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VARIABILITY IN FLAKE TECHNOLOGY AT TREE FROG, A PROTOHISTORIC SITE IN THE CENTENNIAL VALLEY, MONTANA

by

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***…The circle is now complete. When I left you, I was but the learner;
now I am a Master.***

-Darth Vader to Obi-Wan Kenobi,
Star Wars: A New Hope

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Variability in Flake Technology at Tree Frog, A Protohistoric Site
in the Centennial Valley, Montana

Chairman: Thomas A. Foor TAF

The inferred uses and distribution of lithic raw materials is a focus of study throughout the world. Geo-chemical analyses allow a researcher to (1) assign certain types of materials to their "source" and (2) measure the distance between this origin and where the material was recovered in archaeological context. Predictive models such as "Fall-Off" models, raw material availability, and economizing or curation behavior suggest that humans use and distribute raw materials in patterned ways.

This study, the mass flake analysis of lithic material collected during the 1997 and 1998 excavations at Tree Frog and the examination of associated artifacts, provides another source of information for the interpretation of Protohistoric sites in western North America and additional examples of the utility of geo-chemical and mass flake analyses used to facilitate the interpretation of cultural processes at and between archaeological sites.

The lithic materials recovered from Tree Frog were subjected to a mass flake analysis where the presence or absence of formal flake characteristics was tested for independence in relation to material type, presence or absence of cortex, and size of flakes. The results of this analysis suggest that technological changes occurred at Tree Frog. A combination of factors may account for this change: (1) the acquisition of horses which facilitated increased contact between native groups and created a relative ease in procurement of non-local lithic materials due to an increase in mobility as well as passing the burden of transport to horses; (2) the introduction of European trade items which have replaced some lithic tools as curated items allowing for the expedient use of lithic materials; and (3) the presence of a vast amount of local, poor quality obsidian that was used in an expedient manner along with non-local lithic materials.

The composition of flake assemblages, such as that recovered from Tree Frog, can be used to investigate the extent to which these characteristics reflect inferred cultural activities that occurred in the past. This study demonstrates the complexity of the Protohistoric period and the utility of cautiously applying ethnographic accounts when interpreting the results of a lithic analysis.

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The Tree Frog site is managed by the Dillon, Montana Bureau of Land Management resource area under the direction of Mark Sant. Thank you, Mark, for your support, funding, and initial recordation and recognition of the significance of Tree Frog.

The staff and faculty of the Anthropology Department at the University of Montana all contributed to my education, experience as an anthropologist, and growth as a student. A special thanks to Dr. Randall Skelton and D. Garry Kerr for allowing me to gain experience as a forensic anthropologist, a teaching assistant, and for your wonderful words of encouragement throughout my graduate school experience. Much of my success as a student and as an anthropologist after graduation can be attributed to both of you. Thank you.

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Table of Contents

Chapters

Appendices

List of Figures

List of Tables

Chapter I—Introduction

The inferred uses and distribution of lithic raw materials is a focus of study throughout the world (Johnson 1996; Ritchie and Gould 1985; Stocker and Cobean 1984, Torrence 1984; Spence et al 1984; Tykot 1998; Weisler and Clague 1998; Summerhayes et al 1998). This interest is probably related, in part, to the increased use of geochemical type attribution procedures, such as x-ray flourescence (XRF). These procedures allow a researcher to (1) assign certain types of materials to their "source" and (2) measure the distance between this origin and where the material was recovered in archaeological context (Hughes 1998; Renfrew and Bahn 1996). Predictive models such as Renfrew's (1977) "Fall-Off" model, raw material availability and economizing behavior (Odell 1996; Elston and Raven 1992), or curation behavior (Odell 1996; Binford 1980) suggest that humans use and distribute raw materials in patterned ways. In particular, studies suggest that the kinds and spatial distributions of raw material change in relation to the distance to the source in a predictable manner Here, I investigate the extent to which characteristics represented in flake assemblages reflect the inferred cultural activities relative to distance to the source in the following ways: (1) size of the flake; (2) cortex presence; (3) material type/quality; (4) formal characteristics such as a striking platform/bulb of percussion; or (5) combinations of the four previous characteristics (Foor 1997; Ahler 1989a, 1989b).

Other archaeological studies of Montana, Idaho, and other Great Basin/ Plains/Plateau sites also consider the use and distribution of lithic raw materials as a possible reflection of how humans interact with and use their surroundings (Baumler 1997; Connor and Kunselman 1997; Holmer 1997; Kunselman 1997; Schoen 1997;

Yohe and Pavesic 1997; Pavesic 1985; Thompson et al 1997). An opportunity to explore the behavioral patterns proposed above arose when lithic materials were recovered from excavations at the Tree Frog Site (24BE1629) in the Centennial Valley of Southwestern Montana. Archaeological excavation of Tree Frog yielded an assemblage of faunal remains, pottery, lithic material, a glass trade bead, and metal artifacts. The excavation took place in July and August of 1997 and 1998 under the direction of Dr Thomas Foor of the University of Montana, Missoula and Mark Sant of the Bureau of Land Management, Dillon Resource Area, Dillon Montana. My analysis focuses on the lithic assemblage, particularly the mass flake analysis of recovered lithic debris. I will discuss the remainder of the cultural remains whenever it is necessary for site interpretation.

Local Environment and Tree Frog Site Description

The Centennial Valley stretches on an east-west axis in southwestern Montana, overwhelming visitors with the stark beauty of a short grass prairie flooded by large reservoirs (see Fig.1). The north and south boundaries to the valley are tectonically formed parallel ridges known as the Gravelly Range and the Centennial Range respectively Monida, Montana and the Lima Reservoir form the western gateway to this valley and to the east, the Red Rock River and Reservoir stretch to the distant Gallatin Range looming over Yellowstone National Park.

The general environmental conditions in the Centennial Valley vary considerably depending on the season. Air temperature is the coolest in the month of January when the mean maximum temperature is 21° F and - 9° F is the mean minimum temperature (The Greater Yellowstone Coalition, no date). The warmest days in the

Centennial Valley occur during the month of July when the highest mean air temperature is 76.7° F and the mean minimum temperature is 41.1° F (The Greater Yellowstone Coalition, no date). Of course, temperature generally decreases as elevation increases (The Greater Yellowstone Coalition, no date).

Prevailing winds are westerly in the Centennial Valley. Precipitation in the Valley is highly variable: May and June experience the highest amount of precipitation while July through September are the months with the least amount of precipitation (The Greater Yellowstone Coalition, no date). Annual precipitation averages 14.7-27.2 inches per year at the valley floor (The Greater Yellowstone Coalition, no date). Primary vegetation in the valley consists of open sagebrush/grassland meadows (Sant 1992). Occasionally, springs occur at the head of drainages on the hillsides within the Valley

The Tree Frog site is located within the valley on the north slope of the Centennial Mountains at the base of a rhyolite cliff formed as part of the Centennial Fault (Foor 1999). Within the site boundary, a spring provides enough water to support aspen, willow, and lodgepole/fir trees as well as lush, seasonal grasses and plants on the otherwise sagebrush-covered ridges (Sant 1992). Potential natural vegetation includes sub-alpine fir and douglas fir climax forests (Foor 1999). The northern portion of Tree Frog consists of a mid-elevation aspen meadow surrounding a spring-fed creek (Foor 1999). The southern end of Tree Frog is higher in elevation than the northern portion of the site, adjacent to a spring-fed creek surrounded by aspen groves (Foor 1999).

Currently, the variety of plants, water, and access through the mountain passes that cross the Continental Divide located in the Centennial Range, attract large and small game including (but not limited to) antelope, deer, and elk (Foor 1999). Analysis of the faunal remains recovered at Tree Frog confirm that at the period of occupation, a variety of animal resources were available. Identified faunal remains recovered from the site deposits include: bison (*Bison bison)*; antelope (*Antilocapra americana*); horse (*Equus* sp.); marmot (*Marmota* sp.); mountain goat (*Oreamnos americanus*); a large bird (*Aves* sp.); ground squirrel (*Spermophilus* sp.); deer (*Odocoileus* sp.); (Dundas 1998; 1999).

In addition to plant and animal resources, a source of obsidian cobbles litter the surface around and on the ridge near Mud Lake in the Centennial Valley The Tree Frog Site covers most of this ridge, including its north and south faces, above Mud Lake where the obsidian cobbles are most frequent. The depositional environment is both alluvial and colluvial in the area where the heaviest concentration of cultural materials exist (Sant 1992). Soils are typically cryoborolls resting atop either Quaternary alluvium at the North end of the site or colluvial deposits of rhyolite at the southern end (Foor 1999). The site elevation ranges from 6,700 to 7,000 feet above sea level (Sant 1992).

The heaviest concentration of cultural materials at Tree Frog are located on a north-facing slope and because the elevation at the site is higher than the valley floor, the temperature is generally cooler causing greater snow accumulation on this exposure (Foor 1999). Snow accumulation commences in the early portion of autumn and persists until late spring due to the extremely cool temperatures at the site (Foor 1999). Because of these environmental conditions, it is unlikely that the occupation of Tree

Frog occurred during winter months. Therefore, the occupation most likely occurred in the time period between the late spring and early fall (Foor 1999).

Datable material recovered from the 1997 and 1998 excavations were analyzed by Beta Analytic, Inc (1998; 1999). A radiocarbon date of AD 1590-AD 1790 with a 99% confidence interval from bone recovered from the southern feature and AD 1635-AD 1955 from the northern area excavated places the site occupation in the protohistoric period (Beta Analytic, Inc. 1997, 1999). Both determinations are considered here to be confirmatory—that is they are so recent they can only be used to confirm occupation of the site in the past 300 years (Foor 1999).

Obsidian hydration samples were analyzed by the Sonoma State University Obsidian Hydration Laboratory (Origer 1999) in order to establish a relative temporal comparison between the Northern and Southern excavation areas at Tree Frog (see Appendix C). Origer (1999:2) concluded that hydration band measurements suggest late working of the obsidian at the site and "a few readings hint at earlier knapping of this material" Five of the samples lacked visible hydration suggesting very late reduction or recent damage to the sample (Origer 1999). Over all, the samples recovered from the Northern and Southern area appear relatively contemporaneous. Because of the obsidian hydration results, I infer that the southern area was occupied or utilized at roughly the same time period established for the northern excavation area.

The type and style of artifacts recovered from Tree Frog support the chemical analyses conducted in order to establish a temporal framework. Among these diagnostic artifacts are projectile points, pottery, a glass trade bead, bones of horses, a brass ring, and other metal artifacts (see Appendix D). I will briefly describe these artifacts, including the time period in which they were most likely in use.

Projectile Point Types

Projectile point types have traditionally aided researchers in establishing chronological ordering where chemical analyses were not available (Frison 1978; Metcalf 1987; Mulloy 1958). Projectile point types recovered from Tree Frog (see Appendix D) can be classified as Late Prehistoric side-notched, corner notched, unnotched point variants, and one tri-notched point (see *European Trade Items* discussion below) (Frison 1991). These point types appear in the archaeological record approximately 1000 years ago and persist until the early historic time period or the Protohistoric--the historic period varies depending on what portion of North America is under consideration (Frison 1991).

The point types listed above have acquired various labels in the literature according to the physiographic and/or cultural areas in which they were recovered, yet display striking similarities. An example of some of the names applied to these point types are Plains Side-Notched points (or corner-notched and unnotched variants) (Frison 1991), Desert Side-Notched (or a triangular unnotched variant or a corner-notched variant), or side-notched points in the Elko series (Swanson et al 1969) to name a few Despite the differing names applied to these point types, the time period in which they occur in the archaeological record is generally the same—the Late Prehistoric until the Early Historic/Protohistoric (Frison 1991, Swanson et al 1969). Therefore, the presence of small side-notched, corner-notched, and unnotched points at Tree Frog (and the lack of other point types) supports the hydration analyses and ^{14}C results suggesting a Late Prehistoric to Early Historic/Protohistoric occupation.

Horse Remains

In addition to the analyses described above, the recovery of horse remains also suggests a Late Prehistoric/Protohistoric occupation at Tree Frog. The upper right second premolar (RP^2) of a horse (*Equus* sp.) was recovered from the 1998 excavation and identified by Dundas (1999).

