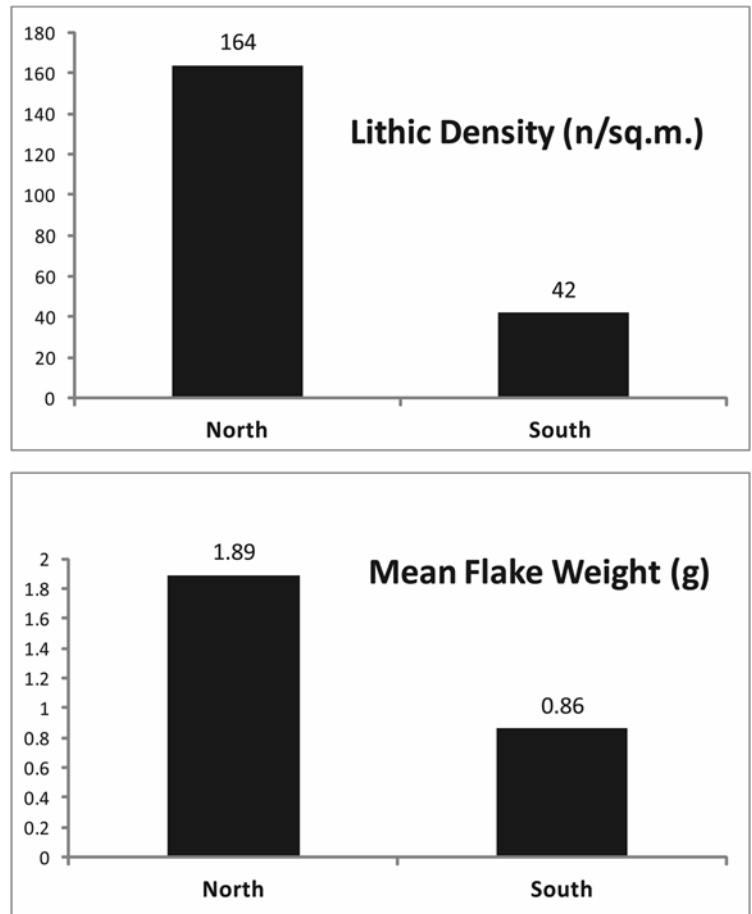
to have been somewhat of a multi-use area for multiple groups from the south, west, and north. Overall, Native Americans actively traveled to the lake from multiple regions, likely representing diverse ethnic groups and/or bands, rather than a single group with a massive territory. Our data, thus, corroborate the multi-users model supported recently by Park (2010, 2011), rather than the single-user model (e.g., Shoshone-centered) recently promoted by Scheiber and Finley (2011).

### ARCHAEOLOGICAL DATA: DIFFERENTIAL STONE TOOL USE AND MANUFACTURE ON THE LAKE SHORES

In addition to the significant variation in lithic material use, lithic artifact data support differential production and use of stone tools on the northern and southern shores of the lake as well. I first compare two fairly proximate areas of the lake, northwest and southwest, separated by 15 km across the lake, but 50 pedestrian km due to the presence of the West Thumb (see Figure 8.2).

On the northwest lake shore, UM excavated 70 1x1-m test units at seven sites, yielding 13,995 lithics from test units for a mean of 199.9 per sq.m. On the southwest shore, combining UM and Lifeways excavations, archaeologists excavated 94 sq. m. at eight sites, revealing 2,178 lithics from test units for a mean of 23.2 per sq. m. Both of these areas yielded high percentages of Obsidian Cliff and/or cherts from northern lithic sources.

These lithic density trends are not restricted to the northwest and southwest shores (Figure 8.7). The overall character of all sites along the entire north shore is of lithic abundance, while on the south shore it is one of lithic scarcity. In addition to the northwest shore data (199/sq.m.), excavations at UM's six Clear Creek sites on the northeastern lake shore yielded 107 lithics per sq.m.. Only 27.5 lithics per sq.m. were recovered at the Osprey Beach site on the southwest shore's West Thumb, while only 14 lithics per sq.m. were recovered at seven sites excavated by UM on the south-central lake shore. UM recovered only 17 lithics per sq.m. at two sites on the



**Figure 8.7. Comparison of Lithic Densities and Mean Flake Weights, North and South Shore Sites, Yellowstone Lake.**

southeast arm of the lake. Excavations at the Donner Site on the southeast arm revealed 97 lithics per sq.m., comprising largely southern-oriented cherts.

Overall, the lithic density at southern lake shore sites is 42 lithics per sq.m. (n=5,557 lithics; 131 1x1m test units; 11 sites) compared to 164 lithics per sq.m. at sites on the north shore (n = 18,809 lithics; 115 1 x 1m test units; 13 sites). The sheer volume of lithics from test units on the north shore—18,809 lithics— compared to the south shore — 5,557 lithics — is even more striking considering that 16 additional sq. m. of excavation were conducted on the south shore compared to the north.

Mean flake weights for the northwest shore and southwest shore sites excavated by UM between 2009-2011 are also significantly different, with southwest

## LITHICS IN THE WEST

shore flakes ( $n = 403$ ; 470.4g) weighing 0.86g on average compared to 1.89g for northwest shore flakes ( $n = 14,361$ ; 7,582.7g). These flake data support the hypothesis that south shore hunter-gatherers used and produced fewer lithics of smaller sizes, likely to conserve material in the face of the toolstone-depleted environment.

Material was also transported to south shore sites in finished or nearly-finished state, reflecting the low availability of lithic raw material sources in this region. Biface-reduction and shaping flakes account for 77.1 percent of typed flakes at south shore sites, compared to 78.0 percent at northwest shore sites, suggesting that biface manufacture was a focus of hunter-gatherers in both areas of the lake. However, the major difference between the northwest and southwest shores in this regard is the greater numbers of final-stage shaping/pressure flakes on the southwest shore (51.7%) compared to biface-reduction flakes (48.3%) compared to the northwest shore (44.9% vs. 55.1%). While this difference is not significant at the .05 level ( $\chi^2 = 2.145$ ;  $df = 1$ ;  $p = .143$ ), the overall ratio of biface-reduction flakes to shaping flakes is 0.93 on the southwest shore (61 shaping flakes; 57 biface-reduction flakes) compared to 1.23 on the northwest shore (2,084 biface-reduction flakes; 1,697 shaping flakes). These flaking debris data suggest that bifaces and projectile points were in a more finished state by the time they reached the southwest shore compared to the northwest shore.

Also, it is clear that significantly greater numbers of late-stage biface-reduction and shaping flaking debris were produced at northwest shore sites ( $n = 3,781$ ) versus southwest shore sites ( $n = 118$ ) (with similar amounts of excavation). These data support those discussed above that tool production was a focus on the northwest shore, but not on the southwest shore in which tools were curated and carried beyond sites.

In support of this curation mode on the south shore, an interesting and somewhat unique type of lithic artifact — freehand cores — were recovered in limited quantities ( $n = 8$ ) at UM's southwest shore sites. Such cores are small (~palm-sized) chert and obsidian cobbles with multiple flake removals from all faces. At the southern

shore lake sites, the cores are produced from both obsidian ( $n = 4$ ) and chert ( $n = 4$ ). These cores are rare to non-existent on the northwest shore, with only two identified at the seven UM-excavated sites around Fishing Bridge and Lake Lodge (MacDonald and Livers 2011).

The use of these small cores on the south shore suggests that they functioned as portable lithic material for mobile hunter-gatherers in the material-depleted south shore. These cores were not used abundantly on the north shore of the lake, likely due to the proximity of the Obsidian Cliff material source and chert sources to the east in the Clear Creek Valley and to the north in the Yellowstone Valley. Material was abundant in this region, but not so on the south shore.

Overall, these lithic data suggest a significant fall-off in lithic use in locations further away from sources, suggesting the curation of lithics to the south shore which lacks adequate replacement stone (Andrefsky 1994; Bamforth 1986; Binford 1979, 1980). This is a pattern exemplified by pedestrian hunter-gatherers minimizing risk in the face of possible stone shortage while travelling in lithic-deficient areas. As discussed more extensively elsewhere (MacDonald et al. 2012), we propose that this pattern of lithic resource use rejects the hypothesis that boats were used by hunter-gatherers at the lake. If they were, such significant fall-offs in lithic material use would not be evident (cf. Blair 2010). Our lithic data from more than two dozen lake-area sites suggest that pedestrian hunter-gatherers curated bifaces and small cores to the south shore of the lake, as evidenced by the low numbers of lithics, their comparatively small sizes, and the high density of late-stage reduction debris and small, portable freehand cores. Hunter-gatherers ensured subsistence success by conserving lithic material in a south shore environment lacking proximate lithic sources.

### SUMMARY AND CONCLUSION

In this paper, archaeological and ethnohistoric data were utilized to inform our view of the prehistoric use of Yellowstone Lake. These data were used to evaluate the

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single-user model (SUM) versus the multi-user model (MUM) of lake use in prehistory. As discussed above, our lithic data support multiple points of origin for hunter-gatherers that visited Yellowstone Lake in prehistory. People camping on the north shore were likely Plains-adapted hunter-gatherers spending most of their time in the northern Yellowstone Valley and vicinity. People camping on the east shore of the lake were likely occupants of the Plains as well and the hot-dry portions of northwestern Wyoming, including the Big Horn Basin. People on the southeast lake shore were likely residents of the Jackson area and points south, while people on the southwest and western shores may derive from north, south, and west, including the northern Great Basin of eastern Idaho. The data thus do not support the SUM model, in which Yellowstone Lake was the center of a large territory used by a single group, as recently argued by Scheiber and Finley (2011). Rather, data presented herein support the MUM model of lake use, in which the GYE and Yellowstone Lake were at the crossroads of multiple tribal and/or band territories, a model best defined by Johnson et al. (2004) and Park (2010, 2011).

Archaeological data from Yellowstone Lake also indicate the differential use and manufacture of stone tools by Native Americans on the north and south shore. Curation was the *modus operandi* on the southern lake shore due to the scarcity of high quality lithic materials. Here, archaeological sites contain low densities of lithic debris, few stone tools, and abundant evidence of curation behavior. People curated stone tools and did not waste it in a toolstone-deficient setting. In contrast, lithic production on the northern lake shore was more wasteful, generating comparatively abundant lithic debris and stone tools due to the proximity of Obsidian Cliff obsidian and Crescent Hill chert sources, both of which are located ca. 30-40 km north.

Both the ethnographic and archaeological data support the multi-user model of Yellowstone Lake use. Many different groups used the lake, deriving from the north, south, east, and west. As North America's largest, high-elevation lake, Yellowstone Lake attracted Native Americans to its shores from the northwestern Plains,

the northern Rocky Mountains and the northern Great Basin. The lake, and the Greater Yellowstone Ecosystem in general, were at the nexus of a variety of tribal territories throughout prehistory, reflected in the variable lithic raw material and stone tool use at sites on its shores.

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## CHAPTER 9

### HUMAN LANDSCAPE USE ON THE SNAKE RIVER PLAIN, IDAHO

By Kathryn Harris

#### ABSTRACT

*Southern Idaho is an ideal setting for the study of prehistoric human landscape use. Obsidian sources are numerous on and near the Snake River Plain of Idaho, and it is common for the lithic assemblages of southern Idaho archaeological sites to be composed of up to 90% obsidian, a fact that holds true at site 10-BT-8. Obsidian source characterization suggests a large circulation range for the prehistoric people using site 10-BT-8, with strong emphasis placed on the American Falls obsidian source. Three other sources, Bear Gulch, Big Southern Butte and Browns Bench were also utilized. While American Falls is the most frequently used source throughout time, there is variability in the utilization of the other obsidian sources. The combination of obsidian source characterization and technological organization data from core tools, bifaces and proximate flake debitage support the model that the people that used 10-BT-8 over the last 3,000 years were utilizing both distant and local obsidian sources while moving over a wide area of southeastern Idaho.*

#### INTRODUCTION

Southern Idaho is an ideal setting for the study of prehistoric human landscape use based on lithic technological organization and obsidian source characterization. Obsidian sources are numerous on and near the Snake River Plain of Idaho, and it is common for the lithic assemblages of southern Idaho archaeological sites to be composed of up to 90% obsidian. This paper will explore obsidian use and lithic technology on the Snake River Plain through the use of a case study site: 10-

BT-8. While lithic technology at this site is characteristic of most mobile North American foragers (bifacial), the extreme distance of the obsidian sources most frequently utilized is not.

Located in a sheltered draw at the southern tip of the Lemhi Mountains in south-central Idaho, site 10-BT-8 was first recorded by the Idaho State College Museum in 1961, as part of Earl Swanson's Birch Creek Project (Figure 9.1). Based on three radiocarbon dates, 10-BT-8 appears to be Middle Archaic in age (approximately 2,990 B.P.) (Table 9.1). A total of six 1x1 meter units were test excavated by archaeologists from the Targhee National Forest during the summer of 1993. About 85% of lithic materials at the site is obsidian. The other 15% is composed of local chert, argillite and quartzite. Though excavated nearly 20 years ago, very little analysis has ever been performed on the assemblage from the 10-BT-8, and no comprehensive site report has been published.

The archaeology of site 10-BT-8 is important because it is located in an unusual place relative to many other excavated sites in southeastern Idaho. Most excavated sites in the region are located either south, on the Snake River Plain, or north, in the more mountainous Salmon River area. This site is unique in that it is located in the transition between these two areas. Additionally, most previous archaeological excavations in this area have focused on cave and rockshelter sites (Butler 1978). Open-air sites, such as 10-BT-8, have received little attention in Idaho archaeological research.

The purpose of this study was to explore two main questions about lithic technology at 10-BT-8. How does the lithic assemblage of 10-BT-8 reflect prehistoric human land use practices from the Middle Archaic to the protohistoric period? And how might these practices relate to the procurement of raw material and manufacture of tools?

#### BACKGROUND

Archaeologists frequently discuss lithic technological organization in relation to behaviors that optimize land use. Specifically, lithic technological organization is generally accepted to be embedded in complex human





**Figure 9.1. Overview of 10-BT-8.**

optimal foraging behaviors (Kelly 1995). Based on his ethnoarchaeological fieldwork among the Nunamiut people of North America, Binford first proposed embedded procurement, where lithic procurement is simply one aspect of a group’s foraging behavior and mobility. In other words, raw material may often be obtained en-route to other resources (such as game) (Binford 1979; 1980). Gould, however, observed what might be termed direct procurement. In ethnoarchaeological work with Australian aboriginal people, Gould recognized that people did sometimes make special trips to obtain raw materials, but often for sacred reasons (Gould 1978).