The presence of horses in Idaho and Montana, "is not definitely known, though there is some evidence that some horses, at least, were acquired directly from the Spaniards and Shoshoni (historically located in the vicinity of Tree Frog) were among the first tribes to have them" (Steward 1997:201). "As early as 1540 (AD) horses began to appear in the southwestern villages and by 1760 (AD) they were common throughout much of the region from the Mississippi to the Rockies" (Embree 1939·127-128). The presence of a significant number of horses was documented in this area by the early 1800's (Frison 1991). Because of the presence of at least one horse at Tree Frog, I infer that the site was occupied after AD 1540, one of the earliest dates that document horses in the United States. The time period after AD 1540 also falls within the Late Prehistoric/Protohistoric, supporting the temporal estimate set forth by the projectile point styles and the chemical analyses.

European Trade Items

The presence of European trade items at Tree Frog supports the late dates attributed to the site, yet also suggests that the site was occupied in the very Late Prehistoric, most likely, the Protohistoric/Early Historic. Items recovered from Tree

Frog include a blue glass trade bead, a brass finger ring, and large and small fragments of wrought iron (see Appendix D). Blue, wire-wound beads are roughly dated between AD 1670 and AD 1820 (Quimby 1966). Iron knife blades and iron or brass kettles were also present between AD 1670 and AD 1820, earlier perhaps, in the areas just west of the Great Lakes (Quimby 1966).

European goods reached the western United States often without direct contact, primarily due to the fur trade (Quimby 1966). The time period in which the fur trade prospered occurred from approximately AD 1670 to AD 1870 (Wissler 1970), however, trading posts in Montana, Idaho, and Washington were not constructed until AD 1807 to AD 1813 (Masten et al 1981). These trading posts operated under the direction of very few Euro-American setters or trappers until AD 1883 when the completion of the Northern Pacific Railroad facilitated the arrival of a much larger number of Euro-American settlers (Masten et al 1981).

During the protohistoric time period in the western United States, European trade items were only found in small amounts and consequently, were highly prized (Frison 1991). Other protohistoric sites, such as the uppermost level at the Medicine Lodge Creek site or the River Bend site along the North Platte River in central Wyoming also contain small amounts of European glass beads, horse bones, iron fragments, and very small tri-notched and side-notched projectile points (Frison 1991, McKee 1988). These assemblages are very similar to the artifact assemblage recovered at Tree Frog, supporting the assumption that the site is a protohistoric one.

The pottery fragments recovered at Tree Frog also contribute to my estimate of a late period of occupation at the site. Nineteen pottery sherds, identified as possible examples of Intermountain Tradition ceramics, were recovered from the 1997 and 1998 excavations at Tree Frog. Intermountain Tradition pottery is characterized as a coarsely-made, flat-bottomed vessel form, most are dark gray or black (Butler 1981 Frison 1971, Lohse and Holmer 1990). Common examples of Intermountain ware have flat bases that flare slightly with bodies that taper in a continuous curve from the shoulder creating a vessel that resembles a "flowerpot" (Frison 1971, Butler 1981).

The earliest radiocarbon dated occurrences of this tradition are AD 1580 and AD 1610, recovered from sites in Wyoming (Butler 1981). The Wahmuza site in southeastern Idaho also yielded Intermountain ware along with European trade items (glass beads, horse harness parts, musket balls) and numerous side-notched projectile points (designated as Desert side-notched of the General and Sierra varieties) (Lohse and Holmer 1990). Wahmuza was dated to approximately AD 1850 indicating that this pottery tradition persisted well into the early protohistoric/historic period (Lohse and Holmer 1990). The presence of this flat-bottomed Intermountain ware at Tree Frog once again supports the previous discussions suggesting that the occupation occurred during the very Late Prehistoric or Protohistoric time period.

General Description of the Late Prehistoric/Protohistoric Period

The results from radiocarbon dating, obsidian hydration dating, projectile point and pottery typology, and the presence of European trade items and horse remains strongly suggest that the occupation at Tree Frog occurred sometime within the Late Prehistoric or Protohistoric time period. As previously stated, the Centennial Valley is located on the periphery of three physiographic and cultural areas commonly referred to as The Columbia Plateau, The Great Basin, and The Great Plains. The convergence of three cultural/geographic areas combined with the rapidly changing lifeways via the introduction of the horse and later, the use of European trade goods in the Late Prehistoric and Protohistoric periods, created complicated human interaction and behaviors that are reflected in the archaeological record. Tree Frog is no exception. To understand and interpret archaeological sites in cultural-geographic-temporal periphery areas, such as the Centennial Valley—specifically Tree Frog, all pertinent geographic/cultural areas must be considered as possible sources of influence. Therefore, a general, brief discussion of the Great Basin, the Great Plains, and the Columbia Plateau during the Late Prehistoric/Protohistoric follows.

The Great Basin/Great Plains/Columbia Plateau Geographic and Cultural Convergence

The Great Basin--The Great Basin is an extremely large physiographic area of the United States that "extends from the Wasatch Mountains on the east to the Sierra Nevada Mountains on the west, from southeastern Oregon and the uplands of southern Idaho on the north to all but the southern portion of Nevada and southwestern Utah" (Steward 1997:10). The Great Basin consists of a series of mountain ranges and high plateau valleys where rivers flow into the Basin rather than to the ocean as an outlet (Kopper 1986) (see figure 3).

The portion of the Great Basin that is the most relevant to my study includes, "extreme northern Nevada and the adjoining portion of southern Idaho," an area that also has been characterized as the southern portion of the Columbia drainage where, "ranges of the Rocky Mountains, especially the Bitterroot Mountains form a massive boundary to the plateau in eastern and central Idaho" (Steward 1997:10). While the geographic area that is considered to be the Great Basin is extremely large and seemingly well defined by topography, "the cultural Great Basin extends beyond the physiographic Great Basin and includes portions of other physiographic provinces, such as the Columbia Plateau and the Rocky Mountains (of the Plains) (D'Azevedo 1986:127). Further, "the Upper Snake and Salmon River Region serves as a natural corridor linking the northwest Plains with the Intermontane area, a geographic position clearly reflected in the region's shifting cultural affiliations with adjoining areas through time" (D'Azevedo 1986:127).

The groups of people that lived in this area adapted to the varying topography and harsh Great Basin climate, well before the Late Prehistoric, by adopting a mobile hunter-gatherer strategy (Kopper 1986). Great Basin groups are generally described as mobile hunter-gatherers that traveled in small bands in order to harvest geographically scattered resources throughout the year (Kopper 1986). Because of this mobile subsistence pattern, tool kits were usually small and "curated" (a term that is further described in Chapter II), and living structures were portable--typically conical wooden or brush lodges and Plains-style animal skin tipis adopted in the Late Prehistoric (Kopper 1986).

The acquisition of the horse in the Late Prehistoric greatly increased a pre-existing mobile lifeway of Great Basin groups and facilitated an increase in the amount of interaction between cultural groups from the overlapping geographic/cultural areas to the North and West (D'Azevedo 1986). Ethnographic evidence suggests that by very Late Prehistoric/Protohistoric time period, groups that had previously resided in the northern Great Basin began to incorporate Plains or Plateau cultural practices after the acquisition of the horse (Steward 1997). Plant foods such as seeds, bulbs and roots were still important food sources for northern Great Basin groups, yet northern plants--camas roots and bitterroot--became increasingly important as well (Steward 1997).

Former Great Basin groups that had acquired the horse became increasingly dependent on larger game, such as bison, deer, mountain sheep, and antelope rather than the fish, insects, very small mammals, and reptiles that the western Great Basin groups depended upon (Steward 1997). One ethnographic account revealed that "Shoshoni, Bannock, Nez Perce, Flathead, and Lemhi (historically recognized Great Basin and Plateau groups) made long excursions across the Rocky Mountains to the buffalo country of the High Plains (Steward 1997:201). Because of, but not limited to, these buffalo hunting trips, adoption of new regional food sources, and the possession of horses and tipis, the people, "who lived by the Snake River were strongly stamped with Plains traits" (Steward 1997:200).

While differing foods and dwelling structures appeared by the Late Prehistoric, the languages, stories, and ceremonies of periphery groups largely remained Great Basin in origin (Crum and Dayley 1997). The northern Great Basin groups that acquired horses greatly increased their existing mobile subsistence patterns and the frequency of contact with people from the Plateau and the Plains. As a result of this increased contact, these mobile groups continued to adapt to the new areas in which they were living yet retained some Great Basin characteristics.

The Plateau—The geographic area known as the, "Plateau of Northwest America lies between the Rocky Mountains on the east and the Cascade Mountains on the west. The northern boundary is roughly the great bend of the Fraser River while on the south this plateau merges with the Columbia Plateau" (portion of the Great Basin) (Ray 1939:1). Similar to the discussion of the northern Great Basin boundary, the southern boundary of the Plateau is quite arbitrary, along the east slope of the Cascades, the Plateau extends to the California boarder, but farther east, the Blue Mountains mark the southern limit" (Ray 1939:1) (see figure 3).

Cultural boundaries that are characterized as Plateau extended beyond the geographic boundaries just as groups from the south were not confined to the Great Basin (Kopper 1986). During the Late Prehistoric/Protohistoric, groups of people from the Plateau continued to rely heavily on salmon and root resources, maintained basketry and building techniques, and retained folklore, ceremonies, and languages common to the geographic area, yet had also adopted the horse (Kopper 1986; Jennings and Norbeck 1964). A very general description of the social structure in the Plateau has been loosely described as a clan dominated society where each village is its own political unit within a larger unit—village composition was fluid (Ray 1939). Easternmost Plateau groups felt the influence of a Plains organizational system where political groups had geographical units or territories (Ray 1939). This Plains style of, "tribal organization in the eastern Plateau is probably not of great age," (Ray 1939:13) and could be the result of an increase in the frequency of contact between the Plains and Plateau groups after the introduction of the horse.

The introduction of the horse did have a profound impact on the groups who obtained and used them. While evidence indicates that the horse was introduced from the south, Plateau groups used this increased mobility to also cross the Rocky

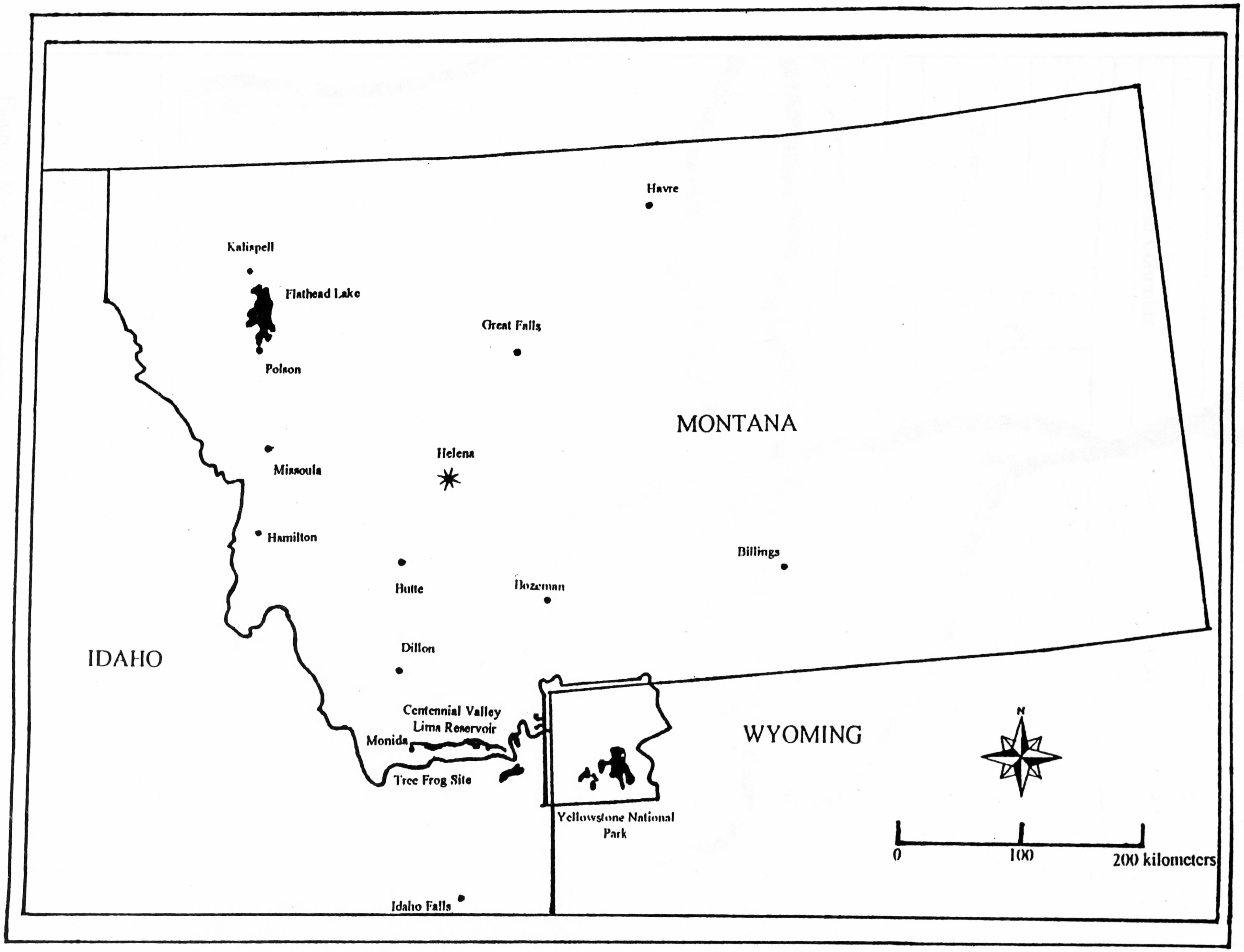


Figure 1: Map of Montana (Map from Espenshade 1986:116-117).

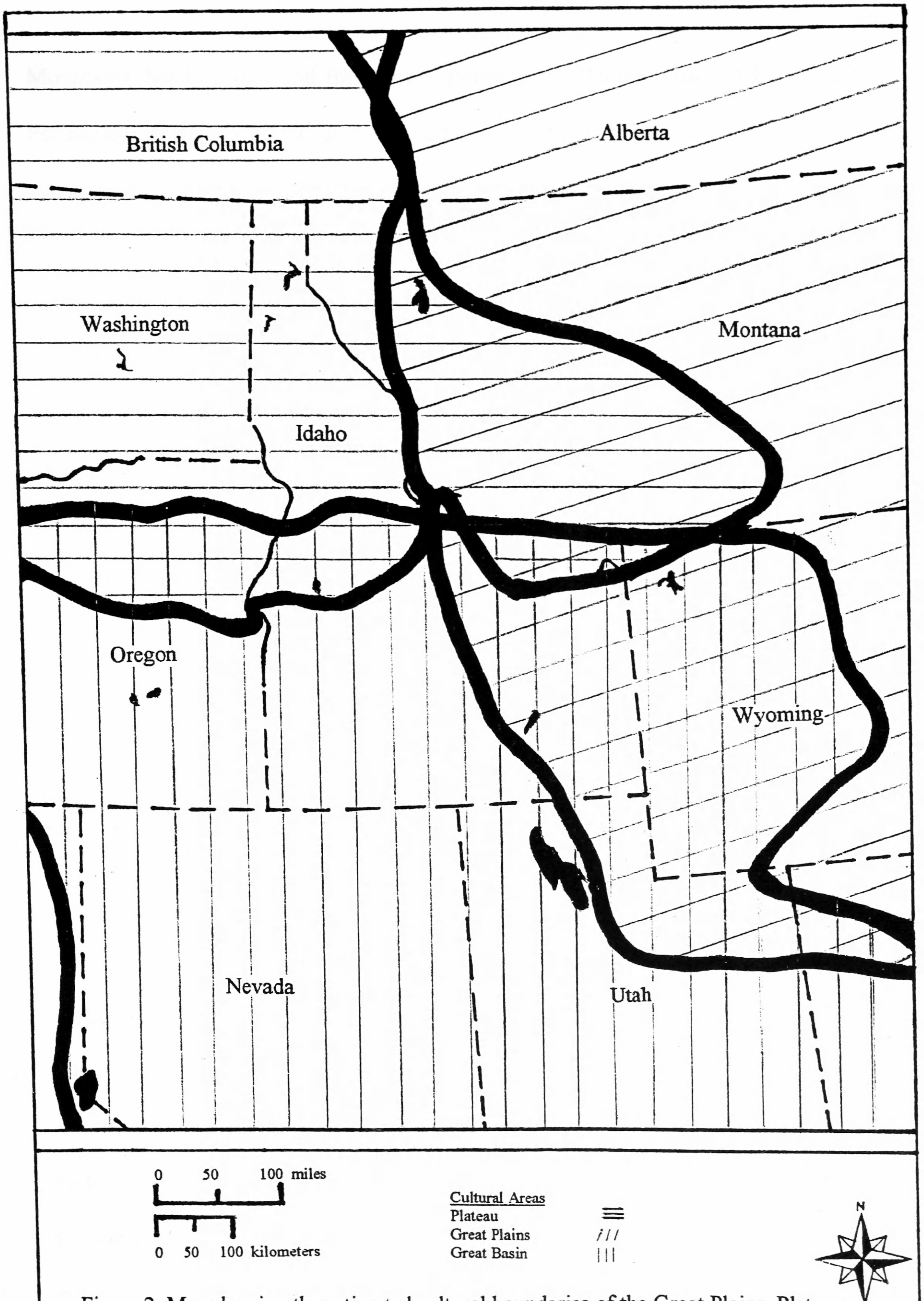


Figure 2: Map showing the estimated cultural boundaries of the Great Plains, Plateau, and Great Basin (D'Azevedo 1986; Walker 1998; Frison 1991).

Mountains, heading east and therefore, "elements of Plains culture to be found in the Plateau are intimately bound up with the horse complex" (Ray 1939:14). Ethnographic accounts from the Protohistoric/Early Historic period, state that "some Plateau tribes took on a patina of Plains horse culture" (Jennings and Norbeck 1964:168).

Those Plateau groups that acquired some Plains traits were often those who had adopted bison hunting as part of their salmon fishing and root gathering subsistence strategy. As previously stated, "Shoshoni, Bannock, Nez Perce, Flathead, and Lemhi (historically recognized Great Basin and Plateau groups) made long excursions across the Rocky Mountains to the buffalo country of the High Plains (Steward 1997:201). Many routes were taken across the Rockies, but the "Upper Snake and Salmon River Region serves as a natural corridor linking the northwest Plains with the Intermontane area" (D'Azevedo 1986:127) and therefore, many Plateau groups may have passed through the area near the Centennial Valley in this Plateau/Great Basin/Plains periphery region as they traveled to and from the Plains.

The Great Plains—The term the "Great Plains" is also used describe a geographical area as well as a broad cultural typology. This geographic area in North America extends from, "Canada to the border of Mexico, and from the base of the Rocky Mountains on the west to the Eastern Woodlands" (Frison 1991:1). Frison (1991:1) accurately describes the western portion of this region by stating, "There are some places where one can almost point to a line separating the Rocky Mountains and the Plains. Elsewhere on the western border of the Plains, mountain ranges extend deep into the Plains and often form intermontane basins, obscuring the line of demarcation." While the Plains extend great distances to the east and south, containing within the region cultural and climatic variability, it is this area where the geographic boundary to the west overlaps with the Great Basin and the Plateau that are most relevant to this study. The Plains in this specific area during the Late Prehistoric/Protohistoric can be generally described as consisting mostly of short grass prairies with vegetation changes depending on the elevation and aridity (Lowie 1954).

A very general description of western Plains indicates that the social structure consisted of "bands" or local groups within larger social groups, jointly traveling in search of sustenance within a designated geographic area (Lowie 1954). These groups as a whole, "share a sufficiently large number of cultural traits to be classed together as representing a distinctive mode of life," (Lowie 1954:5) during the Late Prehistoric/Protohistoric. Groups that lived in this area depended heavily on bison, and other large game, as a food source, for bone tools and, but not limited to, skin coverings for the tipi (Lowie 1954). "Unlike the Basin and Plateau tribes to the west, they made little or no use of fish and of such small game as rabbits" (Lowie 1954:5).

Another prevalent trait of Plains groups, as discussed previously, was the use of the horse for hunting and transport (Lowie 1954). The use of horses was a tremendous advantage to pre-existing mobile groups on the Plains and therefore these groups readily adopted horses and became "equestrian nomads" (Lowie 1954:5). As stated previously, the horse was not introduced in North America until approximately AD 1540 by the Spaniards in the Southwestern United States (Embree 1939) and therefore the use of horses in the Plains is relatively recent (Lowie 1954).

The introduction of the horse allowed the Plains groups to interact and influence groups from neighboring geographic areas as well as provide an opportunity to adopt new traits into their own way of life. While traveling near this periphery area, Plains groups may have used the opportunity to gather roots and berries as Basin and Plateau groups as well as incorporate dress styles and art from these neighbors (Lowie 1954). As described above, Basin and Plateau groups frequented the Plains area (Crum and Dayley 1997; Steward 1997; Ray 1939), allowing the Plains groups to experience differing cultural practices whether they traveled to the periphery area frequently or not.

Simplifying the discussion of cultural groups by classifying their cultural traits by the particular geographic area in which they reside has always been somewhat arbitrary, yet in the Late Prehitoric/Protohistoric this practice becomes increasingly difficult. "Cultural areas are merely convenient ways of classifying peoples, and we must recognize that a different alignment is possible and equally legitimate (Lowie 1954 198). After this general discussion of the Great Basin, the Plateau, and the Great Plains groups that frequented the geographic convergence of the three areas in the Late Prehistoric/Protohistoric, it is evident that all groups that travel through, have contact with, or live in this area have certain traits in common. Commonalties include a tremendous increase in mobility and the ability to transport supplies due to the introduction of the horse, increased contact and therefore selective adoption of traits or practices of cultural groups from the surrounding geographic areas, and the increased frequency or intensity of bison or large game hunting as part of their subsistence base. (Lowie 1954, Steward 1997; Ray 1939; Kopper 1986). The above three traits are of importance to this study because, as determined by geo-chemical analyses and the recovered artifact assemblage, Tree Frog is a very Late Protohistoric site located in this periphery area. Further interpretation of the occupation at Tree Frog in relation to mobility, its location in this periphery area, and the time period in which it was occupied is discussed in Chapter IV

Chapter II—Materials and Method

Theoretical Background

The theoretical background of this study, concentrating on the variability in the lithic assemblage recovered from Tree Frog in the Centennial Valley, Montana, is based on the idea that culture is a series of adaptations based on ecological changes or conditions (Bettinger 1991). This broad approach focuses on how cultures change and can be applied to specific cases where observations of technology and subsistence and settlement patterns reflect on hunter-gatherer adaptations (Bettinger 1991). To understand the formative processes in a particular area, a researcher must conduct a study in which results are directly useful in interpreting the archaeological record, "the forces directly responsible for the formation of the archaeological record itself: how the stuff of living cultures actually comes to form an archaeological record." (Bettinger 1991 62).

Behavioral variability is one force directly responsible for the formation of the archaeological record. "Behavioral variability in one part of the system, say social organization, was likely to be coupled with variability in another part (of the system)," such as in the production of stone tools (Bettinger 1991:63). Binford (1977: 6) states that archaeologists must "convert the observationally static facts of the archaeological record to statements of dynamics." The dynamics or the organizational properties of prehistoric societies existed on a continuum of subsistence-settlement systems from highly mobile to sedentary (Binford 1977). These organizational properties "could be studied archaeologically through carefully deduced arguments relating to behaviors of various sorts to expected archaeological consequences" (Bettinger 1991 63). This study considers three primary factors that most likely effected the variability in lithic technology at Tree Frog: (1) organizational properties or settlement mobility; (2) production trajectory or fall-off; and (3) resource availability and quality (Johnson 1989; Renfrew 1977; Binford 1977). Each aspect of this study is further explained below

Organizational Properties: Settlement Mobility Patterns

As stated previously, the organizational properties of prehistoric societies existed on a continuum of subsistence-settlement systems from highly mobile to sedentary (Binford 1977). Varying technology used by prehistoric societies within this continuum often corresponded to variation in settlement mobility patterns (Parry and Kelly 1986; Kelly 1988; Shott 1986; Odell 1994). The lithic assemblages under investigation in these previous studies were referred to as "curated" or "expedient" tool technologies (Binford 1979, 1980, 1982) and were compared to the settlement pattern represented at the sites in which the artifacts were recovered (Parry and Kelly 1986; Kelly 1988; Shott 1986; Odell 1994).