Raw material preference, distance between sources and optimization of toolkit (e.g. bifaces vs. cores) are all important factors to consider in terms of landscape utilization (Andrefsky 1994). A single forager, or even band of foragers, is physically capable of carrying only so much stone. Therefore, foragers optimized the utility and portability of the materials contained in their toolkits

(Kuhn 1994, Beck et al. 2002). Frequently, this toolkit optimization is interpreted to correlate with an increased use of biface technology, as bifaces are frequently employed as the most efficient way to transport raw material over long distances. Bifaces are also considered an all-purpose tool for foragers, thus their presence may reduce the need to carry many different types of tools (Kelly 1988, Andrefsky 2005). Therefore, a highly mobile group would be expected to use biface technology more frequently than a more sedentary group (Kelly 1998, Parry and Kelly 1987, Surovell 2009). This analysis assumes raw material is procured directly, not through trade.

In general, bifaces are not only frequently used, but are also more highly curated when raw material sources are scarce or of poorer quality (Kelly 1988; Andrefsky 2005, 2006). In addition to size and weight, the extent of biface reduction may be determined through the observation of cortex amount, number of flake scars, and thickness of the biface. A much-reduced biface may indicate curation over long distances and/or periods of time.

Closely related to traveling distance is the subject of the construction of a mobile forager’s raw material “toolkit.” When a foraging group lacks continuous access to a raw material source, they are expected to modify cores in such a way as to maximize the utility of the raw material. In contrast, core technology is more frequently used as a group becomes more sedentary (Parry and Kelly 1987). Bifaces are frequently employed as the most efficient way to transport raw material over long distances. Recently, Surovell (2009) has suggested that while formal tools (such as bifaces) and flake blanks are

**Table 9.1. Radiocarbon dates from 10-BT-8 (corrected).**

Unit	Level	Date
O-W29	13	2990 +/- 120 B.P.
O-W29	14-16 (Hearth Feature)	2930 +/- 160 B.P.
S64-W132	7	100.3 +/- .9 B.P.

## LITHICS IN THE WEST

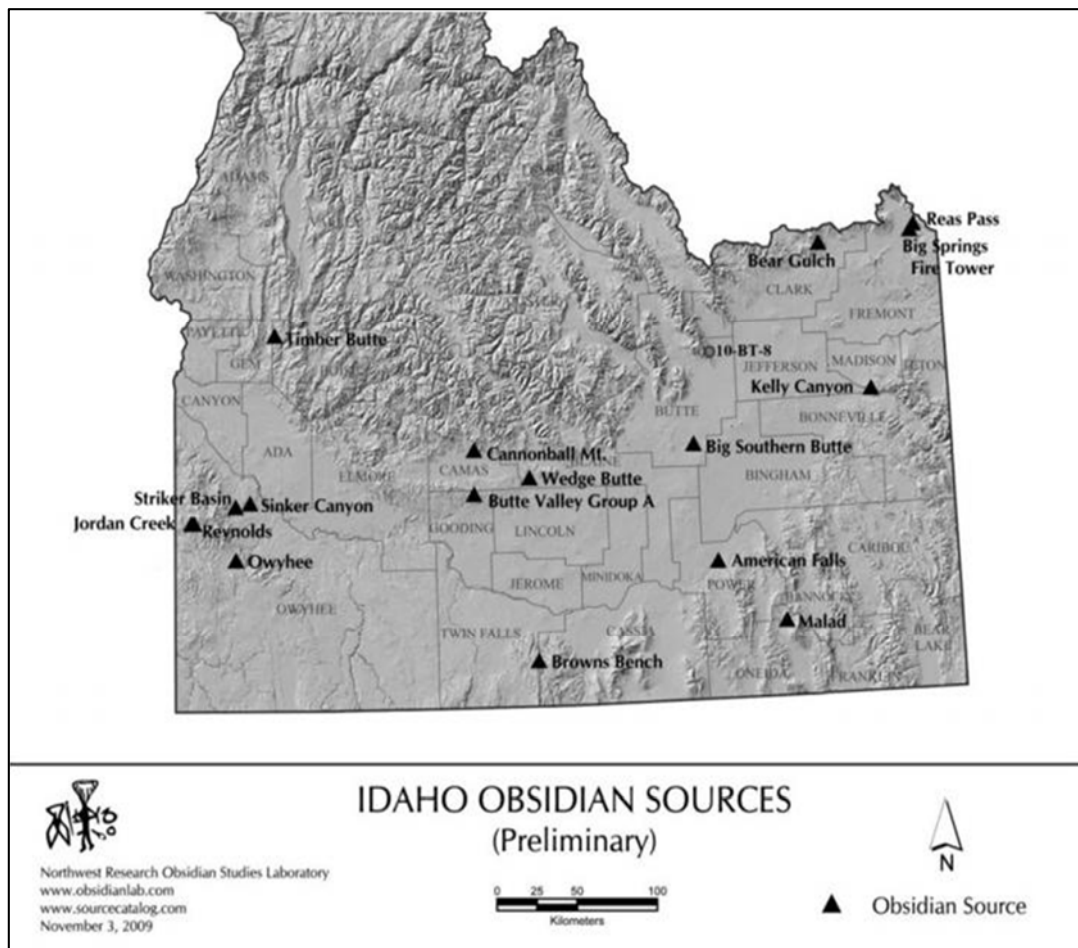


Figure 9.2. Location of 10-BT-8 relative to Idaho obsidian sources. From Northwest Research Laboratory, [www.obsidianlab.com](http://www.obsidianlab.com).

frequently transported long distances, core tools are not. Core tools that have been “exhausted” are often very small in size, and are no longer suitable for the removal of flakes. It should be noted, however, that availability of raw material may influence core size. More readily available raw material may lead to larger sized core tools at archaeological sites (Andrefsky 1994, 2005).

Flakes may also indicate type of technology. In an experimental study, Tomka (1989) found that complex (or faceted) platforms were found in greater frequency among debitage reduced from bifaces rather than core tools. The presence of a flat platform often indicates reduction from a unidirectional core tool. Complex platforms often exhibit angular facets and many small flake scars. Sometimes complex striking platforms have

been modified further through abrasion or rubbing. Abraded and complex platforms are often interpreted to indicate greater preparation in reduction and are frequently associated with the use of biface technology (Andrefsky 2005).

Further, the amount of dorsal cortex left on a flake or biface is generally accepted to indicate the stage of reduction. It is assumed that as a cobble is reduced, the cortex will be removed first. This means that there is generally more cortex present during earlier stages of reduction than in later stages of reduction (Odell 1989). In an experimental study of biface reduction, Maudlin and Amick (1989) observed that nearly all cortex is removed from the biface halfway through the reduction process.

## LITHICS IN THE WEST

I expected the majority of obsidian at 10-BT-8 to be from Big Southern Butte because it is the closest obsidian source to this site (Figure 9.2). Holmer (1997) found that throughout all time periods in southeastern Idaho, people seem to utilize the nearest available obsidian source. Plew 1986 has also suggested that the warming and drying that occurred during the Early Archaic forced people living on the Snake River Plain to seasonally travel north into the mountains in pursuit of game (Plew 1986; 2008). Plew suggests that during the Middle to Late Archaic, highly mobile people were travelling from the Snake River Plain into surrounding mountains to hunt, then returning to the plain after the conclusion of hunting trips.

### RESEARCH DESIGN

Given that the closest known source of obsidian (Big Southern Butte) is 50km from 10-BT-8, I proposed that obsidian was brought into the site in easily transported, efficient packages such as bifaces and not cores or nodules. 101 obsidian tools and flakes were geochemically sourced by Northwest Obsidian Research Laboratory using a Thermo Electron QuanX EC energy-dispersive X-ray fluorescence (EDXRF) spectrometer. I selected artifacts to achieve as representative a sample across artifact types and stratigraphic levels as possible.

I chose to quantitatively analyze all informal and formal tools from 0-140 cm (levels 1-14) in all of the six test units excavated at site 10 BT 8 and examined debitage from 0-140cm three of the six units. Artifacts were only analyzed from the levels 1-14, as the oldest radiocarbon date (2,990 B.P.) was taken from level 14, or above. This allowed for reasonable relative dating.

I developed two land-use hypotheses for 10-BT-8. The first related to Holmer's (1997) assertion that people utilized the nearest obsidian sources, and rarely traveled further to procure material. This pattern relates to the idea that people were traveling from the plain to the mountains to hunt during the Archaic. I would expect biface technology to be used in this case, as the closest source is 50km away.

The second hypothesis has people ranging over a larger area, procuring material from more diverse sources. Biface technology would still be expected, but greater reduction would be expected due to longer travel, and possible longer curation (Kelly 1988; Parry and Kelly 1987).

### RESULTS

#### Obsidian Sourcing

If distance to the source were the only variable affecting the amounts of obsidian at 10-BT-8, I expected Big Southern Butte to be the most frequent in the assemblage. Surprisingly, the results of obsidian sourcing showed that obsidian from the distant American Falls source was the most prevalent at the site (Table 9.2). The closest obsidian sources, Bear Gulch and Big Southern Butte, were present in the sample, but in much smaller numbers. Browns Bench was represented by only one artifact. In fact, observed frequencies were nearly opposite of what might be expected based on Holmer's 1997 study.

**Table 9.2. Obsidian sourcing results.**

Source	Distance from 10-BT-8	Cardinal Direction	Relative Expected Frequencies (%)	Observed Frequencies (%)
Big Southern Butte	50 km	South	80	7.92
Bear Gulch	100 km	Northeast	12	11.88
American Falls	125 km	South	8	79.21
Browns Bench	180 km	Southwest	0	0.99

## LITHICS IN THE WEST

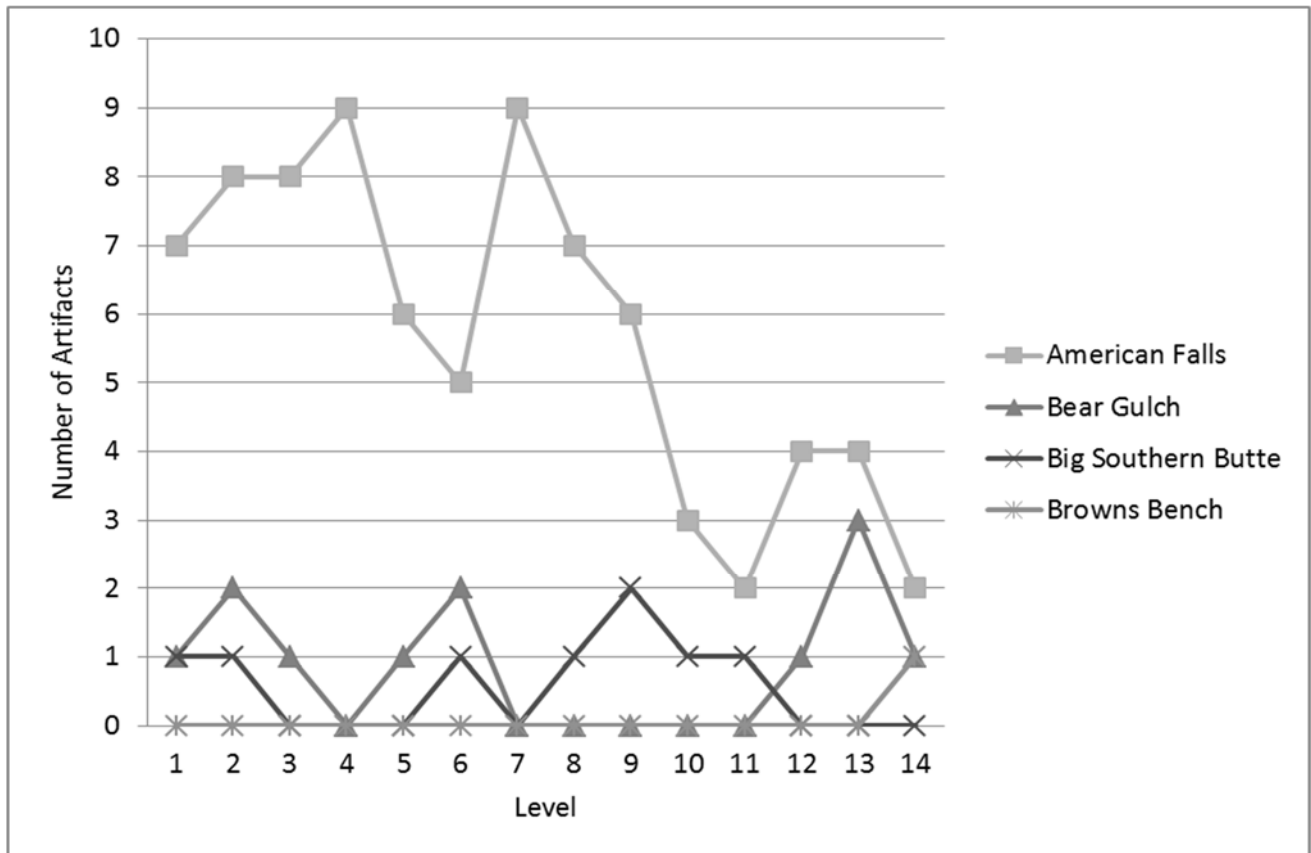


Figure 9.3 Obsidian sources by level (all artifact types).

Obsidian from the oldest levels (12-14), shows a slight increase in American Falls obsidian, though its frequency does not match that of the most recent use period (Figure 9.3). Additionally, Bear Gulch obsidian nearly matches the frequency of American Falls, with the complete absence of Big Southern Butte obsidian. The only artifact sourced to Browns Bench, the most distant source utilized at 10-BT-8, occurs in level 14. The lack of any local source and the higher frequency of more distant sources suggest an extremely wide range of movement. Obsidian in levels 7-11 shows a marked decrease in the frequency of American Falls obsidian. There is an increase in Big Southern Butte obsidian and the complete absence of obsidian from the Bear Gulch source. This suggests a contraction in the overall range of landscape use. The lack of Bear Gulch obsidian indicates that little, if any emphasis is placed on

utilization of the area to the northeast of 10-BT-8. It seems people were utilizing Big Southern Butte more frequently. Obsidian in levels 1-6 is characterized by high frequencies of the American Falls source, accompanied by much lower frequencies of the Big Southern Butte and Bear Gulch obsidian sources. This suggests broad movement across southeastern Idaho, but strong ties to the American Falls area.

### LITHIC TECHNOLOGY

Given the results of the obsidian sourcing analysis, I expected to see several things in the lithic technology of 10-BT-8. First, because of distance, it would be more likely that any obsidian core tools would be from a source nearer to 10-BT-8 than American Falls: most likely Big Southern Butte. Additionally, core tools made of local materials (chert) would be expected to be overall larger than any transported obsidian core tools.