The terms "curated" and "expedient" are used throughout the Tree Frog study as well as the comparative studies mentioned above and therefore demand clarification. In brief, Binford (1979) describes technological organization on a continuum ranging from expedient to curated. A definition of the terms curated and expedient follow·

> Technologies based on curation comprise tools that are effective for a variety of tasks, are manufactured in anticipation of use, maintained through a number of uses, transported from locality to locality for these uses and recycled to other tasks when no longer useful for their primary purposes. Technologies based on expediency comprise tools that are manufactured, used, and discarded according

> to the needs of the moment. Curation should produce assemblages that are technologically sophisticated and probably formally distinct. Expediency should produce assemblages that are technologically simpler and formally less patterned because tool manufacture is an immediate response to the specific task at hand (Binford 1979; Bamforth 1986).

This basic definition is further refined by a general list of characteristics that may occur with each type of technology (Parry and Kelly 1986; Shott 1986; Odell 1994). A curated assemblage may consist of bifaces, discoidal cores, prismatic blade cores (a formal core technology) and formal, standardized tools such as scrapers (Parry and Kelly 1986). An expedient assemblage may include unretouched flakes or casual flake tools that lack a formal shape and no formal core technology is represented (Parry and Kelly 1986).

Because lithic material preserves well and is often abundant in the archaeological record, curated and expedient technologies are readily available for study Therefore, relationship between curated or expedient tool technologies and settlement mobility has been interpreted by archaeologists at many sites in North America (Parry and Kelly 1986; Shott 1986, Odell 1994, Johnson 1989). Parry and Kelly (1986:288) observed that "During the prehistoric period, there was a shift to lithic industries dominated by expedient core technology over most of the temperate-zone of North America." Paleoindian and Archaic lithic technologies are generally considered as curated because of intentionally shaped, formal tools made from standard core forms (Parry and Kelly 1986). The shift to an expedient technology consisting of unretouched flakes and unstandardized cores occurred in the Eastern Woodlands region shortly after A.D 500, on the Plains after A.D 300, and in the Southwestern United States around

A.D. 600 (Parry and Kelly 1986). Parry and Kelly (1986:297) noticed that the "most striking correlate of expedient core technology appears to have been a shift in settlement patterns" where "the shift to sedentism was correlated with a shift to an emphasis on expedient core technology throughout North America."

Within the distinct geographic areas in North America, as explained above, an expedient technology appears when a population becomes increasingly sedentary (Parry and Kelly 1986). Kelly (1988) explains that bifacial technology is conservative, flexible and reliable; primary requirements for a mobile settlement strategy in a non-source area. Because bifaces and other retouched tools are multifunction and multi-use, are generalized forms that can easily be altered, can be resharpened and reused, and are lightweight, portable tools, mobile populations find this curated technology a significant advantage to an expedient tool which might only be used once and subsequently discarded (Parry and Kelly 1986). Mobile groups may have preferred to use a curated technology because it, " requires a smaller weight of raw material to produce sufficient tools to meet anticipated needs" (Parry and Kelly 1986:298). Also, because predicting access to or availability of raw materials or specific tool needs may not be feasible for a mobile group, curated tools become a predictable resource (Parry and Kelly 1986).

As a population becomes increasingly sedentary, the need for a curated technology decreases (Shott 1986; Parry and Kelly 1986). As Parry and Kelly (1986:297) observed, "a significant decrease in the use of formal tools occurred at about the same time as the first occupation of large, nucleated, permanent 'villages' " The shift from curated to expedient technology appears not to have been heavily influenced by local conditions, such as availability of raw materials, topography, climate or vegetation, since the technological shift occurred throughout North America (Parry and Kelly 1986). The strongest correlating factor appears to have been a "logical consequent of decreased residential mobility" (Parry and Kelly 1986:297).

A curated technology, while beneficial to a mobile population, has drawbacks when used by a sedentary group. Formalized tools are costly to manufacture, maintain and use because a core or biface must be made of quality material that may have to be obtained from great distances (Parry and Kelly 1986). Also, a person may have to be trained to create formal tools or learn the manufacturing techniques (Parry and Kelly 1986). Once a tool is created and resharpened, the edge of the tool is not as sharp as an unretouched edge (Parry and Kelly 1986).

The technological disadvantages associated with a curated tool kit are one reason that sedentary communities shifted to an expedient technology A sedentary community may only need to "insure that some amount of usable stone be available at the locations where it is needed," and, "if raw material is abundant. then there is no need to manufacture portable lithic tools" (Parry and Kelly 1986:300). Expedient tools, unretouched flakes or causual flake tools, are sufficient (and predominantly superior because a simple edge often works better than a retouched edge) for a short-term task where function and raw material type are the factors that influence the size and shape of the tool (Parry and Kelly 1986).

In summary, settlement mobility, an organizational property existing on a continuum from highly mobile to sedentary, has been shown to effect the lithic technologies employed by groups of people (Binford 1977, 1979; Shott 1986; Parry and

Kelly 1986; Odell 1994). As a group shifts from a mobile to a sedentary way of life, their tool technology also shifts, "from a standard to an unstandard core reduction," that "may be viewed as a change from a curated to a more expedient technology (Parry and Kelly 1986).

Fall-Off: The Distribution and Frequency of Raw Materials

Settlement mobility, as presented above, is the strongest correlate between the change in lithic technologies through time, yet other factors do affect the production of stone tools. One such factor involves the distance that raw material is recovered from its original geologic source. While Parry and Kelly (1986) note that availability of raw materials and topography and climate do not affect the shift from curated to expedient technologies in a highly influential manner, Renfrew (1977) acknowledges that these factors do influence the distribution of raw material types across the landscape. The distribution of raw materials or, "the distance between the source of the raw material from which tools were fashioned and the location at which they were deposited to enter the archaeological record can be used as a measure of mobility" if other mechanisms of transport were ruled out (Shott 1986:37).

Renfrew (1977:72) sought to identify regularities in patterns in order to interpret the mechanisms of exchange with the hope of gaining "insight into the economic and social processes at work in the society in question." Renfew (1977) hypothesized that the patterns in the distribution of goods or lithic raw materials follow the Law of Monotonic Decrement when a commodity may be obtained at a highly localized origin or source. Therefore, raw material may be found most abundantly near its geologic source and as the distance from the source increases, a fall-off in abundance or decrease in the frequency of the raw materials occur (Renfrew 1977). Geographic barriers such as rivers, mountains, or deserts will also affect the fall-off pattern (Renfrew 1977). The shortest distance between two points is not as informative as the "effective" distance that is point-to point distance and consideration of geographic barriers within this distance (Renfrew 1977).

Shott (1986) explains that essentially, the farther that tools are transported from their geologic source to where the tools were deposited in the archaeological record, the more they have been moved during their period of use. Point-to-point distance and the effective distance may reflect the amount of energy expended in order to move the raw materials (Renfrew 1977). The mode of transportation employed by a population, such as marine travel, the use of camels in desert areas, or the introduction of horses also greatly influences the fall-off of a raw material type (Renfrew 1977). Renfrew (1977:73) hypothesized that if these fall-off distributions, "show basic, simple properties, the same must be true for the (cultural) processes generating them."

Examples of cultural processes that generate the fall-off distributions are the mechanisms of exchange or raw material procurement (Renfrew 1977). Because of these economic and social processes, the raw material procured "reached its destination as a result of a number of exchange interactions" and, therefore, "the artifact finds its way from the source to the place where it finally enters the archaeological record" (Renfrew 1977:77). The raw material or tool formed from it may change hands through exchange and thus continue to be transported farther from the parent source (Newman 1994).

During the period in which the tool is used, "expressed as transportability (the ratio of value to weight and breakage rate in transit) and effective life of the raw material or tool, the size and amount of remaining material decreases due to breakage rate in use, reuse-discard after breakage, loss-recovery rate, or deliberate burial" (Renfrew 1977:77). Newman (1994:495) said that "we predict that economical use of material attempted to keep waste from tool manufacture, refurbishing, and modification to a minimum," and therefore conservation of raw materials limits the amount and frequency of these materials in the archaeological record. Two examples of this economical use of raw materials include the Loomis II site in Central Connecticut where "average flake weight (a related measure to flake volume or size) appeared to be a direct reflection of the ease of lithic material procurement: the further the material source, the smaller the flake" (Newman 1994:496) and the Lookout Valley in northwestern Georgia "as access to chert resource areas decreases, the mean size of lithic flakes at the archaeological site tends to decrease as well" (Newman 1994:496.497).

In summary, the term "fall-off" can be described as the decrease in frequency and abundance in the distribution of a raw material or resource the farther that resource is transported from its source or origin. Many factors influence the rate at which the fall-off occurs, two of which are the effective distance from the source to where the artifact is deposited in the archaeological record and effective life of the material in use (loss, breakage, and re-use). Two additional factors that influence the fall-off of a resource, and are extremely important to this study, are resource availability and resource quality These factors are further discussed below

Resource Availability and Quality

As discussed above, Renfrew's (1977) Fall-Off argument focuses on the manner in which the distance to the source and the use of material as it gradually moves away from this source affects patterns observed in the archaeological record, yet resource availability and quality substantially effect the observed pattern as well. Raw material quality and availability are an integral portion of the fall-off pattern and therefore are important enough to warrant independent discussion.

Quality and availability of raw materials have been shown to affect the fall-off distribution when associated with specific kinds of exchange such as procurement of materials from a distance through down-the-line exchange or prestige-chain exchange (Renfrew 1977). Renfrew (1977·76) explains that "It is in fact intuitively fairly obvious that some communities will travel farther than others and this has been confirmed in quantitative studies by geographers, demonstrating the greater traveling power of high-value goods." The definition of a high-value material depends on what materials are needed by a community or are socially defined as prestigious. Factors that create a high-value material include, but are not limited to, " the regional resource base, the modes of procurement, social distance between knappers and consumers, labor investment, modes of transportation and social organization" (Ericson 1984 1). Also, "a man may have a sense of kinship with some of the localities, and he will value the stone material from them as part of his own being. Stone materials thus acquired are not sacred in any strict sense but are nevertheless valued highly enough to be transported over long distances by the owners" (Gould et al. 1971 160-163). One such example of long distance trade are the "neutron activation studies on Hopewell obsidian" that revealed parent sources "as far away as the Yellowstone Park area of the Rocky

Mountains, while flint came from the Knife River area and North Dakota" (Fagan 1991-414).

While excellent quality goods are transported great distances, poor quality material tends to remain closer to its origin. Renfrew (1977) explains that common bulky goods are supplied only in a limited area, giving the extremely localized assemblage of Roman roofing tiles near Cirences as an example. The Mud Lake/Huckleberry Ridge obsidian, found at the Tree Frog site, is also an example of a poor quality resource that is not found at great distances from the geologic source. The Mud Lake/Huckleberry Ridge obsidian is absent from sites where obsidian source studies have been conducted in the state of Montana, Idaho, or Wyoming even if the site in question is in relative close proximity to the Tree Frog site (Baumler 1997; Holmer 1997; Kunselman 1997; Thompson and Pastor 1997; Connor 1997).

Renfrew (1977) reasons why some resources are transported over great distances while other resources are not. First, the most local area of a resource is called a "supply zone" reached "from a single journey traveling directly to the purchaser The result is extreme localization in the distribution of the product. There is a radius beyond which the specific product is very rarely found and thus is usually the length of a single journey" (Renfrew 1977:84). The regression line (fall-off) of the resource is steep in the supply zone (Renfrew 1977).

The second term used by Renfrew (1977:85) to describe resource transport is the "contact zone" where the "commodities are worth exchanging beyond the limits of the supply zone (down-the-line exchange). These (resources) are either more desirable, or easier to transport, or both."

In summary, resource availability and quality are factors that may affect the fall-off in distribution of raw materials or goods across the landscape (Renfrew 1977; Fagan 1991). If the material or object is of high quality or is targeted as socially desirable, it is likely that this material will be transported farther from its source (supply zone) than a poor quality material through down-the-line-exchange (contact zone) (Renfrew 1977; Ericson 1984, Gould et al 1971).

With the above description of the supply zone and the contact zone, previous discussions of settlement mobility, the fall-off distribution of raw materials, and quality and availability of raw material may now be seen as complex partners in the procurement, use, and conservation of lithic material that have created the archaeological record. Humans have created observable patterns and these patterns aid in the interpretation of the mechanisms of exchange and therefore grant insight into the economic and social processes at work (Renfrew 1977).

In this study, I will incorporate the previous discussions to interpret the social processes that resulted in the lithic assemblage recovered from Tree Frog. The basis for this study is a mass flake analysis of the lithic assemblage recovered during the 1997 and 1998 field season's excavations further discussed in Chapter III.