Secondly, there should be a relatively high proportion of nonhafted bifaces to core tools at site 10-BT-8. While all four obsidian sources present in the assemblage may be distant enough to require biface technology, I would expect nonhafted obsidian bifaces from more distant sources (American Falls, Bear Gulch, Browns Bench) to be relatively smaller in size and of late reduction stages. Third, the platform types of proximal flakes should reflect biface technology. In this case, I would expect few cortical or flat platforms, but a dominance of complex platforms, indicating the transport and retouching of more complete tools. Fourth, the amount of dorsal cortex on proximal flakes should be low. In particular, the farther the obsidian source from 10-BT-8, the less dorsal cortex should be present. Last, the apparent high mobility of the people using 10-BT-8 should also be reflected in high diversity of obsidian source in the hafted biface assemblage.

#### Core Tools

Core tools are not numerous at site 10-BT-8. All three of the obsidian core tools had an original provenience of the American Falls obsidian source (Table 9.3). Four other core tools were of presumed local yellow chert (based on my own familiarity with the area). The obsidian core tools were highly utilized. Overall, the weights of the chert core tools are larger than that of the obsidian core tools, supporting the fact that most chert was likely procured near to 10-BT-8.

With a source as distant as American Falls, it is

somewhat surprising that core tools were transported, given that bifaces are generally accepted to be a much more efficient and useful method for transporting raw material. However, there are several factors that may explain this unexpected result. The overall sizes of the obsidian core tools are quite small. Further, relative to the number of bifaces excavated at 10-BT-8, the count of core tools is extremely small (7 core tools as compared to 57 nonhafted bifaces). Nonhafted bifaces still far outnumber core tools. Additionally, it is possible that these core tools were not utilized only for raw material, but as scraping or chopping implements. If they were used as tools, it might explain why they were kept and transported over such long distances. Finally, the three obsidian cores (all from American Falls) were excavated from levels two and three, some of the most recent levels at the site. While mere conjecture, it is possible that this obsidian was procured after the introduction of the horse. This would likely have made long-distance transport of stone less difficult.

#### Nonhafted Bifaces

All bifaces without an identifiable haft were considered nonhafted bifaces. These bifaces may remain unhafted tools, or a haft may be added for prehensile use (Andrefsky 2005). Like core tools, their overall size may indicate reduction stage of a biface. In addition to size, biface reduction stage may be determined through the observation of cortex amount, number of flake scars, and thickness of the biface. Similar to Callahan (1979), bifaces were classified into stage from 0 to 5, with 0 representing a blank and 5 representing a thinned, reduced biface. No nonhafted obsidian bifaces are in production stage 1, while the majority of nonhafted bifaces are in production stage 3 or beyond (Figure 9.4). A high level of reduction and an overall smaller size would be expected among obsidian bifaces, given the distances of all relevant obsidian sources from 10-BT-8. Of course, the final size of the tool may also be dependent on the size of the original objective piece. However, bifaces are generally still smaller and more reduced when transported over long distances. Only one artifact from 10-BT-8, a nonhafted biface, was sourced to

**Table 9.3 Core tool weight (g) by raw material type and level.**

Material	Level	Weight
Obsidian	2	13.9
Obsidian	2	11
Obsidian	3	29.4
Chert	2	28.7
Chert	5	95.2
Chert	5	148.1
Chert	2	99.7

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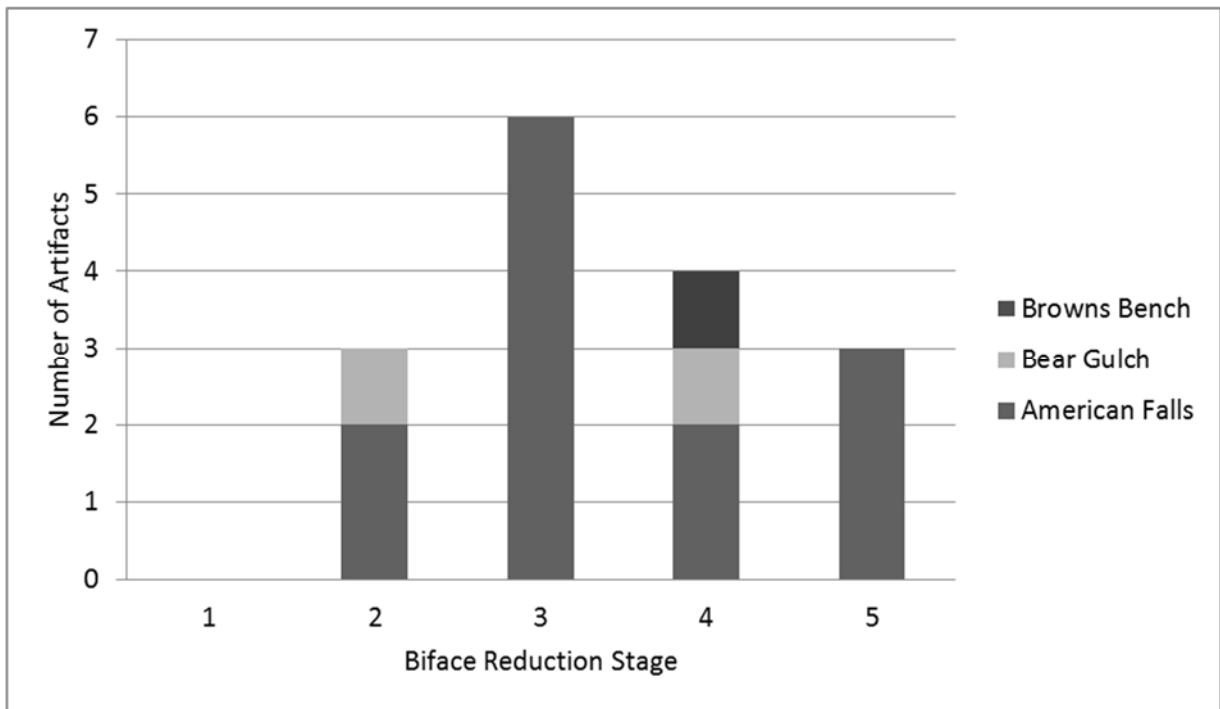


Figure 9.4. Nonhafted biface stage and obsidian source.

the far-distant Browns Bench Source. Notably, no nonhafted bifaces were sourced to the Big Southern Butte obsidian source, the closest obsidian source. While this must be cautiously interpreted, the fact that a nonhafted biface was moved so far (approximately 180 km from Browns Bench) is important for considerations of movement across the southern Idaho landscape.

The mean weight of nonhafted bifaces geochemically sourced seems to indicate a loss in weight relative to the distance from site 10-BT-8, with the most distant source (Browns Bench) having the smallest mean weight, and the nearest source (Bear Gulch) having the largest mean weight (Table 9.4). There are, however, two larger

bifaces present from the American Falls source, which is unexpected given its distance. A nonhafted biface was characterized as the far distant (180km) Browns Bench obsidian, holding to expectations that the use of very distant sources should produce biface technology. Notably, no nonhafted bifaces were sourced to the Big Southern Butte obsidian source. Perhaps the people who utilized 10-BT-8 did not consider this source distant enough to reduce raw material into a nonhafted biface form.

Table 9.4. Nonhafted biface weight (g) by obsidian source.

	American Falls	Bear Gulch	Browns Bench	Big Southern Butte
Mean Weight (g)	9.09 (n=13)	11.25 (n=2)	7.9 (n=1)	None
Distance	125 km	100km	180 km	50 km

## LITHICS IN THE WEST

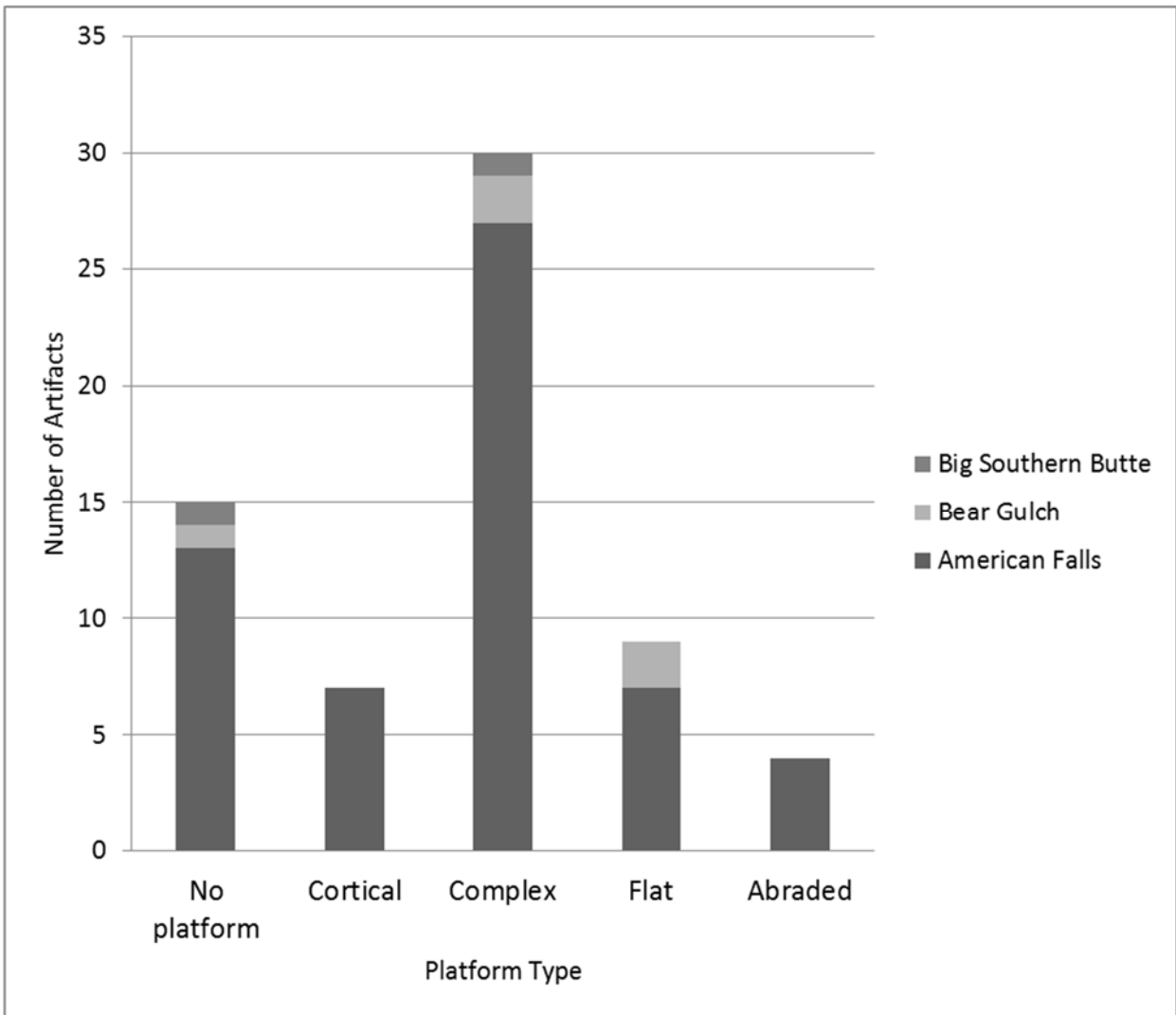


Figure 9.5. Platform type and obsidian source.

### Debitage

Complex platforms are the most prevalent type at the site, suggesting biface technology (Figure 9.5). Of the 1,807 proximal flakes in the assemblage, they constitute 83 percent. Complex platforms are also the most prevalent type for flake tools (37 percent), though not to the same extent as proximal flakes. Complex platforms are the dominant type in every level. While Big Southern Butte obsidian exhibited only complex platforms, both the American Falls and Bear Gulch sources (which are a much greater distance away), exhibited more diverse platform types. It is possible that this result may be

partially due to small sample size of sourced proximal flakes (65 out of 1807 is only 3.5%). However, complex platforms still occur at the highest frequency of any other type of platform, indicating a common use of biface technology at 10-BT-8.

While dorsal cortex was present, approximately 81 percent of proximal flakes did not have any dorsal cortex. Another 13 percent of proximal flakes had a dorsal surface covered in less than 50 percent cortex. The American Falls source exhibited the highest diversity of cortex (Figure 9.6). It was the only source to exhibit all four amounts of dorsal cortex. Artifacts sourced to Big

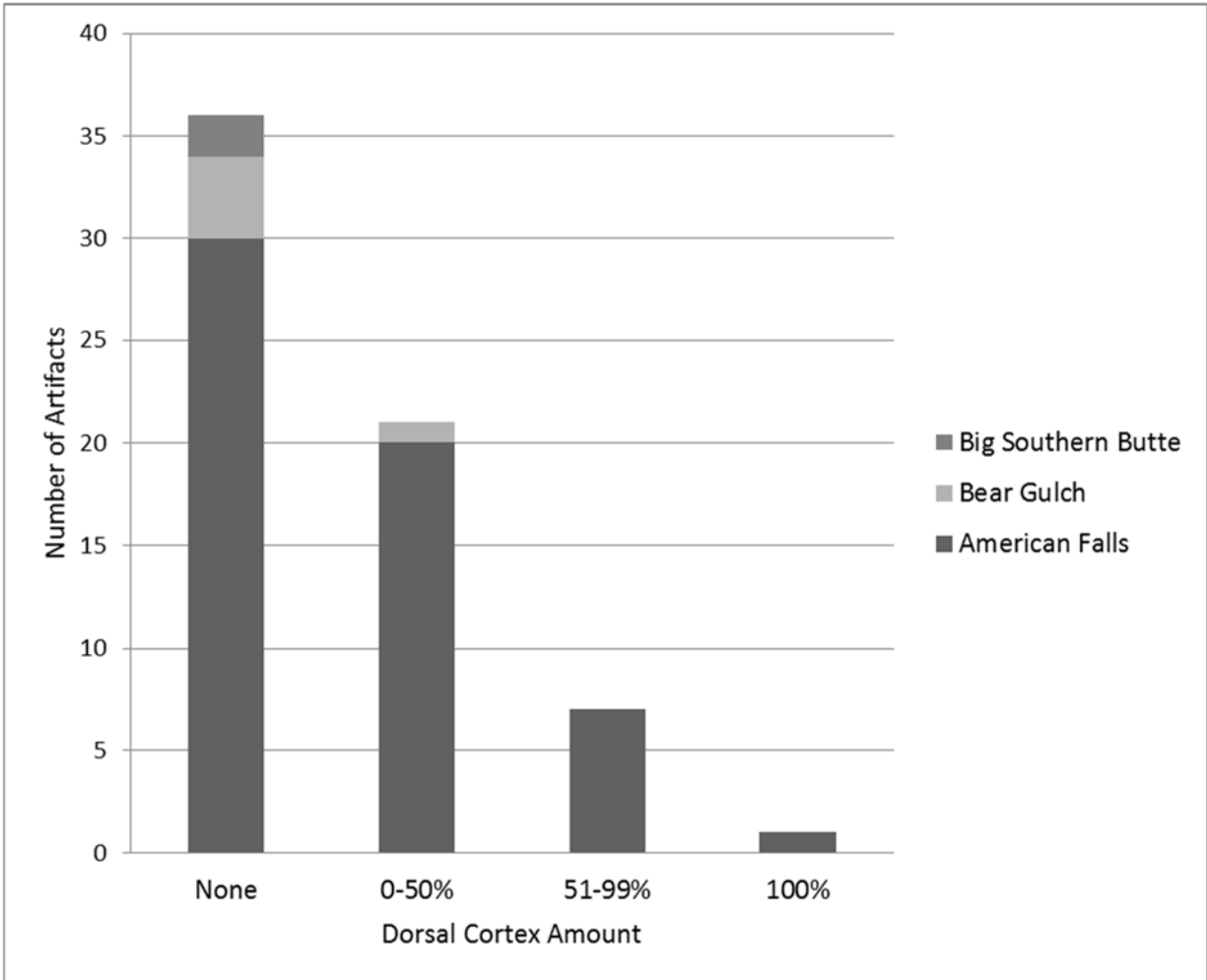


Figure 9.6. Dorsal cortex percent and obsidian source.

Southern Butte had no cortex present, while those from Bear Gulch exhibited less than 50% cortex. All of these obsidian sources are generally found in cobble form, so high amounts of cortex should be present on flakes from the early stages of cobble reduction. It is possible that this result is somewhat biased, as XRF sourcing requires larger artifacts for accurate geochemical characterization, and cortex is more likely to be present on larger flakes. Per Northwest Research Obsidian Studies Laboratory standards, all flakes analyzed were at least 10mm in diameter and 1.5mm thick.

#### Hafted Bifaces

Because the sample of hafted bifaces was very small ( $n=17$ ), very few analyses of the hafted biface data are possible. However, the diversity of obsidian sources in the hafted biface assemblage is much higher relative to other chipped stone types in which the American Falls source dominates (Table 9.5). This is consistent with expectations that foragers transport and curate formal tools over great distances.



**DISCUSSION**

While some expectations created by the obsidian source assemblage were supported by lithic technological data, not all expectations were fully met. Most significantly, the majority of the obsidian at site 10-BT-8 did not come from Big Southern Butte, but from the much more distant source of American Falls. Of my two land-use hypotheses, the second best explains human land use at 10-BT-8. The first of the land-use hypotheses does not account for the overall high frequency of American Falls obsidian throughout all levels. These results immediately suggest a much broader circulation range across southern Idaho for people during the Late Archaic and Protohistoric.

**CONSIDERATIONS AND FUTURE RESEARCH**

There are a few items that should be noted in relation to the interpretation of human landscape use at 10-BT-8. First, the sampling of artifacts for geochemical characterization could present a possible confounding factor in overall sourcing results. While 101 artifacts is a relatively large sample in terms of obsidian sourcing studies, it does not begin to reach the total number of artifacts excavated from 10-BT-8 (0.1% sample of total artifacts).

A second factor that may yet influence future interpretation of obsidian sourcing results at 10-BT-8 is related to the characterization of the American Falls obsidian source. The American Falls obsidian source, also known as the Walcott Tuff, is spread over a large geographic area across the Snake River Plain in southern Idaho. While geographically diverse, Hughes and Smith have suggested that the American Falls source is homogeneous in its XRF trace element signature, making precise identification of the original geographic location of obsidian difficult to determine (Hughes and Smith 1993). This would certainly make the issue of obsidian use at 10-BT-8 more complicated if obsidian at this site could be procured from a multitude of minor American Falls outcrops closer to the site. This might also explain high amounts of dorsal cortex being present only on debitage sourced to American Falls. Of course, I did not

**Table 9.5. Obsidian source frequency in hafted biface assemblage.**

Source	Hafted Biface Frequency
American Falls	6
Bear Gulch	5
Big Southern Butte	6

consider the qualities of various sources, nor whether American Falls might have been seen as a superior raw material.

Third, while Big Southern Butte is a reliable raw material source, the area immediately surrounding it is an extremely dry desert with treacherous recent volcanic flows (such as Craters of the Moon). While the other obsidian sources might be technically more distant, water sources are generally more reliable, with the exception of the Snake River itself, near the mountains north and south of the Snake River Plain. People may have preferred to keep to places where subsistence resources were more readily available.

Lastly, there are other components of 10-BT-8 that may shed further light on the use of this site: a fairly large faunal assemblage deserves analysis, and further radiocarbon dates would serve to bracket time frames more definitively. Any of the aforementioned issues will be important for any future research done at site 10-BT-8, and would greatly add to this study.

**CONCLUSIONS**

Analysis of lithic artifacts at 10-BT-8 indicates an unexpected pattern of landscape use on the Snake River Plain. In light of the technological organization and obsidian sourcing results of 10-BT-8, it is most likely that the site was a frequently utilized camp site within a larger-scale circulation pattern of very mobile hunter-gatherers. The picture of human landscape use at 10-BT-8 from the Archaic to the Protohistoric is not one of groups of people simply moving back and forth between the Snake River Plain and the central mountain area of Idaho. Rather, it is a dynamic picture of land-use change over the past 3,000 years.

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## CHAPTER 10

### FROM CLIFF TO CACHE: ANALYSIS OF A MIDDLE ARCHAIC OBSIDIAN CACHE FROM SOUTHWESTERN MONTANA

By Scott L. Carpenter and Philip R. Fisher

#### ABSTRACT

*The Yearling Spring site (24PA1377) consists of a cache of ochre-covered bifaces, flake tools, and core fragments all made of obsidian. This site was found eroding from a cutbank south of the Yellowstone River in southwestern Montana. Sixty-one of the 62 pieces were found on the ground surface or within the sod layer down slope from a recent bank washout. Archaeological excavations undertaken during the spring of 2011 revealed a portion of a subsurface ochre-stained pit with one obsidian biface in situ. No other artifacts or features were found in association with this subsurface pit. No flake debitage was found, indicating that the pieces were not manufactured on site. Two specimens with possible use wear were analyzed for protein residue, and were found to exhibit sera for Salmonidae and Cervidae. An ochre sample tested positive for Ursus sera. Obsidian specimens were submitted for x-ray fluorescence sourcing, and are attributed to Obsidian Cliff, Wyoming. Hydration rim measurements dating to approximately 3680 years B.P., indicate a probable single event of procurement and caching. Geoarchaeological studies have been undertaken, with optically stimulated luminescence dating supporting the obsidian hydration date.*

#### INTRODUCTION

The Yearling Spring Cache site (24PA1377) is located in southwestern Montana near the present day town of Livingston (Figure 10.1). The site lies near a small spring a few miles uphill from the Yellowstone River. Research is

ongoing at the site and, to date, 62 obsidian artifacts have been recovered. Obsidian is the only lithic raw material present at the site, and the lack of debitage indicates that the artifacts were produced elsewhere and cached at the site. Dating by obsidian hydration (OH) and optically stimulated luminescence (OSL) indicates that the Yearling Spring Cache was created during the Middle Archaic Period, approximately 3,700 years ago. A number of the artifacts were found covered in ochre, and a large ochre-stained pit was identified eroding out of a cut bank believed to be the cache area. At the bottom of this pit a single flake tool was recovered *in situ* during excavation. The other specimens were found down slope from this pit either on the ground surface or within the existing sod layer (Figure 10.2). We believe that all of these artifacts likely had been recently eroded out of the pit and some were subsequently covered by slopewash sediments.

Cache sites are relatively uncommon and can occur as isolated sites or as part of a larger site with one or more functions. Most lithic caches in western North America appear to be isolated from other sites and are often discovered only after some or all of the material has eroded or been accidentally excavated from their primary context (Rennie and Rittel 2007). Lithic caches have been discovered in North America throughout the Archaic period (Rennie and Rittel 2007), and the earliest known caches are associated with Clovis technology (Collins 1999; Gramly 1993; Kilby 2008; Kohntopp 2010; Lassen 2005; Wilke et al. 1991). In the region surrounding the Yearling Spring Cache site there are a number of known biface caches. These caches, located in southwestern Montana and Idaho, vary in the stage of reduction of the bifaces and in age of the site. The oldest and closest cache to Yearling Spring is the Anzick site (Lahren and Bonnicksen 1974; Owsley and Hunt 2001; Wilke et al. 1991) which is located about 38 km to the north of Yearling Spring. Others in the region include the Yellowstone Bank Cache, Montana (MacDonald et al. 2010), the Fenn Cache, from an undisclosed location in either Utah, Idaho, or Wyoming (Kornfeld et al. 2010; Frison and Bradley 1999) and in Idaho the Simon Clovis Cache (Kohntopp 2010), the China Creek Cache

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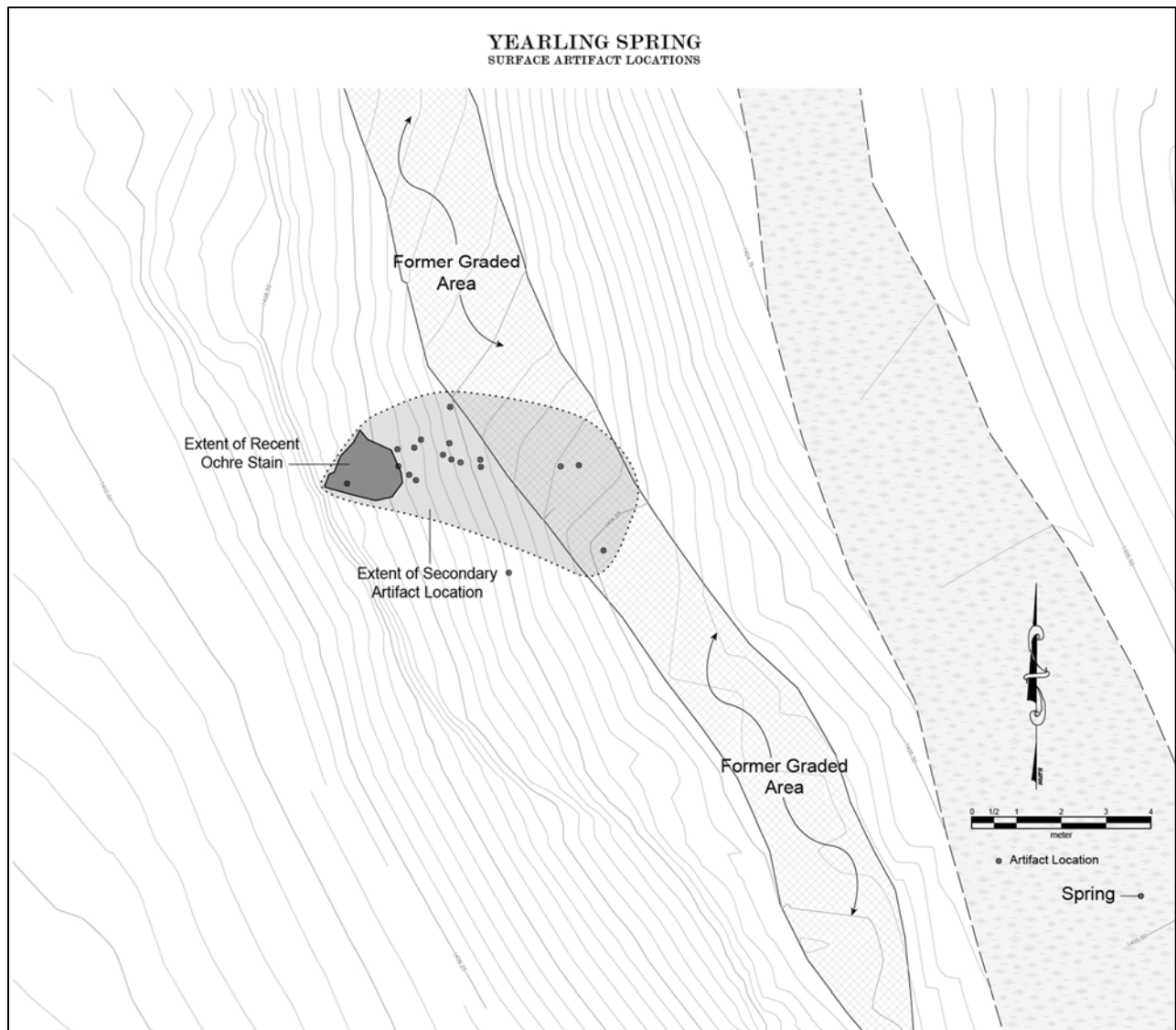
**Figure 10.1. Map showing general location of Yearling Spring Cache Site in southwest Montana and location of Obsidian Cliff obsidian source in Yellowstone National Park, Wyoming.**

(Kohntopp 2001), the Cedar Draw Cache (Kohntopp 2006) and others (Pavesic 1966, Plew and Woods 1986).

Caching is a behavior in which an individual or group of individuals hides or conceals a resource for possible retrieval at a later date (Garfinkel et al. 2004; Lassen 2005). The definition of prehistoric caches often refers to lithic materials, but caches can also include other items. The cached material presumably held some value to the cacher (Rennie and Retter 2007) due to the fact that if the artifacts are in early stages of production and or use and they have the potential to be used in a great deal of future activity (Odess and Rasic 2007). Tools in early stages of production and use are not at a point in their use-life that warrants abandonment and would not be expected to have been intentionally discarded (Odess and Rasic 2007). Caching is therefore an intentional act by those who cached the material.

A number of hypotheses have been proposed to explain caching behavior. However, caches vary greatly in

assemblage content, time period, and context, thus they must be approached carefully when trying to determine why a cache was created (Kilby 2008; Lassen 2005). One explanation proposes that caches form a safety net of sorts where a collection of tools are stored that can be recovered for later use. Caches can therefore be viewed as utilitarian in nature and function as a place of storage for a variety of later uses (Garfinkel et al. 2004, Kilby 2008; Lassen 2005; Rennie and Rittel 2007). Another hypothesis is that caches are the result of ceremony or ritual. Ritual caches are often associated with human burials such as the Anzick site in Montana (Kilby 2008; Lassen 2005; Wilke et al. 1991). However, ritualistic caches need not be associated with human remains. Ritual caches can be dedications to ancestors or deities as well as towards future endeavors (Kilby 2008; Lassen 2005; Kohntopp 2001). Caches must be assessed individually when seeking to determine their possible



**Figure 10.2. Topographic map of Yearling Spring Cache site area showing locations of obsidian pieces and ochre stain that eroded out of collapsed cutbank during the spring of 2010.**

function, such as utilitarian or ritualistic or a combination of both (Kilby 2008; Lassen 2005).