Field Procedure

The excavation of two areas within Tree Frog occurred in July and August of 1997 and 1998. Both the Northern and Southern areas were given separate feature numbers. Within each area, locations selected for excavation were given a feature number as well. Each feature (otherwise described as a unit) designated for excavation measured 2 x 2 meters square and corners were established in relation to the site datum by a transit. Excavation proceeded in 20 cm arbitrary levels because natural stratigraphy was not evident. Excavation did not follow the natural contour of the slope therefore, depth was measured from the corner of the 2 x 2 meter feature that was highest in elevation. Subsequent 20 cm levels were excavated until sterile sediment (no greater than 60 cm below datum, averaging 40 cm below datum) or the underlying talus was encountered. Each of the 20 cm levels received a feature number If a concentration of cultural material was recovered from a portion of the unit, the unit may have been subdivided into quadrants or the artifacts were point-plotted in situ, yet the feature number remained the same as the rest of the feature/level. For clarity, one 2 x 2 meter excavation area would be documented as the following:

Feature 19· 1998 Northern Excavation Area as a whole—nine (9) 2 x 2 meter units oriented in a large square, 3 units wide, 3 units deep
Feature 20: one 2 x 2 meter excavation area within Feature 19
Feature 21 0-20 cm below datum within Feature 20
Feature 22: 20-40 cm below datum within Feature 20

The 1998 excavation of Tree Frog was conducted under the same design as the 1997 excavation. Five (5) additional 2 x 2 meter units/features were excavated in the previous season's designated Southern Area while six (6) additional 2 x 2 meter units/features were excavated in the Northern Area (see figure 3). The features within the Northern and South Areas were laid out on a grid and excavated to emphasize the horizontal dimension of the site—shallow and broad (Renfrew and Bahn 1996).

Laboratory Procedure

In addition to the radiocarbon and obsidian hydration dating conducted (see Chapter I), representative samples of obsidian flakes and tools from the site, along with 20 unmodified obsidian cobbles from local alluvium were analyzed at the Geochemical

Research Laboratory in Sonoma, California (Hughes 1998). Hughes (1998) performed x-ray fluorescence (XRF) analysis on above stated samples, establishing at least 7 sources of obsidian: (1) Bear Gulch, Idaho; (2) Timber Butte, Idaho; (3) Obsidian Cliff, Wyoming; (4) Malad, Idaho; (5) Big Southern Butte, Idaho; (6) Mud Lake/Huckleberry Ridge, Montana; and (7) Unknown (see Appendix B and figure 4). Hughes (1998) established that all cobbles recovered from the local alluvium are Huckleberry Ridge/Mud Lake in type (see Appendix B).

Actual source location for non-obsidian lithic materials has not been chemically established. Non-obsidian lithic raw materials recovered from Tree Frog are considered to be non-local for this study because their place of origin is not within the Tree Frog site boundary The following mass flake analysis focuses on all of the lithic debris and stone tools recovered from the two seasons of excavation at Tree Frog.

Mass Flake Analysis

The mass analysis of lithic debris recovered during the 1997-1998 Tree Frog Site excavation resembles the mass flake analysis proposed by Ahler (1989a), and was conducted as follows. After separating the lithic debris from all other artifacts (faunal remains, pottery, charcoal, etc.), laboratory assistants further divided the debris according to raw material types. The raw material types recovered included. local obsidian, non-local obsidian (as determined by XRF and further explained below), basalt, rhyolite, quartzite, and sedimentary silicates (Connor and Kunselman 1997). The above material types were then placed in three categories: (1) local obsidian, (2) non-local obsidian, (3) and all other material types. Because of the results of Hughes' (1998)

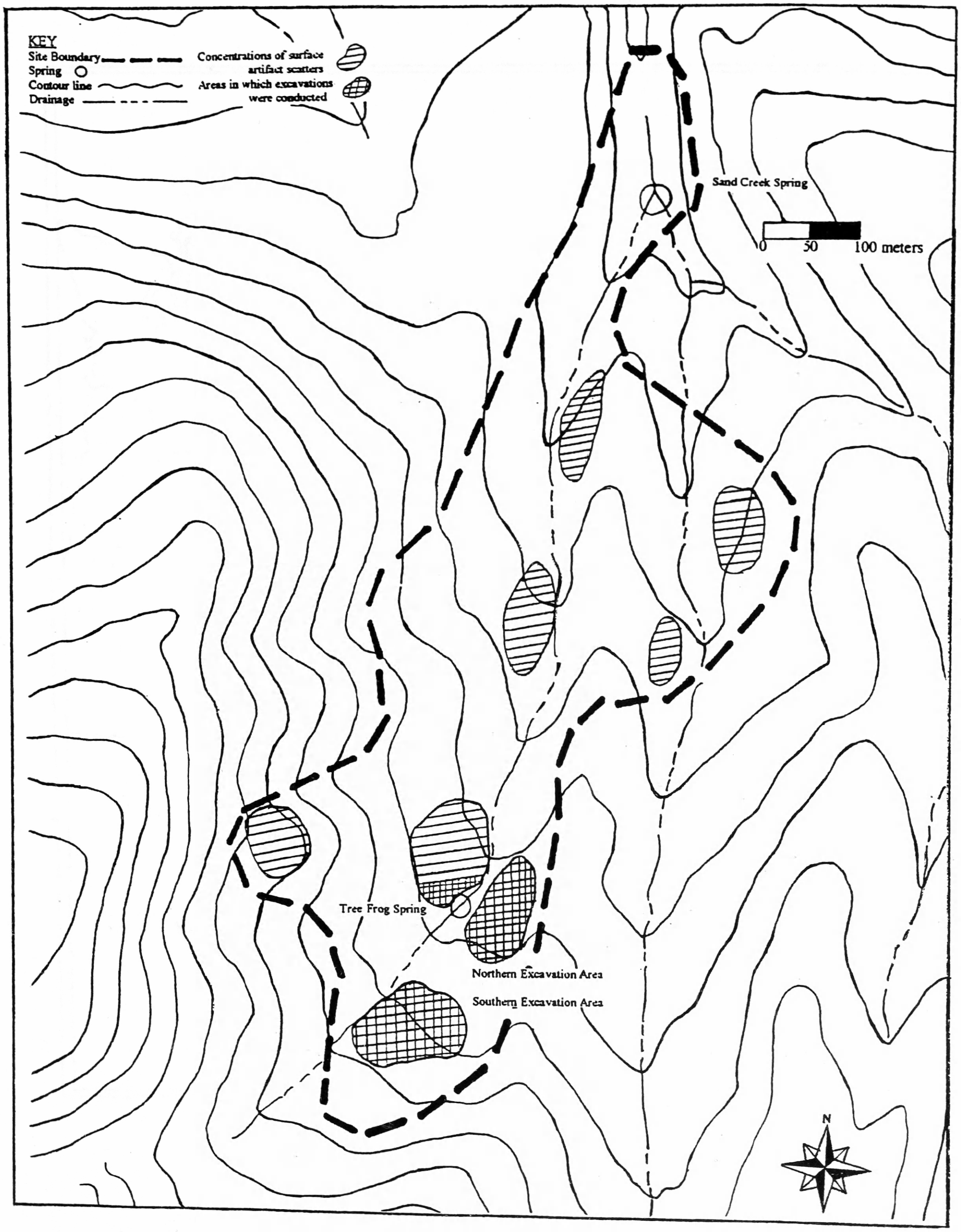


Figure 3: Sketch map of the Tree Frog Site 24BE1639 (Map from Sant 1992: 8).

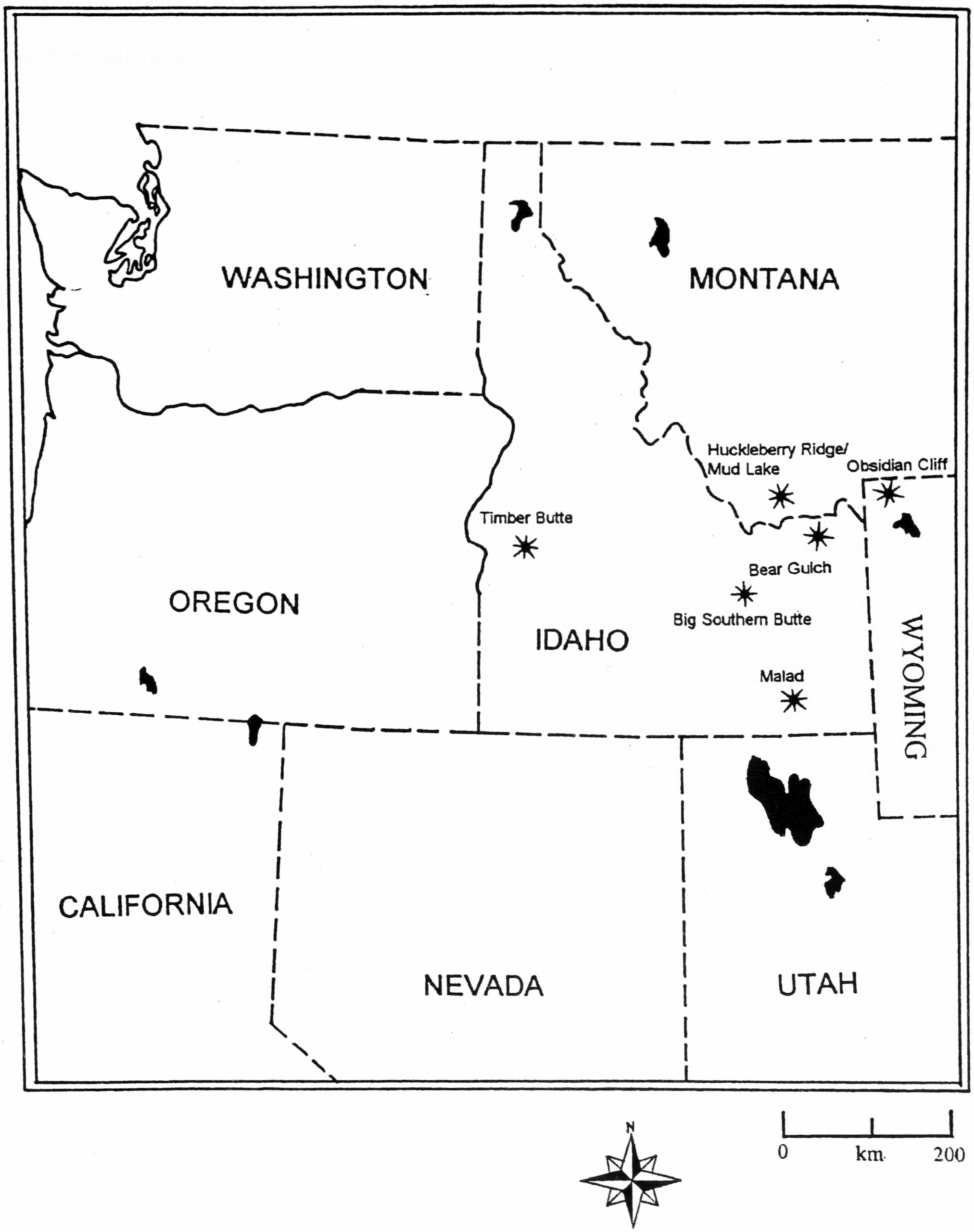


Figure 4: Map showing the source locations of obsidian tools and flakes recovered from Tree Frog (Map adapted from Sappington 1984:24, 28, 30).

analysis, distinction between Mud Lake/Huckleberry Ridge obsidian (local) and exotic obsidian (all obsidian recovered from Tree Frog excluding ML/HR obsidian) in this analysis is made by visual inspection. The presence of large occlusions (phenocrysts) of feldspar and quartz obviously distinguish the HR/ML obsidian from the exotic obsidians. Occlusions of this type are absent from the other chemically distinct obsidians.

All separated lithic debris remained in bags labeled with the feature and field specimen numbers, therefore, retaining provincial information. Each raw material type was then passed through a series of nested, geologic screens and placed in bags according to the size-grade of each screen (Ahler 1989a, 1989b). The size-grades correspond to the following screen mesh sizes used for this analysis: (1) G-1, 1"; (2) G-2, 1/2"; (3) G-3, 1/4"; (4) G-4, 1/8"; (5) G-5, 1/16"

The next step of the mass flake analysis consisted of counting the number of flakes of each material type with the following attributes (Foor 1997):

(1) cortex present, striking platform and bulb of percussion present;
(2) cortex present, striking platform and bulb of percussion absent;
(3) cortex absent, striking platform and bulb of percussion present;
(4) cortex absent, striking platform and bulb of percussion absent.