The use of ochre is often associated with prehistoric caching in North America (Binford 1972; Kilby 2008; Kohntopp 2010; Lassen 2005; Wilke et al. 1991). Ochre has been used for pigment, medicines, and ceremonial purposes throughout the world for over 100,000 years (Henshilwood et al. 2011; Popelka-Filcoff 2006). Iron

oxide ( $\text{Fe}_2\text{O}_3$ ), commonly known as red ochre, is an impure variety of hematite (Erlandson et al. 1999; Mrzlack 2003; Tankersley et al. 1995). Hematite can be found occurring naturally in geological formations (Erlandson et al. 1999). Prehistoric use of ochre is not limited to caches and is often associated with utilitarian, medicinal, ritualistic, and ceremonial activities. A few important uses of ochre include the tanning of hides, as a

## LITHICS IN THE WEST

pigment in rock art, decorative application to peoples' skin, for medicinal purposes, and use in ceremonial contexts associated with burials (Erlandson et al. 1999; Mrzlack 2003; Tankersley et al. 1995; Wilke et al. 1991).

Prior to archaeological excavation at the Yearling Spring Cache site, an ochre stain was observed in the exposed cut bank profile. Many of the obsidian artifacts that were recovered nearby on the surface and from the sod layer were also covered in ochre and/or a mud/ochre stain. The staining could be a result either of direct application of ochre to the artifacts before caching, of being placed in an ochre-filled pit, or as a result of secondary deposition in a mud/ochre mixture after slope failure exposed the cache. It appears that the ochre and the cache of obsidian artifacts are associated with one another, given that one flake tool was discovered *in situ* at the base of what appears to be the edge of the ochre-filled subsurface pit. Based on X-ray fluorescence spectrometry and obsidian hydration dating, it appears that the site is the result of a single caching event. The lack of debitage at the site suggests that the artifacts were produced off site. Currently the Yearling Spring Cache site does not appear to be part of a larger site.

The data presented here are preliminary, and further archaeological investigation is ongoing. It is possible that additional artifacts associated with the cache are buried downslope in the sod layer in a secondary context. As work continues it should be expected that the artifact count and other data presented in this chapter will change.

### ECOLOGICAL SETTING

The Yearling Spring Cache site is located within the Middle Rocky Mountains. Average elevation is 1403 m (4600 ft.) above mean sea level (amsl). Major natural features in the region include the Absaroka Range to the south and the Yellowstone River and the Crazy Mountain Basin and Sheep Mountain to the north. The Yearling Spring site is situated within an intermittent drainage that flows north to approximately 2.75 km (0.71 mi.) to the Yellowstone River. The unnamed drainage and other

adjacent streams originate to the south on Elephant Head Mountain at 2875 m (9431 ft.).

Rock lithologies in the headwaters are amphibolite and gneiss, transitioning downstream (northward) into the drainage midsection to steeply dipping Cambrian through Cretaceous sedimentary rocks including sandstone, limestone, dolomite, quartzite, and shale (Eckerle 2011; Berg et al. 2000). Glacial moraine deposits also occur in the headwaters and midsection of Mission Creek that is situated nearby. The drainages in the vicinity of the site flow across a piedmont slope which consists of a composite set of gravel-capped, pro-glacial, outwash fans which transition to terrace treads near the axis of the Yellowstone River. The upstream origin of the fans begins near the confluence of Beaver Creek at around 1463 m (4800 ft.) and the fans extend to the south margin of the Yellowstone Valley where their gradient flattens to a gravel terrace tread before they terminate at a scarp-edge at an elevation of ~1402 m (~4600 ft.). These terraces are mapped as "Alluvium of fourth youngest alluvial terrace" and "Alluvium of fifth youngest alluvial terrace, oldest" (Berg et al. 2000, map legend). The mouth of area drainages, where they grade to the Yellowstone River valley bottom are incised ~36.6 m (~120 ft.) below these terraces. The presence of this fan-terrace landscape is attributable to bedload deposition from Mission Creek and other adjacent drainages at a time when the channel of the Yellowstone River stood greater than 30 m higher than its present elevation of 1323 m (4330 ft.) (Eckerle 2011). The downstream portion of the fan overlies the Cretaceous Sedan Formation (possible equivalent of portions of the Livingston Formation) consisting of sandstone, mudstone, and ash-flow tuff (Berg et al. 2000).

The vegetation at the site and surrounding immediate vicinity is limited to sparse grasses and forbs, with indications of recent and historic cattle grazing. The adjacent Yellowstone River drainage to the north exhibits mixed riparian vegetation with cottonwood, willow, and other species. Adjacent terraces have very sparse tree cover with cottonwood and cultivated species, grasses, and forbs.

**SITE DESCRIPTION**

The site consists of a small, subsurface cache pit and 62 obsidian bifaces, preforms, cores, core fragments, and flake tools, some of which are ochre-covered (Figures 10.3 and 10.4). The top of the ochre-filled cache pit is located at a level approximately 70 cm below existing ground surface. One obsidian biface reduction flake was found *in situ* during excavation within the remaining edge of the sub-surface, ochre-filled cache pit. Twenty obsidian pieces were found on the ground surface after a bank/slope failure in spring 2010. The recent surface distribution of artifacts was located immediately east and downslope of the ochre-filled cache pit location. The remaining 41 specimens were found in the same downslope area within the recent sod layer, indicating an earlier but recent slope failure that first exposed the cache pit.

**RESEARCH METHODOLOGY**

Artifact discovery and collection first occurred in the spring of 2010 when 20 obsidian artifacts were discovered lying on the surface near Yearling Spring by non-archaeologists who reported their discovery to professional archaeologists. It appears the artifacts were deposited on the surface that spring after a slope failure caused the artifacts to erode out of primary context and slide downhill on wet grass. This was apparent from the fact the 20 artifacts were resting either atop freshly eroded soil or on a bed of new season's growth of grass. At first it was believed that these artifacts might represent the entirety of the cache located adjacent to a heavy ochre stain in the mud wall of the cut bank. However, subsequent excavations



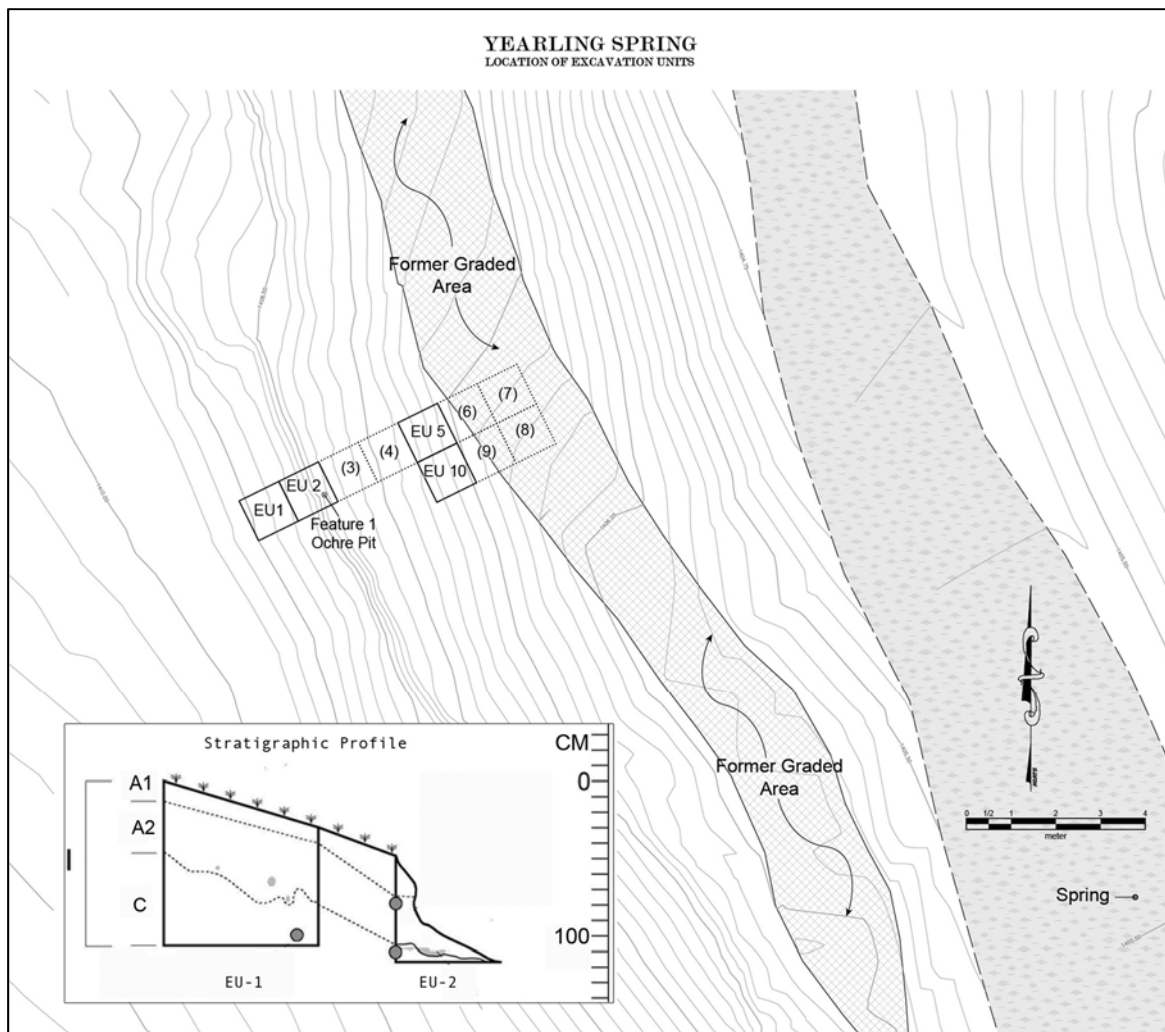
**Figure 10.3. Photograph view to west of placement of EU-1 and EU-2 at site. Note recent bank running left to right, resulting from recent slope failure.**



**Figure 10.4. Photograph view to west showing EU-2 with details of ochre-filled cache pit (outlined with dotted line) and location of in situ obsidian flake (Artifact 49) at bottom of cache pit. OSL-002, -003, -004 mark locations of sediment cores taken for OSL analysis.**



## LITHICS IN THE WEST



**Figure 10.5. Topographic map showing arrangement of excavation units and stratigraphic profile at Yearling Spring Cache site.**

undertaken by the authors have revealed a larger number of obsidian artifacts that almost certainly are associated with the cache.

The remaining 42 obsidian artifacts were recovered through excavation of the cut bank and the sod layer below the slope failure. The orientation of the excavation units (EU-1 and EU-2) is shown in Figure 10.5.

Sub-centimeter topographic mapping of the site and surrounding land surfaces was carried out with the use of Real Time Kinematic (RTK)/dual station Global Positioning System (GPS). A large area around the site was mapped at 15- and 30-cm contours to indicate

topography, artifact locations, excavation units, and other elements.

A single excavation unit (EU-1) was placed up slope above the cut bank to determine the possible lateral extent of the cache area. During excavation, 1/8<sup>th</sup> inch screens were employed to ensure recovery of very small items. Excavation of EU-1 failed to recover any artifacts or concentrations of ochre. A second excavation unit (EU-2) was placed directly to the east and down slope, and exposed the extent of the ochre stain noted in the cut bank. Only the eastern half of the unit was excavated, leaving a 50cm thick balk-wall between EU-1 and EU-2

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**Table 10.1. Biface reduction stages and tool types exhibited by the Yearling Spring Cache (24PA1377).**

Tool Type	Count (n)	Maximum Length (range, cm)	Weight (range)
Bifaces	31	6.88-20.12	41.94-601 g
Flake tools	27	5.62-9.62	19.55-125.35 g
Biface core	1	26.02	2.498 kg
Biface thinning flakes	2	10.98-15.64	128-272 g
Core fragments	1	15.64	793 g

(see Figure 10.5). At the bottom of the ochre stain in EU-2 a single *in situ* artifact was recovered.

Recovery of the other 41 artifacts all occurred within the sod layer down slope from the cutbank and cache pit. Horizontal provenience was recorded and depths measured relative to both the site datum and below ground surface. The depths below surface at which artifacts were recovered ranged from one centimeter to just over 15cm. The sod layer itself was less than 20cm thick and contained all of the excavated artifacts. It is likely that this indicates at least one previous slope failure at some undetermined number of years ago and re-deposition of artifacts before those on the surface were discovered in 2010. All artifacts are in secondary context except for the single flake tool located at within the ochre-filled pit observed in EU-2.

The absence of lithic debitage at the site suggests that the artifacts at Yearling Spring were produced elsewhere and later cached at the site. When obsidian artifacts were uncovered during excavation a number of procedures were employed to ensure the integrity of the artifacts for subsequent technical analyses. Artifacts were handled with plastic protective gloves to prevent human contamination during protein residue analysis. Artifacts were wrapped in aluminum foil and then placed into paper bags, rather than plastic, in case chemicals from plastic bags could off-gas and contaminate the specimens or related residues.

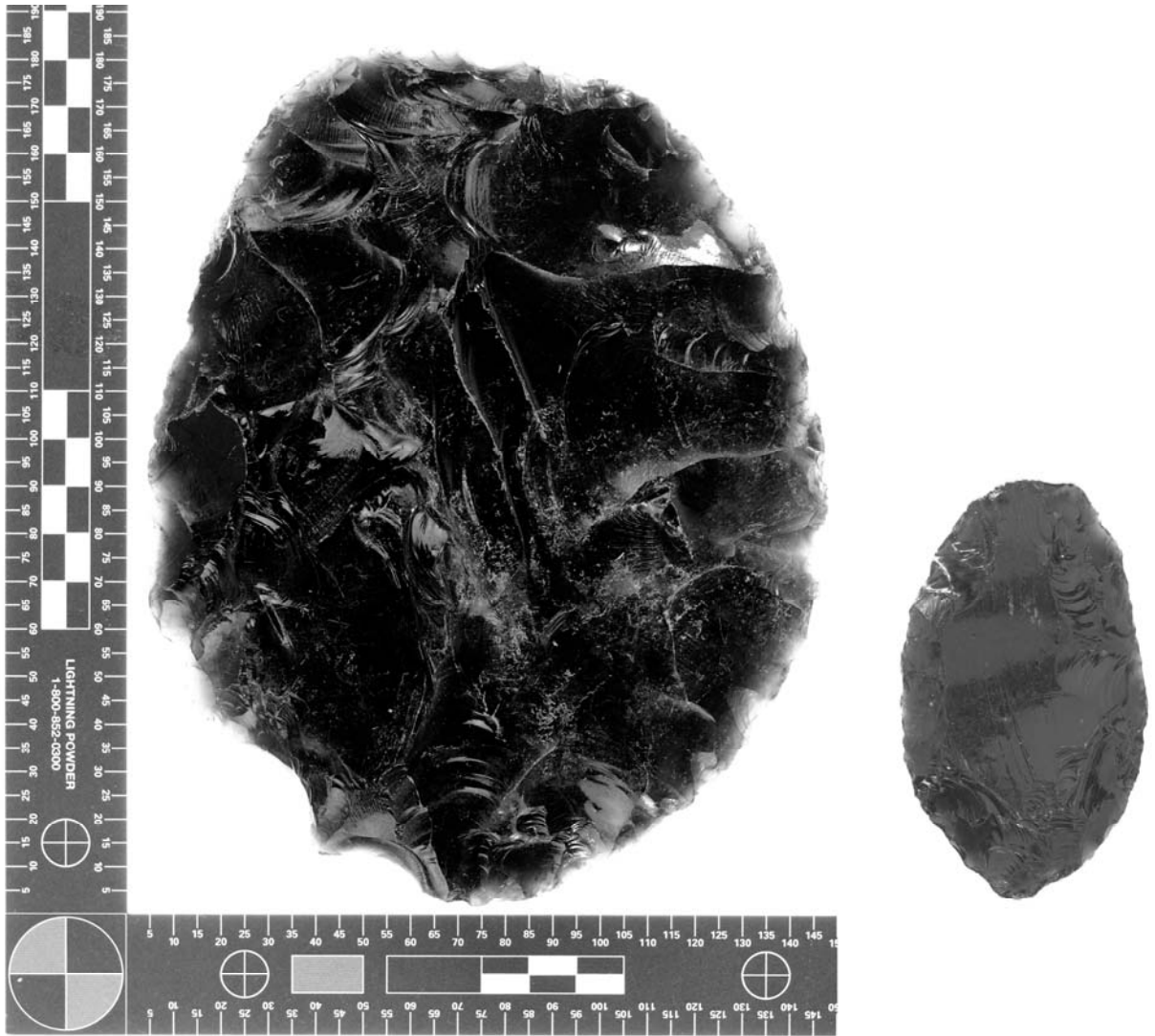
### ASSEMBLAGE ANALYSIS

The Yearling Spring Cache assemblage consists of 62 obsidian artifacts. It should be noted that excavation of

the site is not complete and with continued excavation this number might increase, thus changing the totals presented below. The lithic specimens have been classified into five broad categories. These artifact categories include bifaces, flake tools, biface cores, large biface thinning flakes, and core fragments. The assemblage of obsidian artifacts from the Yearling Spring Cache weighs a total of 8.375kg. Measurements taken on individual specimens include maximum length, maximum width, and maximum thickness in centimeters, as well as the weight in grams of each artifact. If platforms are present on flake tools additional measurements of platform width and thickness in centimeters have been recorded as defined by Andrefsky (2005). Other attributes such as transport wear, possible use wear, and the presence or absence of ochre stains have been noted during lab analysis. Basic measurements were taken before potentially destructive analyses were performed. Table 10.1 presents the distribution of artifact types present in the Yearling Spring Cache.

A total of 31 artifacts from the cache are classified as bifaces. Bifaces are defined as those exhibiting flake scars that are present on both sides of the artifact and extend to at least its center line (Andrefsky 2005). All of these artifacts are at least bi-marginally worked on both sides but the flake scars do not extend to at least the center line. Rather, the original flake scar from detachment remains in the center of the artifact.

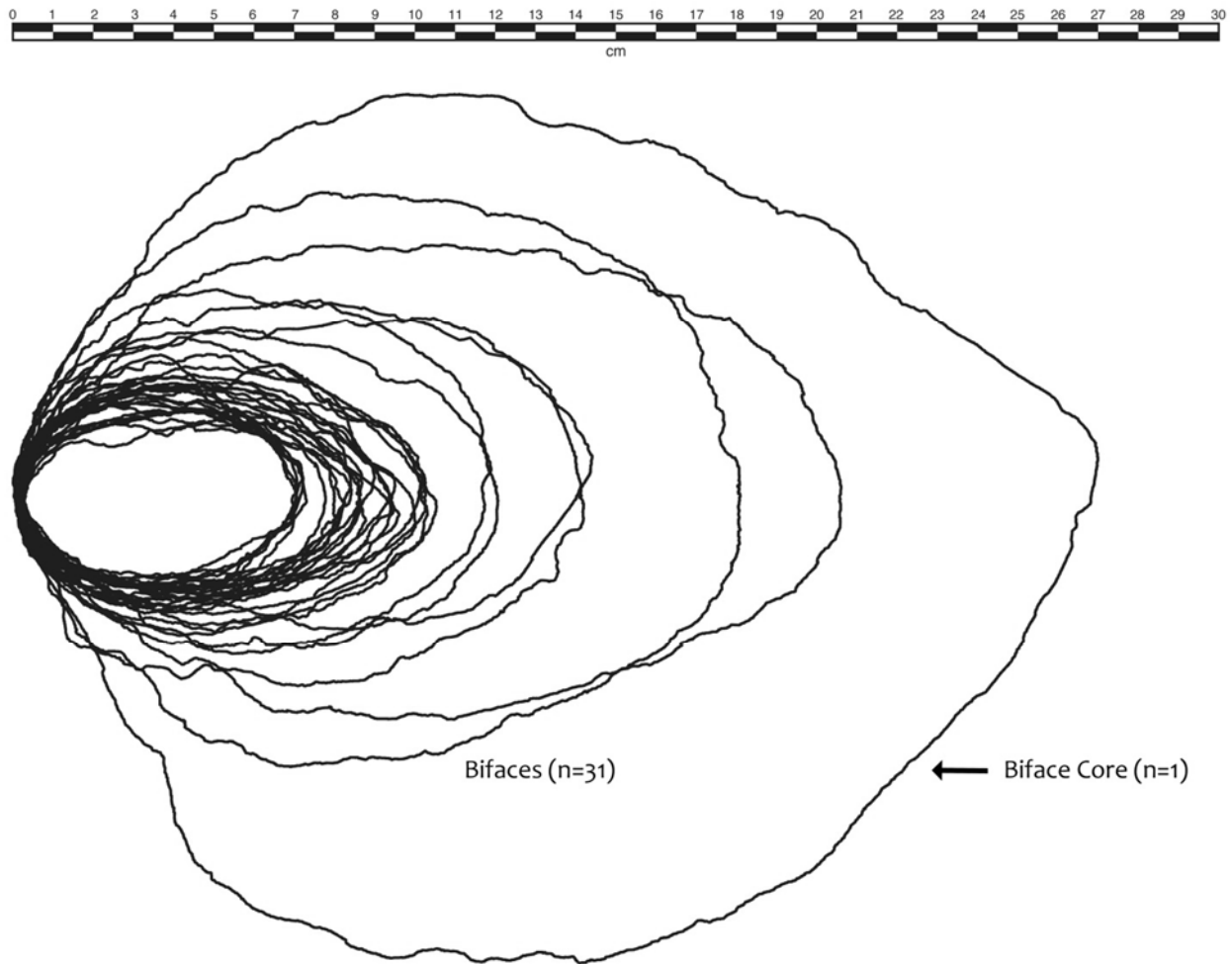
In these instances the artifact was classified as a biface even though it is not what is classically considered a biface (Figure 10.6). Such classification was undertaken because the artifact appeared to have been reduced to the point, as a rough preform or blank, where further



**Figure 10.6. Photographs of two typical bifaces from the Yearling Spring Collection. Right – Artifact 2010-F-001, showing full biface reduction with edge preparation; Left – Artifact 2011-A-036, showing bi-marginal flaking that does not extend across mid-line.**

work was not needed to reduce, thin, or shape the artifact. The maximum length of bifaces ranges from 6.86cm to 20.12cm and weight ranges from 41.94g to 601g. Figure 10.7 shows an overlay of all 31 bifaces and the large biface core. The bifaces are all in early stages of reduction. These bifaces are all roughed-out preforms with no diagnostic form or features to enable classification to a specific cultural complex or time period.

Flake tools are defined as artifacts with uni-marginal or bi-marginal flaking on either the dorsal, ventral, or both sides. Flake tools still have flake characteristics present, such as a bulb of percussion and/or conchoidal fracture lines (ripple marks) on the ventral side, and in some cases the presence of a platform (Figure 10.8). A total of 27 flake tools have been classified within the Yearling Spring collection.

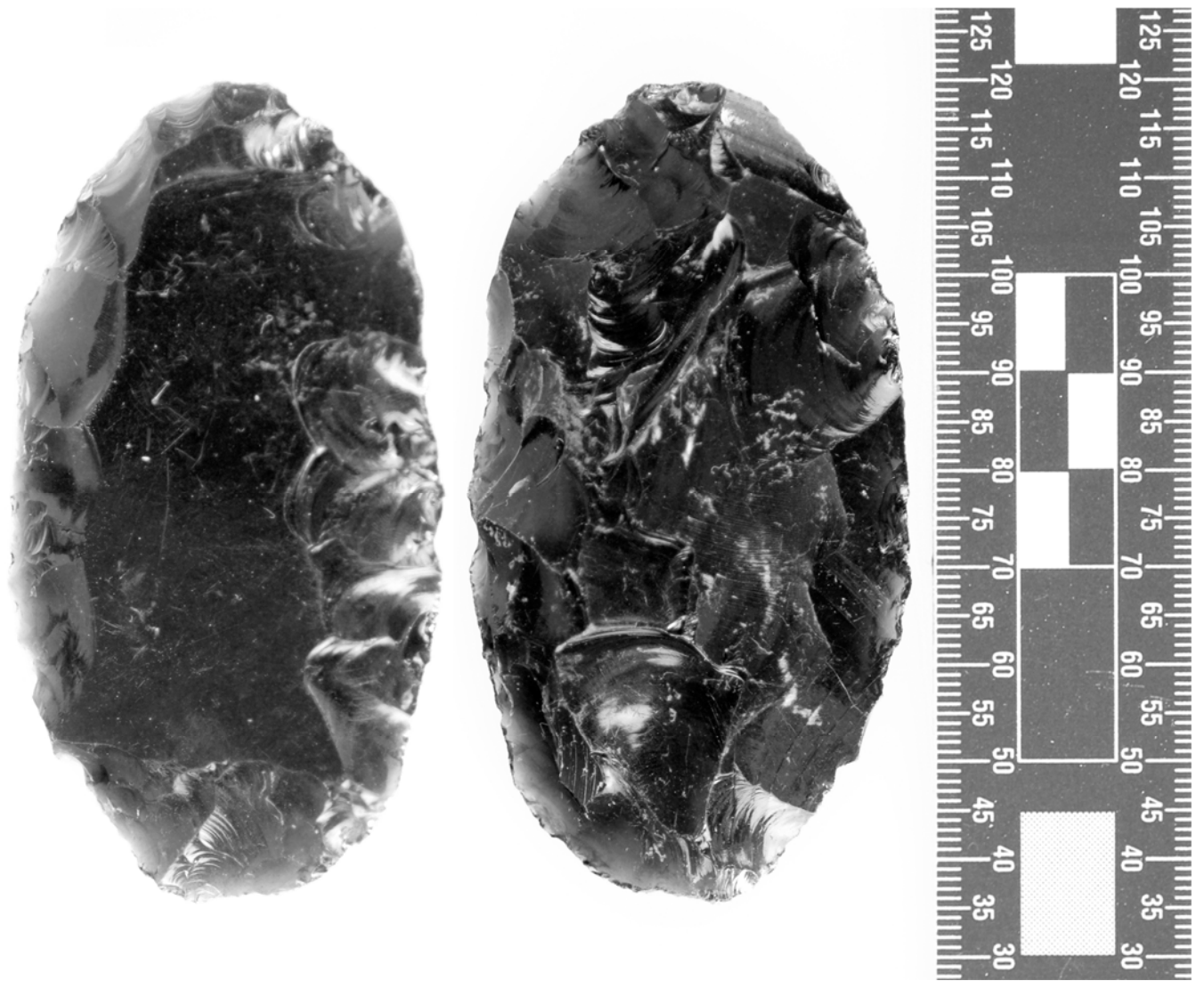


**Figure 10.7. Composite overlay of outlines of 31 bifaces from Yearling Spring cache.**

In our classification of Yearling Spring Cache artifacts, flake tools differ from the second type of biface discussed above in that these flake scars on a uni-marginal or bi-marginal edge are more limited in their internal penetration from the edge of the artifact to its center, as well as in the extent of the flaking around the perimeter of the artifact. Reduction has not completely erased flake characteristics such as platforms, bulb of percussion, ripple marks, and errillure scars - unlike the previously discussed bifaces. Flake tools range in maximum length from 5.62cm to 9.62cm. Weight of these artifacts ranges from 19.55g to 125.35g.

A single artifact is classified as a biface core. This specimen happens to be the largest artifact in the assemblage (see Figure 10.9). A biface core is a biface on

which the edges are used as platforms for the removal of flakes (Andrefsky 2005). Some of the flake scars on this biface core are large enough to have produced a majority of the tools in this cache. None of the artifacts, however, have been refitted to the biface core. The biface core has a maximum length of 26.02cm and weighs 2.498kg. The outline of the single biface core can be seen in Figure 10.9. The biface core is the largest artifact in the overlay and in the cache itself.



**Figure 10.8. Photograph showing ventral side (left) and dorsal side (right) of typical flake tool from Yearling Spring cache (2011-A-036). Note, ventral side exhibits original ventral flake scar with bi-marginally worked edge; dorsal side exhibits reduction flake scars and edge preparation.**

Two of the artifacts from the cache are classified as biface thinning flakes. Large biface thinning flakes are characteristic flakes with a platform and a bulb of percussion on the ventral side. The dorsal side shows remnants of flake scars from earlier biface reduction (see Figure 10.10). The edges of these artifacts have little to no use wear or visible retouch. Biface thinning flakes range in maximum length from 10.98cm to 15.64cm and range in weight from 128g to 272g.

The final tool type category is the core fragment. A core fragment is defined here as a non-diagnostic multidirectional obsidian core that exhibits a number of flake scars from previous flake removals. There is a single core fragment from the cache; it weighs 793 g, and has maximum dimensions of 15.64cm by 10.98cm.