Visual inspection—with a hand lens or unaided—confirmed the presence or absence of the above attributes. A flake placed in the "cortex present" category needed to display some amount of cortex. Cortex may be defined as the natural outer portion or "rind" of a cobble or raw material that is removed, usually in the initial stages of tool production (Crabtree 1972). All flakes with cortex are considered decortication flakes, therefore, the terms *primary* and *secondary* used to describe the degree to which a flake is covered with cortex does not apply to this study (White et al 1963). During analysis, the occlusions present in the HR/ML flakes, especially smaller flakes, resembled cortex. These flakes were further examined with a hand lens to distinguish between cortex and occlusions and subsequently placed in the correct category.

The presence of a striking platform and a bulb of percussion comprised the second category. A striking platform is described as a surface of cleavage used to remove a longitudinal flake (White et al 1963). A bulb of percussion on a flake is defined as, "a distinguishable swelling. immediately below the point of impact, presumably due to compression of the material at the moment of striking" (Hodges 1989:100). Whole or broken, flakes placed in this category must possess both a striking platform and a bulb of percussion.

The above categories were chosen because the presence or absence of these attributes reflect techniques used while flaking or preparing raw materials for use: "the size and shape of a tool is related to the size and shape of the raw flake from which it is made" and, therefore, flakes "furnish valuable information about chipping and retouching techniques" (White et al 1963 4). Flaking debris is a "byproduct of past tool manufacture and maintenance activities," that "provides a seemingly direct link to discrete episodes of prior human behavior" (Ahler 1989a:85-86).

Larger flakes with cortex are usually associated with the initial stages of tool production or the removal of natural irregularity from a nodule (White et al 1963) or primary bifacial reduction (Ahler 1989a, 1989b). Smaller flakes without cortex tend to be associated with tool maintenance, such as resharpening a biface (Ahler 1989a, 1989b).

Referring back to Renfrew's (1977) fall-off model, larger amounts of a raw material would be expected to be deposited closer to a source area, while smaller amounts of a raw material are expected to be deposited at a distance from its place of origin. These expectations, along with the amount of cortex present and flake size, suggest that initial reduction of a raw material occurs close to the source area while tool maintenance occurs at a distance from the source of the material if the population is a mobile one.

Ideas about settlement mobility (Chapter 2) spark expectations during examination of tools—expedient or curated tool technologies corresponding to sedentary and mobile communities respectively (Parry and Kelly 1986; Kelly 1988; Shott 1986; Odell 1984). Because the environment in the Centennial Valley and the seasonal availability of most resources at Tree Frog and the lack of evidence suggesting long term housing structures and related features, I inferred that the group of people that occupied this site were mobile.

Because the analysis of flaking debris provides the above information, I should expect to find a predictable pattern reflecting the inferred cultural activities relative to the distance of the lithic material's source. At Tree Frog, I expect to find the following when analyzing the local HR/ML, poor quality obsidian:

1 A. A high proportion of large flakes with cortex.
  B. A high ratio of large flakes to small flakes.
2. No identifiable prepared core technologies.
3 The material is most often used for tools of expediency
4 A high ratio of large flakes to finished tools.

A predictable pattern should also occur with the analysis of high quality materials having sources distant from the site. Material types include non-local obsidians and all silicates:

1. A. A relatively low proportion of large flakes with cortex.
   B. A relatively low ratio of large flakes to small flakes.
2. A prepared core technology
3. Quality material used more often for finished tools.
4. A low ratio of large flakes to finished tools.

In addition to visual inspection of the flakes recovered at Tree Frog, I weighed the flakes in each category listed above for all material types (Ahler 1989a, 1989b; Foor 1997). Weight is not used for the interpretation of the mass flake analysis in this study, but is included for future reference.

While similar studies to that proposed above have been conducted, new information added to the existing literature would greatly increase current understanding of the movement and role of raw materials, particularly obsidian, in this geographic area (Baumler 1997). Further, since datable remains at the south and north ends of the site securely place the settlement during a restricted time in the Protohistoric period, can I use these conclusions to investigate the effects of contact with Europeans on this later assemblage recovered from Tree Frog.

Chapter III—Results of Analyses

Chi-Squared Test for Independence—Flake Size and Material Type

My first hypothesis involves whether the proportion of large to small flakes was independent of the material type (Foor 1997). Tables 1. and 2. present the results of cross classifying all flakes from the site by size and material type determined by the previously described mass flake analysis (Chapter II). Chi-squared for this table is 45.01 which exceeds the critical value of 5.99 for a .05 level of significance and 2 degrees of freedom. Inspection of the tables shows that there are many more large flakes of local obsidian than would be expected if the two variables were independent. Also, there are fewer large flakes of non-local obsidian and non-obsidian materials than would be expected if size and material type were independent.

This hypothesis is further supported by breaking the flake collection into those recovered from the northern portion of the site and those found from the southern portion of the site. Tables 3. and 4 present the flake counts from the northern end of the site, which is about 300 meters closer to the local alluvial source of obsidians than the southern half. Chi-squared for these data is 20.6 with two degrees of freedom. This result is also significant at the .05 level. Inspection of this table suggests that there are more large flakes and fewer small flakes of local obsidians than expected, and fewer large flakes and more small flakes of non-local obsidians than expected if material type was independent of size. Flakes made of non-obsidian stone were distributed about as expected if material type was independent of size.

Finally, flake counts from the southern portion of the site are presented in Tables 5 and 6. The chi-squared result for these figures is 31.03 with two degrees of freedom for a

05 level of significance. Inspection of this table again suggests that there are more large flakes of local obsidian and fewer large flakes of non-local obsidian than are expected if size and material type were independent. Interestingly, there are more large flakes of non-obsidian than would be expected under the hypothesis of independence. Additionally, there are fewer local obsidian and non-obsidian small flakes and more non-local obsidian small flakes than would be expected if material type was independent of size.

Chi-Squared Test for Independence—Presence or Absence of Cortex, Flake Size, and Material Type

My second hypothesis involves determining whether or not the presence or absence of cortex is independent of material type (Foor 1997). The flakes for this test are divided into two sizes that are represented in separate tables: (1) large—size grades 1 and 2 combined; and (2) small—size grades 3,4, and 5 combined.

Total Site Flake Count

Both the large and small flake categories, for the site as a whole, exceed the critical value of 5.9 for a 05 level of significance with 2 degrees of freedom with chi-squared results of 14 13 and 65 49 respectively These results suggest, for the large flake category, that there are fewer local obsidian flakes with cortex than expected and more local obsidian flakes without cortex than expected if the presence of cortex was independent of material type. Also in the large flake category, more non-local obsidian and non-obsidian flakes with cortex are present than expected, while flakes of the same material types lacking cortex are fewer than expected (see Tables 1 and 2).

LO- 2054
NLO- 2375
NO- 690

Tree Frog Flake Variability	Total Site Count	
	Large Flakes	Small Flakes
Local Obsidian	451	1603
Non-Local Obsidian	343	2032
Non-Obsidian	144	546

2054
2375
690
5119

938
4181

Tree Frog Flake Variability	Large Flakes	
	Cortex Present	No Cortex Present
Local Obsidian	215	262
Non-Local Obsidian	108	221
Non-Obsidian	49	95

5943

Tree Frog Flake Variability	Large Flakes	
	SP/BP Present	No SP/BP Present
Local Obsidian	172	276
Non-Local Obsidian	168	172
Non-Obsidian	48	90

926

Tree Frog Flake Variability	Small Flakes	
	Cortex Present	No Cortex Present
Local Obsidian	343	1853
Non-Local Obsidian	176	2075
Non-Obsidian	68	478

LO = 2673
NLO = 2580
NO = 690

Tree Frog Flake Variability	Small Flakes	
	SP/BP Present	No SP/BP Present
Local Obsidian	372	1296
Non-Local Obsidian	612	1639
Non-Obsidian	174	370

4463
5389

Table 1· Total flake count from the Tree Frog Site mass flake analysis.

TOOLS
unspecified
greater than 47

LO - 2116
NLO 2591
NO - 682

Chi-Squared Test For Independence

	Tree Frog Flake Variability		Total Site Count	
	Large Flakes	# Expected	Small Flakes	# Expected
Local Obsidian	451	376.4	1603	1677.6
Non-Local Obsidian	343	435.2	2032	1939.8
Non-Obsidian	144	126.4	546	563.6

X = 45.01

	Tree Frog Flake Variability		Large Flakes	
	Cortex Present	# Expected	Cortex Absent	# Expected
Local Obsidian	215	186.8	262	290.2
Non-Local Obsidian	108	128.8	221	200.2
Non-Obsidian	49	56.4	95	87.6

X = 14.13

	Tree Frog Flake Variability		Large Flakes	
	SP/BP Present	# Expected	SP/BP Absent	# Expected
Local Obsidian	172	187.7	276	260.3
Non-Local Obsidian	168	142.5	172	197.5
Non-Obsidian	48	57.8	90	80.1

X = 13.01

	Tree Frog Flake Variability		Small Flakes	
	Cortex Present	# Expected	Cortex Absent	# Expected
Local Obsidian	343	285.2	1853	1937.8
Non-Local Obsidian	176	264.6	2075	1986.4
Non-Obsidian	68	64.2	478	481.8

X = 65.49

	Tree Frog Flake Variability		Small Flakes	
	SP/BP Present	# Expected	SP/BP Absent	# Expected
Local Obsidian	372	432.8	1296	1235.21
Non-Local Obsidian	612	584.1	1639	1666.94
Non-Obsidian	174	141.2	370	402.85

X = 23.66

Table 2. Chi-squared results from the total site mass flake analysis (see Table 1).

The results of cross classifying all small flakes from the site by material type and presence or absence of cortex yielded interesting results as well. Non-obsidian flakes were distributed about as expected if material type was independent of presence or absence of cortex. However, the number of non-local obsidian flakes with cortex exceeds expectations and the amount of flakes of this material without cortex is lower than expected. The amount of flakes representing local obsidian displays the opposite of the non-local obsidian flakes listed above—less with cortex and more without cortex than expected (see Tables 1 and 2).

Northern Area Flake Count

Both the large and small flake categories for the northern excavation area exceed the critical value of 5.9 for a .05 level of significance with 2 degrees of freedom. The chi-squared results were 28.8 and 38.12 respectively These results suggest for the large flake category that there are less local obsidian flakes with cortex than expected, and more local obsidian without cortex than expected. The opposite is true for non-local obsidian and non-obsidian—more large flakes with cortex are present and less without cortex are present than expected if material type was independent of presence or absence of cortex (see Tables 3 and 4).

The small flake category in the northern excavation area mirrored the results of the large flake category—fewer local obsidian flakes with cortex than expected, and more local obsidian without cortex than expected. Also, more small flakes of non-local obsidian and non-obsidian with cortex are present than expected and less flakes without out cortex were present than expected if the material type was independent of presence or absence of cortex (see Tables 3 and 4).

	Tree Frog Flake Variability: North Area Total	
	Large Flakes	Small Flakes
Local Obsidian	381	1246
Non-Local Obsidian	261	1279
Non-Obsidian	87	355

	Tree Frog Flake Variability	Large Flakes
	Cortex Present	No Cortex Present
Local Obsidian	187	194
Non-Local Obsidian	84	177
Non-Obsidian	21	66

	Tree Frog Flake Variability	Large Flakes
	SP/BP Present	No SP/BP Present
Local Obsidian	140	214
Non-Local Obsidian	129	131
Non-Obsidian	32	47

	Tree Frog Flake Variability	Small Flakes
	Cortex Present	No Cortex Present
Local Obsidian	304	1518
Non-Local Obsidian	142	1356
Non-Obsidian	41	314

	Tree Frog Flake Variability	Small Flakes
	SP/BP Present	No SP/BP Present
Local Obsidian	296	1007
Non-Local Obsidian	461	1037
Non-Obsidian	113	242

Table 3 Total flake count for the northern area at Tree Frog.

Chi-Squared Test For Independence: Northern Excavation Area

	Tree Frog Flake Variability		Northern Area Count	
	Large Flakes	# Expected	Small Flakes	# Expected
Local Obsidian	381	328.6	1246	1298.4
Non-Local Obsidian	261	311.1	1279	1228.9
Non-Obsidian	87	89.3	355	352.7

X = 20.6

	Tree Frog Flake Variability		Large Flakes	
	Cortex Present	# Expected	Cortex Absent	# Expected
Local Obsidian	187	152.6	194	228.4
Non-Local Obsidian	84	104.5	177	156.5
Non-Obsidian	21	34.8	66	54.2

X = 28.8

	Tree Frog Flake Variability		Large Flakes	
	SP/BP Present	# Expected	SP/BP Absent	# Expected
Local Obsidian	140	153.8	214	200.2
Non-Local Obsidian	129	112.9	131	147.1
Non-Obsidian	32	34.3	47	44.7

X = 6.50

	Tree Frog Flake Variability		Small Flakes	
	Cortex Present	# Expected	Cortex Absent	# Expected
Local Obsidian	304	241.5	1518	1580.5
Non-Local Obsidian	142	198.5	1356	1299.5
Non-Obsidian	41	47	314	308

X = 3812

	Tree Frog Flake Variability		Small Flakes	
	SP/BP Present	# Expected	SP/BP Absent	# Expected
Local Obsidian	296	359.19	1007	943.8
Non-Local Obsidian	461	413	1037	1085
Non-Obsidian	113	97.8	242	257.2

X = 26

Table 4 Chi-squared results from the northern area mass flake analysis (see Table 3).

As with the previous chi-squared results, the large and small flake categories for the southern excavation area, exceed the critical value of 5.9 for a .05 level of significance with 2 degrees of freedom with chi-squared results of 6.202 and 26.12 respectively Upon inspection, the large flake category suggested that fewer non-obsidian flakes with cortex are present and more large non-obsidian flakes without cortex are present. Local obsidian in the large flake category demonstrated that more flakes with cortex are present than expected and less without cortex are present if the material type and presence or absence of cortex were independent. The number of non-local obsidian flakes is distributed as expected (see Tables 5 and 6).

The small flakes observed in the southern area are also significant at the .05 level. Fewer small, local obsidian flakes with cortex are represented than expected while more local obsidian flakes without cortex are present. These Tables also suggest that a greater number of non-local obsidian and non-obsidian flakes with cortex are present and fewer flakes of the two materials without cortex are present than expected if the presence or absence of cortex is independent of material type (see Tables 5 and 6).

Chi-Squared Test for Independence—Presence or Absence of a Striking Platform and Bulb of Percussion, Flake Size, and Material Type

My third hypothesis involves whether the presence or absence striking platforms and bulbs of percussion are independent of material type (Foor 1997). The flakes for this test are also divided into two sizes that are represented in separate tables: (1) large—size grades 1 and 2 combined; and (2) small—size grades 3,4, and 5 combined.

	Tree Frog Flake Variability: South Area Total	
	Large Flakes	Small Flakes
Local Obsidian	70	357
Non-Local Obsidian	82	753
Non-Obsidian	57	191

	Tree Frog Flake Variability	Large Flakes
	Cortex Present	No Cortex Present
Local Obsidian	28	68
Non-Local Obsidian	24	44
Non-Obsidian	28	29

	Tree Frog Flake Variability	Large Flakes
	SP/BP Present	No SP/BP Present
Local Obsidian	32	62
Non-Local Obsidian	39	41
Non-Obsidian	16	43

	Tree Frog Flake Variability	Small Flakes
	Cortex Present	No Cortex Present
Local Obsidian	39	335
Non-Local Obsidian	34	119
Non-Obsidian	27	164

	Tree Frog Flake Variability	Small Flakes
	SP/BP Present	No SP/BP Present
Local Obsidian	76	281
Non-Local Obsidian	151	602
Non-Obsidian	61	128

Table 5. Total flake count for the southern area at Tree Frog.

Chi-Squared Test For Independence: Southern Excavation Area

	Tree Frog Flake Variability		South Area Total	
	Large Flakes	# Expected	Small Flakes	# Expected
Local Obsidian	70	59.1	357	367.9
Non-Local Obsidian	82	115.6	753	719.4
Non-Obsidian	57	34.3	191	213.7

X = 31.03

	Tree Frog Flake Variability		Large Flakes	
	SP/BP Present	# Expected	SP/BP Absent	# Expected
Local Obsidian	32	35.1	62	58.9
Non-Local Obsidian	39	29.9	41	50.1
Non-Obsidian	16	22	43	37

X = 7.522

	Tree Frog Flake Variability		Small Flakes	
	SP/BP Present	# Expected	SP/BP Absent	# Expected
Local Obsidian	76	80.4	289	284.6
Non-Local Obsidian	151	165.9	602	587.1
Non-Obsidian	61	41.65	128	147.35

X = 13.57

	Tree Frog Flake Variability		Large Flakes	
	Cortex Present	# Expected	Cortex Absent	# Expected
Local Obsidian	28	34.8	68	61.25
Non-Local Obsidian	24	24.6	44	43.4
Non-Obsidian	28	20.6	29	36.4

X = 6.202

	Tree Frog Flake Variability		Small Flakes	
	Cortex Present	# Expected	Cortex Absent	# Expected
Local Obsidian	39	28.4	335	345.6
Non-Local Obsidian	34	57.13	119	95.9
Non-Obsidian	27	14.5	164	176.5

X = 26.12

Table 6. Chi-squared results from the southern area mass flake analysis (see Table 5).

Total Site Flake Count

Both the large and small flake categories, for the site as a whole, exceed the critical value of 5.9 for a .05 level of significance with 2 degrees of freedom with chi-squared results of 13.01 and 23.66 respectively These results suggest for the large flake category that the number of local obsidian and non-obsidian flakes with a striking platform and a bulb of percussion are greater than expected. Large flakes of the same material types lacking these characteristics are less than expected. The results also suggest that the number of large, non-local obsidian flakes displaying formal characteristics is less than expected while the number of non-local obsidian flakes without a striking platform and a bulb of percussion is greater than expected if material type and these formal, flake characteristics are independent (see Tables 1 and 2).

The chi-squared results demonstrate that the number of small, local obsidian flakes with formal characteristics is greater than expected and the number without a striking platform and a bulb of percussion is less than expected. The number of non-local obsidian and non-obsidian flakes with formal characteristics observed is less than expected while these same material types presented more flakes without formal characteristics than expected if the presence or absence of a striking platform and bulb of percussion were independent (see Tables 1 and 2).

Northern Area Flake Count

The chi-squared results for both the large and small flake categories in the northern area followed the above trend, exceeding the critical value of 5.9 for a .05 level of significance with 2 degrees of freedom with chi-squared results of 6.50 and 26.0 respectively The large flake category results show that the observed number of local obsidian flakes with a striking platform and a bulb of percussion are greater than expected. Results also suggested that the observed number of large flakes of the same material without formal characteristics was smaller number than expected. In contrast, the observed number of large, non-local obsidian flakes with formal characteristic is less than expected while the number of non-local obsidian flakes without a striking platform and bulb of percussion is greater than expected if material type and presence or absence of formal characteristics is independent. The number of non-obsidian flakes with or without formal characteristics is distributed about as expected (see Tables 3 and 4).

Small flakes demonstrating formal characteristics recovered from the northern area are distributed in a different manner than the large flakes. Once again, the number of local obsidian flakes with formal characteristics is greater than expected while the number of flakes without is less. Both the number of non-local and non-obsidian flakes with formal characteristics are less than expected and flakes of the same material without a striking platform and a bulb of percussion are more than expected (see Tables 3 and 4).

Southern Area Flake Count

The results of the chi-squared tests for large and small flakes, with or without formal flake characteristics in the southern area, also exceeded the critical value of 5.9 for a 05 level of significance with 2 degrees of freedom. The results are 7.522 and 13.57 respectively The large non-local obsidian flakes with formal characteristics recovered from the southern area are less than expected and consequently, the number of flakes of this material type and size without formal characteristics is greater than expected. The distribution of local obsidian and non-obsidian flakes, however, suggest that more flakes with formal characteristics exist, while less flakes without formal characteristics are present if material type and a striking platform and a bulb of percussion are independent.

The results of the chi-squared test suggest that small flakes in the southern area are distributed differently than the large flakes. Non-local and local obsidian flakes with a bulb of percussion and striking platform were observed in a greater number than expected, while flakes of the same material without these characteristics are less than expected. Interestingly, the observed number of non-obsidian flakes with formal characteristics is less than expected under a hypothesis of independence. Small non-obsidian flakes lacking formal characteristics exceeded expectations if the presence or absence of a striking platform and a bulb of percussion are independent of material type.

Basing interpretation on the above chi-squared results, I can begin to recognize patterns in the inferred uses and distribution of lithic raw materials. As briefly described in Chapter II, flakes, "furnish valuable information about chipping and retouching techniques" (White et al 1963 4). Flake size, amount of cortex present, formal flake characteristics, and general amount or abundance of a raw material recovered at a site reflect stages of tool production, maintenance and manufacture techniques, and possible distance from a material's source (Ahler 1989a and 1989b; White et al 1963, Refrew 1977). These patterns may then be compared to settlement mobility, fall-off in the distribution and frequency of the materials, and resource quality and availability, all of which aid in the interpretation of the social processes that resulted in the lithic assemblage at Tree Frog (Parry and Kelly 1986; Kelly 1988; Shott

1986; Odell 1984). The implications and conclusions of the above stated chi-squared results are discussed further in Chapter IV

Chapter IV—Implications and Conclusions

By analyzing the raw materials recovered from Tree Frog in the manner described in Chapter II, I expected to find patterns similar to those outlined by Renfrew (1977), Foor (1997), and Odell (1996). For clarity, these expectations are listed again below

After analysis, of the poor quality, local obsidian that is very close to the site, or actually found as cobbles at the site such as the local ML/HR material, I should expect to find the following:

1. A. A high proportion of large flakes with cortex.
   B. A high ratio of large flakes to small flakes.
2. No identifiable prepared core technologies.
3. The material is most often used for tools of expediency
4. A high ratio of large flakes to finished tools.

A predictable pattern should also occur with the analysis of high quality materials that are sourced at a distance from the site. Material types include non-local obsidians and all silicates:

1 A. A relatively low proportion of large flakes with cortex.
  B. A relatively low ratio of large flakes to small flakes.
2. A prepared core technology
3 Quality material used more often for finished tools.
4 A low ratio of large flakes to finished tools.

First, in reference to these initial expectations, the following expectations were confirmed by lithic tools and mass flake analyses: (1) there were no identifiable local obsidian prepared core technologies present; (2) the local material was most often used for tools of expediency; and (3) a high ratio of local obsidian large flakes to finished tools is present in the Tree Frog assemblage. Additional results, however, range from slight differences to major deviations of the above remaining assumptions. These are discussed below in relation to settlement mobility, raw material fall-off, and raw material quality and availability First, the patterns observed in the variation in lithic technology at Tree Frog do not wholly correspond to Renfrew's (1977) Fall-off Model where the frequency of lithic materials decreases the further they are transported from their source or origin. Second, as determined previously, the groups living in this area during the Protohistoric were most likely mobile people and therefore, their technology is typically thought to be of a curated nature (Binford 1979; Parry and Kelly 1986; Kelly 1988; Shott 1986; Odell 1994). Results from the mass flake analysis and evaluation of lithic tools recovered from Tree Frog suggest that the lithic technology utilized was not completely a curated one. Finally, expectations for the use of and frequency in occurrence of high quality materials do not correspond directly to the results of the mass flake analysis either.

While the following explanations are discussed as individual sections, keep in mind that these categories are linked and it is difficult to differentiate where one factor in the social organization and behavior of the group that created the assemblage at Tree Frog ceases to effect the other The results from the Tree Frog stone tool and mass flake analyses present interesting deviations from the expected outcome and, therefore, an interpretation follows.

Interpretation of the Settlement Mobility Pattern at Tree Frog

As outlined in Chapter II, the dynamics of or the organizational properties of prehistoric societies existed on a continuum of subsistence patterns from highly mobile to sedentary (Binford 1977) with varying lithic technology accompanying these settlement patterns (Binford 1979; Parry and Kelly 1986, Kelly 1988, Shott 1986; Odell

1994). Because of cultural group dynamics of this periphery area, limited seasonal access to and the presence of at least one horse at Tree Frog, I infer that the group using this site was a mobile one, hence more likely to have a highly curated technology However, Bamforth (1986) stresses that the notion of expedient and curated use of materials is a complicated one, where a variety of factors influence a technological strategy Therefore, while flake size and the presence or absence of formal flake characteristics or cortex are relevant to the discussion of curated or expedient technologies, formal characteristics are also described in this study's discussion of raw material fall-off or material availability and quality in an attempt to simplify this complicated relationship. The remainder of this portion of discussion relates to the identified curated and expedient lithic tools recovered from Tree Frog including minimal discussion of the mass flake analysis results.