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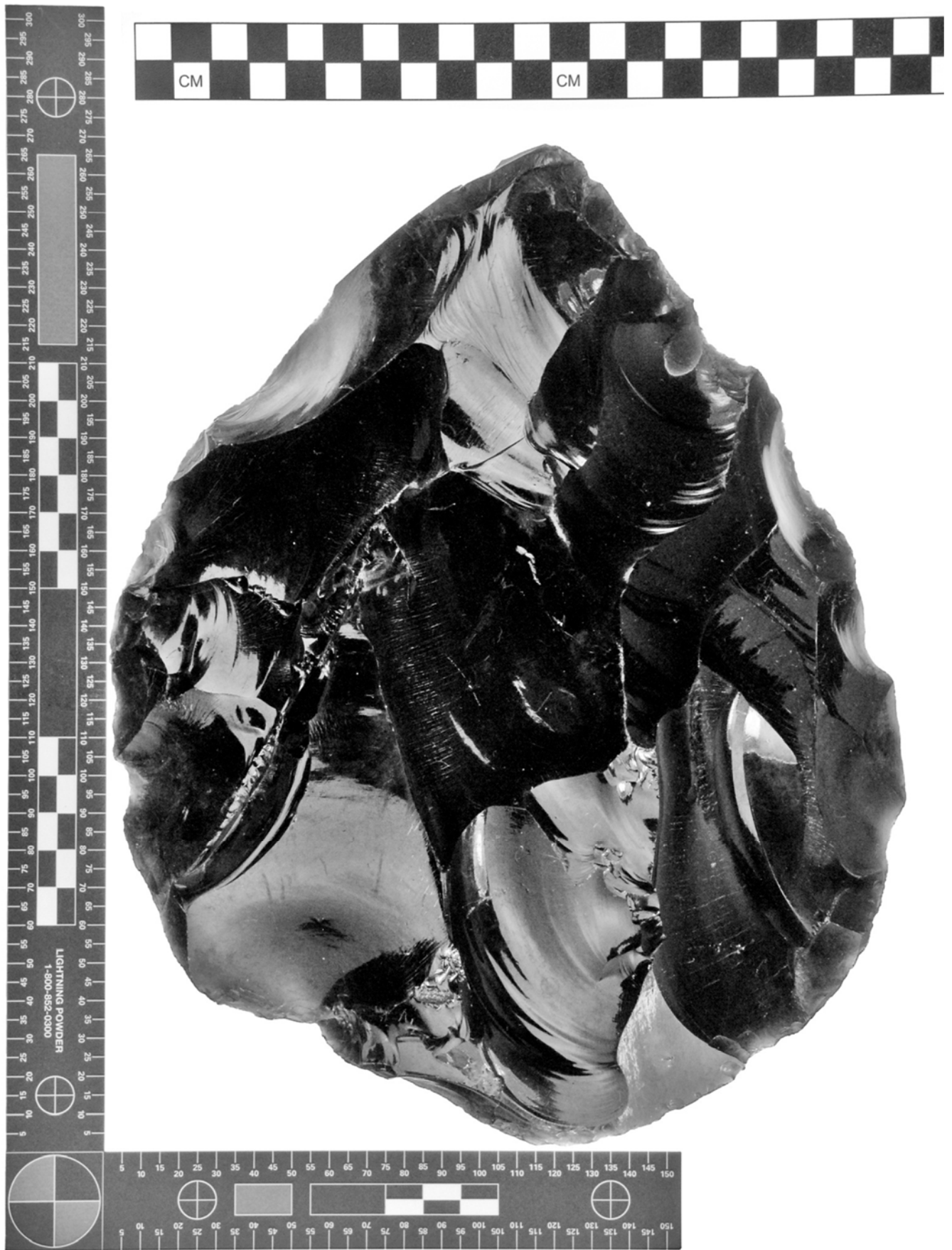


Figure 10.9. Photograph of large biface core from Yearling Spring cache (2010-F-003).



**Figure 10.10. Photograph showing remnants of previous biface reduction flake scars on dorsal side of large biface thinning flake (2010-F-005).**

small flakes were recovered from the screen during excavation. All of these flakes weigh less than one gram and average around 0.25 g. These flakes all appear to have been recently produced and seem not to be the result of artifact production in the past. We believe these small flakes are likely the result of trampling by large animals when the artifacts were exposed on the surface after the slope failure. As the site is located near a spring it is subject to heavy traffic by large mammals including cattle. While none of these small flakes have been refitted to larger artifacts there is no reason to believe they won't fit artifacts in the assemblage or others yet to be excavated. Other artifacts also show signs of recent trampling damage. Examples of this include artifacts with heavy mud and ochre staining on the exterior that have been broken into at least two pieces. On the broken and

most recently exposed surface of the artifact the mud and ochre staining is light to nonexistent indicating that it is a recent phenomenon and not a result of production or initial cache deposition.

Specimens from the cache assemblage have been subjected to a number of technical analyses. A large portion of the assemblage has been subjected to analyses that include x-ray fluorescence (XRF) spectrometry source characterization, obsidian hydration dating, protein residue analysis, and FTIR starch residue analysis. In addition to these special studies, we have estimated minimum cache volume, and specialists have undertaken geomorphological and chronometric studies of the soil matrix, including the use of optically stimulated luminescence (OSL) dating. These studies are discussed further below.

## SPECIAL STUDIES

### ED-XRF Source Characterization

Sixty of the obsidian specimens from the Yearling Spring cache were submitted to Geochemical Research Laboratory for Energy Dispersive X-ray Fluorescence Spectrometry (ED-XRF) obsidian source characterization (Hughes 2011, 2012). ED-XRF is a special analytical tool used to determine the selected major, minor, trace, and rare earth element composition of volcanic rocks. The distinctive combinations of various chemical elements can aid in the determination of likely geologic source of origin for archaeological artifacts.

The 60 specimens from this project were all found to be from the Obsidian Cliff source in Yellowstone National Park, approximately 155 km south of the Yearling Spring Cache site (Figure 10.11).

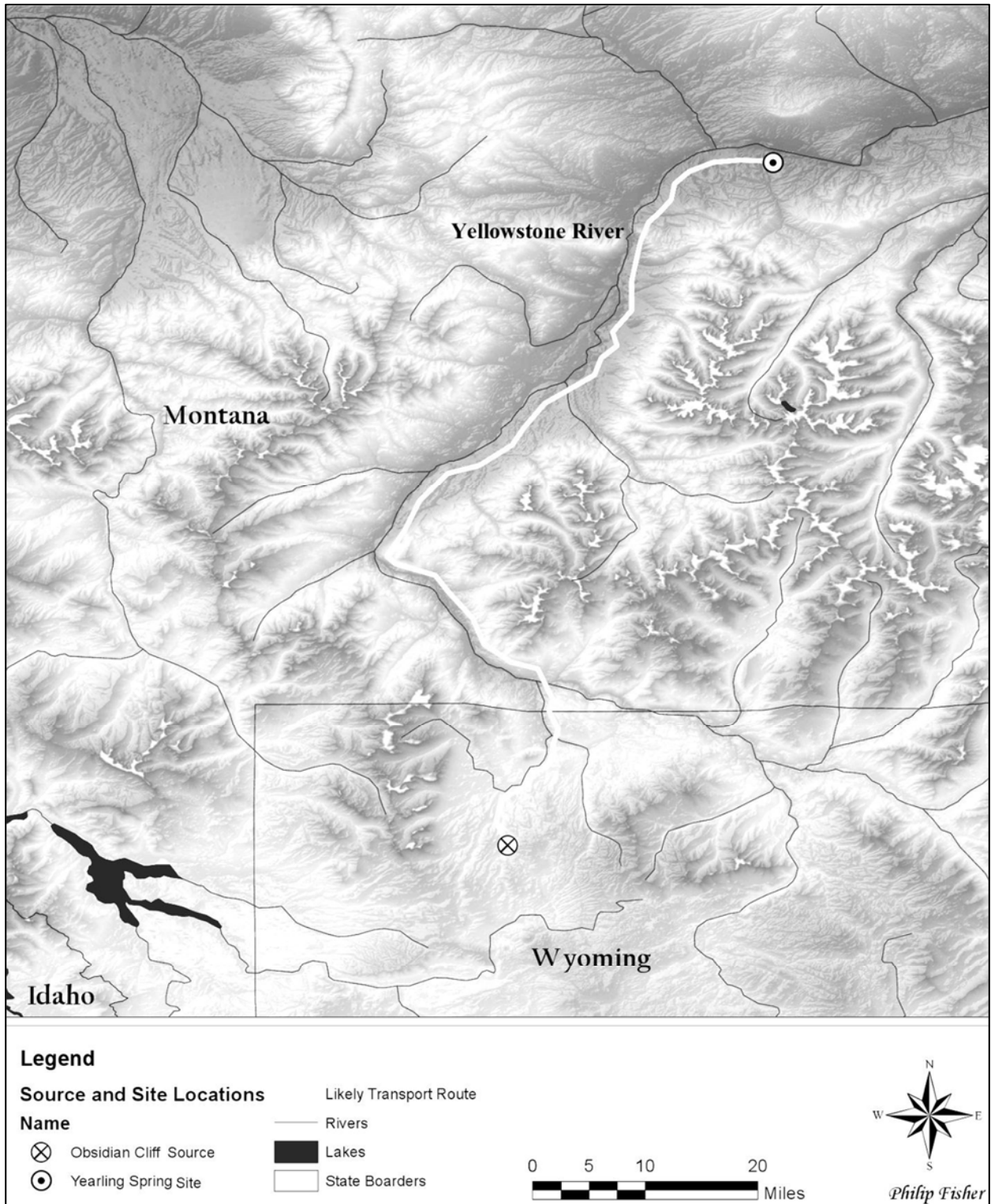


Figure 10.11. Map showing possible transport route between Obsidian Cliff source and Yearling Spring Cache site, based on least-cost geospatial model application.



### **Obsidian Hydration Dating Measurements**

Twenty-four of the Yearling Spring obsidian specimens were submitted for obsidian hydration (OH) measurement to Tom Origer & Associates (Origer 2011). Obsidian, a volcanic glass, obeys the property of mineral hydration and absorbs molecular water when exposed to air. Over time, water slowly diffuses into the artifact forming a narrow band or rim that can be observed and measured. Under most environmental and archaeological conditions hydration bands will accumulate at a relatively constant rate. The resulting measurement of the thickness of the hydration layer allows for the determination of relative and sometimes absolute dating of the time that has passed since the artifact was manufactured.

OH measurements for the Yearling Spring sample clustered in a very tight range from 3.9 - 4.1 microns ( $\pm 0.1$  micron), indicating a high potential that all measured pieces were obtained during the same procurement event. Origer (2011) calculated absolute dates for the derived hydration rates by determining the rate of hydration through comparison to an obsidian with well-established rates, and then calculating the "effective hydration temperature" (EHT) for the specimens' known location. Adjusted calculated hydration dates for the Yearling Spring collection is estimated to be approximately 3,683 years ago. This OH date has not been corroborated by other absolute dating methods such as radiocarbon dating, but has been substantiated by bracketed soil dates obtained through optically stimulated luminescence (OSL) dating, described below.

### **Protein Residue and Fourier Transform Infrared Spectroscopy Analysis**

Protein residue analysis is used to identify the presence of prehistoric, historic, or even modern proteins, both animal and plant that are present on a specimen. Proteins are present in plant tissues and in all body fluids and tissues, including blood, urine, saliva, fecal material, etc. This analytical tool can be used to determine what animals were processed using prehistoric tools. Additionally, animal and/or plant

proteins may indicate the use of such products in the manufacture and use of ochre pigments.

Fourier Transform Infrared Spectroscopy (FTIR) analysis is used to detect specific signatures resulting from organic compounds, including those that originate from food residues on artifacts.

Three obsidian artifacts and one ochre sample from the Yearling Spring cache were submitted to PaleoResearch Institute for Protein Residue and FTIR analysis (Yost et al. 2012). Organic residue analysis by means of FTIR proved inconclusive for specific organic starches other than ubiquitous/local environmental components. One of the two obsidian specimens with identifiable protein residue tested positive for Cervidae (deer, elk, etc.) and the other tested positive for Salmonidae (trout, salmon). A sample of ochre from the intact portion of the ochre-filled cache pit tested positive for Ursus (bear). Lithic analysis of the two obsidian pieces indicates minimal, if any use-wear. Hence, the existence of animal proteins most likely is the result of formulation of the ochre mixture with various animal fats, blood, oils, or other by-products.

### **Geoarchaeological Analysis**

Limited geoarchaeological studies have been conducted at the site (Eckerle 2011). Geoarchaeological investigations focused on sediments exposed in excavation units EU-1 and EU-2. The site occurs in a north-flowing first order stream drainage with a spring located immediately downslope from the cache site, within the drainage bottom. The defined soil constituents of EU-1 and EU-2 are characterized by a single stratum (I) of dark grayish brown, massive (unbedded), slightly pebbly, muddy, very fine sand (sedimentary texture) unit. The upper portion of Stratum I is characterized by three soil layers of similar appearance and constituents. A1 is the present-day organic sod layer, and A2 is an earlier organic/depositional layer. The top of Layer C is situated at the top of the sub-surface ochre pit, and possibly relates to an early ground surface.

### **Optically Stimulated Luminescence Dating**

Optically stimulated luminescence (OSL) dating is a method of determining how long ago minerals in soil

layers were last exposed to daylight. When an archaeological site exhibits buried deposits indicating possible earlier soil surface layers, OSL can be used to differentiate the ages between these specific layers.

Two sediment samples were submitted to the Utah State University Luminescence Laboratory for controlled analysis with Optically Stimulated Luminescence (OSL) dating techniques (Rittenour 2012). Both samples were taken in EU-2, one above the top of the remaining portion of the ochre-filled pit and one below the pit. The upper sample was assigned an OSL age of  $2,590 \pm 410$  years. The lower sample was found to date to  $6,800 \pm 1,220$  years. Both of these dates bracket the estimated OH date calculation of 3,683 years ago for the obsidian cache.

#### **Minimum Cache-Pit Volume Calculation**

A minimum cache-pit volume calculation was made to determine the minimum volume required to contain all of the known 62 obsidian specimens. This calculation assumes that all of the documented specimens were originally deposited within a cache-pit of some unknown size. To make the calculation, all specimens were wrapped in protective plastic bags and placed within a plastic cylinder of known dimensions. The obsidian pieces were placed into the cylinder three different times with the volume averaged to allow for potential different arrangements within a space. It should be noted that this calculation is only a minimum volume to determine the smallest size pit to hold all specimens. Obviously, a pit of larger volume could be utilized to cache all artifacts with more space between each artifact.

The minimum cache-pit volume calculation suggests that, if all specimens had been placed within the pit, the minimum volume would be approximately  $7700 \text{ cm}^3$ . The volume of the remaining west edge of the ochre-filled cache pit defined as Feature 1 in EU-2, is calculated to be approximately  $12,500 \text{ cm}^3$ . The recent slope/bank failure, transport of obsidian pieces down slope, and existence of ochre-stained soil suggests that some portion of the originally larger ochre-filled cache pit was destroyed during the recent slope/bank failure.

#### **FUNCTIONAL INTERPRETATION OF THE YEARLING SPRING CACHE**

A number of ideas have been proposed to determine the function of prehistoric caches. Because caches vary greatly in assemblage content, time period, and context, they must be approached carefully at an individual level when trying to determine function (Kilby 2008; Lassen 2005). We explore three hypotheses and related expectations for the caching of lithic material to evaluate the Yearling Spring Cache.

The first hypothesis proposes that lithic caches are the result of ritual or ceremony. Putative ritual or ceremonial caches are often associated with ochre use and human burials - such as the Anzick site in Montana (Kilby 2008; Lassen 2005; Tankersley 2001; Wilke et al. 1991). However, ritualistic caches need not be associated with human remains. Ritual caches can be dedications to ancestors or deities as well as towards future activities (Kilby 2008; Lassen 2005; Kohntopp 2001). Schiffer (1987) defines ritual caches as having a discrete concentration of complete artifacts that are largely unused and that are located in primary context. Additional expectations for ritual caches are the presence of ochre and the presence of complete tool kits, not just complete specimens. Also helpful in associating the function of a cache as ritualistic is proximity to a burial (Tankersley 2001).

Falling under ritualistic caching but deserving of a separate hypothesis is the idea of ideological caching. Gillespie's analysis of Clovis caches (2007) argues that some Clovis caches are an ideological adaption, which, allows hunter-gatherers to transfer a mobile sense of the landscape to a fixed one. The expectations for ideological caches are, thus, somewhat similar in nature to expectations for ritual caches, but differ in key ways. Gillespie's (2007) expectations under which the function of a cache can be described as ideological are as follows: 1) the finished tools (in his study these are Clovis points) are exceptionally well crafted and aesthetically pleasing, are unused, and are larger than utilitarian specimens of the same tool type; 2) the raw material is of high quality, sometimes having potentially traveled a great distance from the source; and 3) ochre is present within the cache

or on the cached artifacts. Additionally, Wilke et al. (1991) propose a possible ideological explanation for the Anzick Clovis cache and burial based on ideas about the afterlife. The lithic assemblage from the Anzick Cache contains multiple specimens from varying stages of production. The authors therefore propose that the Yearling Spring Cache could be a “teaching kit” to aid individuals in the afterlife based on the technological information evident in the physical assemblage.

The final hypothesis is utilitarian in nature and proposes that lithic caches form a safety net of sorts where a collection of artifacts is stored that can be recovered for later use. The function of utilitarian caches can therefore be viewed as a place of storage for a variety of later uses (Collins 1999; Garfinkel et al. 2004; Kilby 2008; Lassen 2005; Meltzer 2002; Rennie and Rittel 2007). This third hypothesis looks into the economic or utilitarian aspect of caching. If the function of a cache is to safely store material for later retrieval and use (Collins 1999; Garfinkel et al. 2004; Kilby 2008; Lassen 2005; Meltzer 2002; Rennie and Rittel 2007) then the artifacts can be expected to be in various stages of reduction and production. Expectations for a utilitarian cache could consist of completed tools, unfinished tools, or a combination of both. As later retrieval and use is expected from a utilitarian cache, the tools could have been used prior to caching. The most important difference to note between utilitarian versus ritual and ideological is that tools need not be completed and they need not be unused. Another expectation helpful in determining the function of a cache as utilitarian is its geographic location – wherein a plausible argument for one or another economic process or possible course of action can be made.

Relationships to the raw material source such as distance and travel time should be examined. The surrounding topography is also important. Surrounding topography refers to relationships to physical features on the landscape such as mountains, rivers, canyon mouths, or passes. Location as a criterion is not as clear-cut as other expectations and should be examined on a cache by cache basis. Nonetheless, the location of a given

cache was specifically chosen by those who cached the material; therefore, it deserves examination.

We do not expect the Yearling Spring Cache will necessarily fit cleanly into the expectations of a single functional hypothesis. It is hard to define categories of caching that will neatly subsume all caches. Indeed, the same expectations can be found under more than one hypothesis. Moreover, it is probably unrealistic to expect that a cache will meet all the expectations for a given hypothesis. However, we proceed on the premise that the hypothesis that best fits the Yearling Spring evidence is the best explanation for the function of the Yearling Spring Cache.

After evaluating the various hypotheses, we infer the Yearling Spring Cache to be utilitarian. According to the expectations for either a ritual or ideological cache the artifacts should be complete, finished tools that probably should not show signs of use. We do not believe that the function of the Yearling Spring Cache was ritual or ideological due to fact that all of the artifacts are in early stages of reduction or production. All of the bifaces appear to be preform blanks and there is no definable tool kit with typologically diagnostic artifacts present. Some of the artifacts in the assemblage show signs of use-wear and possible retouch. Protein residue analysis found remains of fish and ungulate on two of the tested artifacts. While this does not definitively demonstrate that the artifacts were used to process meat (fat from these animals could have been used as a binder with the ochre), the presence of protein residues is consistent with the inference that these artifacts had been used. Finally, unlike the Anzick site, the Yearling Spring Cache is not associated with a burial. As all of the artifacts are in early stages of reduction or production and there are no complete or finished diagnostic tools, the Yearling Spring Cache assemblage best fits the expectations for a utilitarian lithic cache.

Finally, the location of the Yearling Spring Cache in relation to the surrounding area is extremely important. The cache is only a few miles south of the Yellowstone River and at the interface between the Rocky Mountains and the Great Plains. The Yellowstone River was likely the easiest and fastest way to travel to the Yearling

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Spring Cache from the raw material source at Obsidian Cliff (Figure 10.11). From the Yearling Spring Cache site the artifacts could have been transported either into the Rocky Mountains or onto the Great Plains. In fact, Obsidian Cliff obsidian has been found as far east as Hopewell sites in Ohio (Hatch et al. 1990).

The presence of ochre is the only exception to the expectations that support Yearling Spring as a utilitarian cache. Many of the artifacts were coated in ochre, and the partially eroded ochre-lined pit is probably where the artifacts had been cached. Prehistoric use of ochre is often associated with ceremonial and ritual activities, but it could also be used for symbolic transformation or transformation of power (Gillespie 2007). To this end, it is possible that the Yearling Spring Cache is result of a combined utilitarian and ritualistic function. It is conceivable to us that ochre was used at a utilitarian cache, as we infer the Yearling Spring Cache to be, to ritually protect the cache from being discovered and to keep it safe until the cached artifacts could be retrieved. In sum, the Yearling Spring Cache is best explained, at this point, as a utilitarian cache.

### LITHIC MATERIAL PROCUREMENT MODEL

The Yearling Spring Cache presents a unique glimpse into single-source procurement and caching activities. As discussed earlier, the cache indicates a single procurement event from a single source with no apparent lithic reduction or utilization at the terminal cache location.

Ongoing research includes the examination of tool-quality lithic sources in southwestern Montana, northwestern Wyoming, and southeastern Idaho. Existing prehistoric site data related to known lithic quarry and procurement sites in Madison, Gallatin, Park, and Sweet Grass Counties has been synthesized from the Montana State Historic Preservation Office. Additionally, available information from area site records and studies in southwestern Montana, Yellowstone National Park, and known obsidian sources in Idaho and Wyoming have been utilized.

A total of 92 tool-quality lithic sources, including the Obsidian Cliff source, have been documented within an approximate 200 km radius of the Yearling Spring Cache site. It should be noted that this distribution of lithic sources may exhibit apparent patterns that may be attributable to a greater or lesser degree to area geology and where archaeological studies have been performed. The procurement pattern presented here may in fact change as more lithic sources are documented.

Table 10.2 presents summary statistics of known lithic procurement sites by primary stone type within 200 km radius of the Yearling Spring Cache site, grouped by 20 km radius zones.

The Obsidian Cliff source in Yellowstone National Park is located approximately 100km, straight line, south-southwest of the Yearling Spring Cache site. Obsidian Cliff is a major high-quality lithic source utilized throughout prehistory over the greater Yellowstone area. Obsidian Cliff obsidian is characterized as a very homogeneous and mostly flawless obsidian prized for effective stone tool production. The source is located at approximately 2,256 meters (7,400 feet) above mean sea level, an elevation of about 854 km (2,802 feet) above Yearling Spring. Because of the substantial elevation difference, access to Obsidian Cliff was most likely limited to non-winter months (Adams, et al 2011).

Figure 10.12 presents a simple bar graph indicating the number all types of known lithic material sources within the 20 km zones radiating from the location of the Yearling Spring site, up to a distance of 200 km. The graph also shows the number of known obsidian sources within the same area. This graphic representation clearly shows the number of lithic material sources that are closer to and farther from Yearling Spring than the Obsidian Cliff source.

The Yearling Spring Lithic Material Procurement Model indicates that 66 lithic material sources (72.5%) are known to be located at distances closer to Yearling Spring than the Obsidian Cliff source. Twenty-five known lithic material sources (27.5%) are located at distances greater than Yearling Spring is to Obsidian Cliff within the 200 km radius around the site.

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**Table 10.2. Summary data of known tool-quality lithic sources within 20 km radius zones, up to 200 km away from the Yearling Cache site.**

Radius Distance from Yearling Spring	Silicious Cherts	Quartzite	FGV <sup>a</sup>	Obsidian	Total - All Types
0-20km	0	0	0	0	0
20-40km	5	1	0	0	6
40-60km	5	2	0	0	7
60-80km	17	0	2	0	19
80-100km	25	7	2	0	34
Obsidian Cliff				1	1
100-120km	1	0	2	1	4
120-140km	0	1	2	1	4
140-160km	3	0	5	3	11
160-180km	5	0	0	1	6
180-200km	0	0	0	0	0
Totals	61	11	13	7	92

<sup>a</sup>FGV = Fine Grained Volcanics, such as basalt, dacite, etc.

From this simple model showing the spatial distribution of known lithic procurement sites we can see that over 70% of the known sources are located closer to Yearling Spring than the utilized Obsidian Cliff source. Least-cost models for possible transport routes have not been derived for these sources, but it is presumed that most, if not all of the closer sources would be accessed with less actual energy cost than travel to and from Obsidian Cliff. The data are also clear that the Obsidian Cliff source is *the closest* known obsidian source to Yearling Spring.

It can be posited that the Obsidian Cliff lithic material was perhaps considered by prehistoric peoples to be of a higher quality for tool manufacture than other closer sources, but correlation between attributes of quality and past behavior is difficult to match.

In summary, the Obsidian Cliff lithic material was obtained during a single event, subjected to initial stages of biface reduction then transported over 100 km linear distance to cache at Yearling Spring. Such activity transforms the raw obsidian at its geologic source into a value-added commodity for future use.

### CONCLUSIONS

To date, archaeological investigation of the Yearling Spring Cache (24PA1377) has yielded an artifact assemblage that is composed of 62 obsidian specimens. This assemblage constitutes one of the largest lithic caches in southwestern Montana. The artifacts, ochre, and surrounding sediment matrix from the cache were subjected to a number of technical analyses that help determine the age and raw material source of the obsidian artifacts, as well as the possible organic binder of the ochre. Based on the tight cluster of obsidian hydration rim measurements and the single raw material source (Obsidian Cliff, WY), it is likely the site represents a single caching event at an estimated age of 3,683 years ago.

The behavioral reason underlying prehistoric caching has been evaluated and the caching event at the Yearling Spring Cache site appears to be utilitarian in function, based on the artifacts in the assemblage and its location near the Yellowstone River in southwestern Montana. The site location is at a transitional zone between the Rocky Mountains to the south and west and the Great Plains to the north and east. Obsidian Cliff, the geological source of these specimens, lies 155 km, by likely travel route, to the south-southwest. We conclude that the

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obsidian pieces were cached as a utilitarian source for future use. Such use might have been determined as either an intermediate location for future use or as a raw material cache for trading with groups in other locales. Such locations may have included eastward down the Yellowstone River, northward into the High Plains, or westward into and across the Rockies. The lack of late-stage reduction and tool production, as well as finished bifaces in the cache possibly points to a utilitarian cache event for later use rather than a ritualistic or ideological cache.

The use of prepared ochre to mark or store the artifacts presents an interesting element of potential site function and intended use. Ochre has often been documented for use related to spiritual or ceremonial activities and rituals. It is possible that a cache of artifacts placed for future utilitarian purposes could have been deposited with some level of ritual behavior. Unfortunately, the limited archaeological information about the Yearling Spring Cache that is available to us at this time does not enable answering such questions with confidence.

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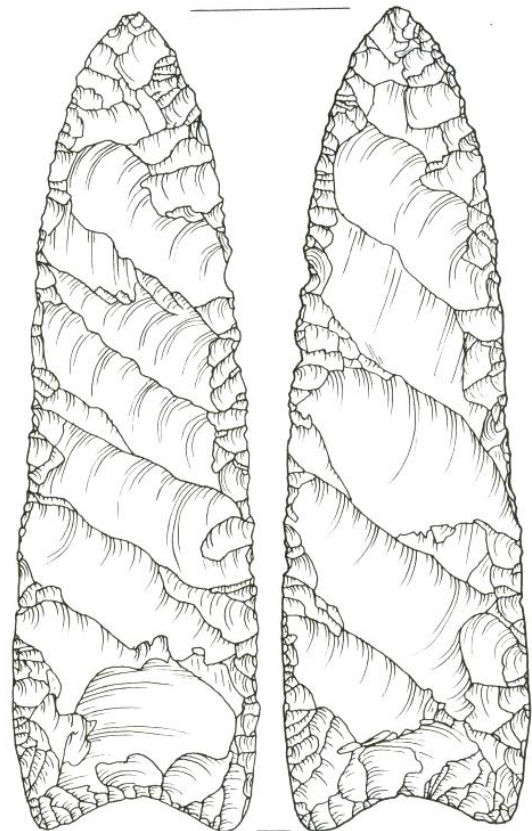
Using Lithic Analysis to Solve Archaeological Problems in Western North America

Edited by Douglas H. MacDonald, William Andrefsky, Jr., and Pei-Lin Yu

Stone tools and the by-products of their manufacture are the dominant type of artifact found at prehistoric archaeological sites in North America and much of the world. For that reason, the study of lithic artifacts facilitates our understanding of human use of landscapes, resources, and technology in the past. On an international scale, stone tool and debitage analysis has matured intellectually from its culture-historical origins, incorporating elements of human behavioral ecology, technological organization, land-use strategies, functional interpretations, and a variety of methodological advancements. A multitude of middle-range approaches are now utilized to understand human behavior in the past via the study of stone tools.

*Lithics in the West* seeks to link the rich archaeological lithic data base from the western United States with some of the contemporary theoretical and analytical approaches used in global settings in stone tool and debitage analysis today. The book highlights the role that lithic analysis (in all its forms) plays in solving research problems in the prehistory of western North America.

Contributors include William Andrefsky, Jr., Robert Kelly, Nicole Waguespack, Pei-Lin Yu, Doug MacDonald, Robert Brunswig, Scott Carpenter, Jackie Cook, David Diggs, Philip Fisher, Katie Harris, Brian Ostahowski, Mary Prasciunas, Ken Reid, and Todd Surovell.



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