The archaeological assemblage recovered from Tree Frog during the 1997 and 1998 excavations included only a limited number of formal lithic tools (see Appendix D). Formal lithic tools included 17 projectile points or point fragments, 2 perforators or drills, and approximately 28 other bifacial and unifacial tools or fragments that may have been used as tools themselves or as prepared cores (See Appendix D). The remaining lithic tools consisted of utilized flakes, retouched or unmodified, made from local obsidian, non-local obsidian, and non-obsidian raw materials.

As Binford (1979) described, a mobile group using a curated technology would be indicated in the archaeological record by site assemblages consisting of technologically sophisticated and formally distinct tools that (1) are manufactured for anticipated use; (2) are effective for a variety of tasks; (3) are transported from locality to locality; (4) and are recycled to other tasks when no longer useful for their primary purposes. While the group at Tree Frog was most likely a mobile one, formal tools described by Binford (1979) did not occur in a number significant in relation for the size of the site and overall assemblage size. However, most lithic tools recovered from Tree Frog are flake tools falling under Binford's (1979) definition of expedient tools—technologically simpler and formally less patterned because tool manufacture is an immediate response to the specific task at hand.

So, while a small amount of curated lithic tools were recovered from Tree Frog, the remaining assemblage is most accurately described as an expedient one. If the group that utilized Tree Frog was a mobile one, then why does this technological pattern differ from other studies conducted regarding the relationship between settlement mobility and tool technologies (Parry and Kelly 1986; Kelly 1988; Shott 1986; Odell 1994; Johnson 1989)? Two factors may account for this discrepancy: (1) the presence of European trade items; and (2) the procurement of raw materials with the aid of a horse.

The Presence of European Trade Items

As previously established, Tree Frog is a Protohistoric occupation where European trade items were in associated with lithic artifacts and pottery. The three pieces of wrought iron recovered from Tree Frog are of specific interest because these small fragments may have, at some point, been cutting or scraping tools. The small number of trade items may seem insignificant compared to the amount of lithic material recovered, yet this may not be a correct assumption. Ahler (1989:71) states that "We can conclude that the metal artifacts we actually find in the archaeological sites probably under-represent the actual importance of early trade items in the native technological systems. The largest of the metal items, such as axes and adzes, were probably few in number but highly valued and heavily used, recycled, and re-traded, and, therefore, are not found in the archaeological record." The metal items found in the archaeological record were most likely curated and recycled until their value was exhausted and therefore were finally discarded as scrap metal and not as a whole tool (Toom 1979). Hill (1982:271) confirms this notion by stating, "In general, iron trade items were more likely than copper or brass items to be discarded after they were broken possibly because they were more difficult to repair "

Because pieces of metal rather than complete metal tools were recovered at Tree Frog (recalling a portion of Binford's (1977) definition of a curated tool, the metal was transported from locality to locality, and recycled to other tasks when no longer useful for its primary purposes), I infer that metal tools recovered from Tree Frog were used in a curated manner I consider these metal tools to be the curated technology of this mobile group, their presence effecting the remaining lithic tool assemblage.

The occurrence of metal tools or other trade goods in the Protohistoric archaeological record is not unique to Tree Frog (Hudson 1993; Ahler 1988; Toom 1979). The transformation from reliance on native industries to adoption and use of Euroamerican trade goods has been shown to change tool use and technology Chipped stone cutting and scraping tools are both rapidly and gradually replaced by metal tools depending on the native group and their access to trade goods (Hudson 1993, Ahler 1988; Toom 1979; Goulding 1980; Arkush 1990; Pyzczyk 1997). Hudson (1993:269) states that “in general, there should be a decrease in frequency of both (formal) chipped stone tools and ground stone tools as metal tool usage increases.”

The decrease in formal chipped stone tools after selective adoption of European trade items may have occurred over a period of many years, possible before any direct contact with Europeans (Rogers 1990; Pyszczyk 1997). Metal tools were fewer in number and often difficult to obtain while native technologies were, arguably, initially superior in uselife or availability (Rogers 1990). For instance, “among the Arikaras, ceramic manufacture and the use of the bison scapula hoes continued long after metal counterparts were available and even preferred by neighboring groups such as the Mandans and Hidatsas (Rogers 1990: 20). Other groups, such as the Cree/Assiniboine, acquired trade items directly from European trappers and immediately passed the items to other native groups without retaining many trade items themselves (Pyszczyk 1997). Therefore, native-stone, formal tool industries seem to have been modified and selectively retained rather than completely abandoned after the introduction of European trade items. The formal tool assemblage recovered from Tree Frog appears to represent a time when shifts from curated to expedient in a mobile group’s use of stone tools as well as adoption or incorporation of some European trade goods took place.

Pyszczyk (1997) recognizes some possible similarities between the Protohistoric archaeological record in North America and the !Kung Bushmen living in the Kalahari Desert. Essentially, the !Kung acquire small amounts of modern articles from the Bantu, yet maintain a mobile, simple lifestyle and continue to use traditional artifacts as well (Pyszczyk 1997; Yellen 1977; Marshall 1976). Apparently, the !Kung do not discard traditional artifacts at the same rate as modern artifacts (Pyszczyk 1997) and, therefore, modern artifacts may not be represented in the archaeological record as compared to the actual amount in which they are used and are part of the !Kung tool kit. Pyszczyk (1997:72) cautiously compares the !Kung practices and uses them to interpret how the introduction of European trade goods effects tool use in the protohistoric period in southern Alberta, Canada: "(1) varying degrees of retention of traditional activities and materials; (2) limited use of new European articles and materials (depending on which native group is in question); and (3) re-use and recycling of European material into other objects." Pyszczyk's (1997) comparison also seems to apply to the Protohistoric Tree Frog assemblage.

The Presence of Horses

Prior to the acquisition of horses, mobile groups traveled by foot, carrying their belongings with them (Roper 1989). As discussed in Chapter II, a curated tool technology is the most efficient for a mobile group because it is predictable, portable, multifunction, and lightweight (Binford 1979). During this period in time, some mobile groups used domesticated dogs to carry excess items and to aid in hunting (Roper 1989). Very early ethnographic accounts document the specific use of the domesticated dog; "they load these dogs like beasts of burden, make (pack)saddles for them, and they fasten them with leather thongs, when they go hunting, they load these with necessities and when they move, these dogs carry their houses. tied to a packsaddle, besides the load which they carry on top, and the load may be according to the dog, from 35 to 50 pounds" (Roper 1989:44).

Horses, where available, replaced dogs as pack animals as well as allowing human passengers. Horses could carry or drag more belongings than dogs while at the same time increase the speed and distance people could travel over short and long periods of time (Roll and Deaver 1978). Therefore, "the horse could have been taken over with immense profit and without serious readjustment (to the group's social structure)" (Roper 1989:46). As a result, during the Protohistoric period, groups that had horses greatly increased their mobility, enabling frequent contact with neighboring groups and possibly a greater ease in procuring raw materials (Roll and Deaver 1978).

At Tree Frog, a large quantity of non-local raw materials were recovered, and I infer that their presence may be attributed to this extreme mobility and relative ease of travel with the horses. As discussed above, Tree Frog possesses a natural, large surface scatter of obsidian cobbles that are of poor quality, yet they are sufficient for expedient tools. However, in addition to the formal tools, a large quantity of non-local lithic raw material, obsidian and silicates in the form of debitage, were recovered. This material appears to have been flaked or tested, leaving more of this excellent quality material at the site than would be expected. The flakes were large enough to be further refined into formal tools or utilized as tools without further modification, but do not appear to have been.

The mass flake analysis revealed that for the site as a whole, large and small non-local obsidian flakes were less likely to display formal flake characteristics than expected. These results suggest that perhaps because this group had horses, the travel times to other obsidian sources, such as Bear Gulch or Obsidian Cliff (see Figure 4), were relatively short and, therefore, raw material conservation was not as important as it was previously because they could quickly obtain more materials from a known geologic source. Large cobbles of non-local materials could be carried with relative ease by horseback across great distances from their geologic source. Large and small flakes without a striking platform or a bulb of percussion were then discarded because of this lack of need for conservation or curation of raw materials.

This relative ease of procurement could also account for more large and small non-local flakes with cortex than were expected at Tree Frog. Initial cobble reduction could take place away from the geologic source, where previously, a large amount of the bulky cobble (including cortex) would have been removed before transport (Ahler 1989a).

Ahler's (1989b) experiment focusing on Knife River Flint suggested that cobble testing and preliminary core reduction occurred at quarries and workshops only, while biface thinning and sharpening occurred predominantly at residential areas at a distance from the material's source. As previously discussed, larger flakes with cortex are usually associated with the initial stages of tool production, the removal of natural irregularity form a nodule (White et al 1963) or primary bifacial reduction (Ahler 1989a; 1989b). Smaller flakes without cortex tend to be associated with tool maintenance, such as resharpening a biface (Ahler 1989a; 1989b). These expectations rest on the assumption that flake size distribution, "centers on the observation that flake aggregates produced by different technologies (e.g. hard hammer, pressure) and in different stages of manufacture (e.g. early and late stage biface production) will exhibit markedly different size grade distributions" (Ahler 1989b:205).

Because of Ahler's (1989b) observations and my previously outlined expectations, I would expect to find at Tree Frog a relatively low proportion of large flakes with cortex (both non-local obsidian and non-obsidian), a low ratio of large flakes to small flakes, a low ratio of large flakes to finished tools, and a prepared core technology However, the mass flake analysis revealed that more large flakes with cortex were recovered than expected, the ratios of large flakes to small flakes and large flakes to finished tools were not markedly different, and a non-local material prepared core technology was minimal.

These results suggest that at Tree Frog, large cobbles of non-local material were transported to the site in order for this amount of non-local obsidian and non-obsidian large and small flakes with cortex to accumulate. It appears that minimal core reduction was conducted before cobbles were transported to the site, accounting for the reduced presence of a prepared core technology Once initial reduction commenced, non-local obsidian displayed fewer formal characteristics than expected and apparently was not conserved or used for formal tools as expected.

The introduction of the horse made it easier to obtain lithic raw materials. European metal tools appear to have replaced stone as a curated tool technology at Tree Frog effected the dynamics of the recovered assemblage and the expected outcome of the mass flake analysis. These unexpected results in the distribution and frequency of raw materials at Tree Frog also differ from the expected lithic distribution in the Fall-off model (Renfrew 1977) proposed in Chapter II. Renfrew (1977) stressed that departures from the Fall-off model are likely to be of interest and significant, therefore, further discussion follows.

Departure from the Fall-off Model at Tree Frog

According to Renfrew (1977 72), lithic raw material "finds are abundant near the source, and there is a fall-off in frequency or abundance with distance to the source. frequency of occurrence declines with distance (from the source)." As demonstrated above, the lithic assemblage at Tree Frog does not fully support Renfew's (1977) premise. I attribute this departure from the Fall-off model to a change in the location of where specific points in the production of the tool (stone tool production trajectory) are taking place (Ahler 1989a). Differing flake sizes are usually associated with a certain stage of production: large flakes with cortex—initial core reduction or bifacial thinning; small flakes without cortex—maintenance or resharpening an existing tool; etc. (Ahler 1989a). Because lithic tool production is a reductive technology, it seems logical to expect that flake debitage should decrease progressively as the tool itself becomes smaller (Ahler 1989a). This assumption supports a general fall-off trend where smaller flakes with less cortex should occur in greater frequencies than larger flakes with cortex the farther the material has been transported from its source because the tools are in a later stage of the production trajectory (Ahler 1989b).

As shown above, the amount of non-local lithic debitage recovered from Tree Frog (large and small flakes, with and without cortex) suggests that some initial reduction was taking place at a distance from the geologic sources in which they were obtained. The transport of large amounts of raw materials away from their source affects the fall-off of the material's frequency and quantity significantly The results from the mass flake analysis actually resemble a technologically mixed composition similar to a long-term sedentary or semisedentary habitation (Ahler 1989a), as well a mobile group of people (Parry and Kell 1986, Kelly 1989; Shott 1986, Odell 1984). Semisedentary or sedentary communities are "in locations often far removed from lithic raw material sources," and "one can expect that flaking debris will be a diverse mixture of byproducts from early and late stage core reduction and tool production" (Ahler 1989a:106).

At Tree Frog, however, there is no evidence of long-term residential structures and, as explained in Chapter I, the environmental conditions permit a limited window of use during the year Also, lithic materials occur naturally in great quantities at the site unlike most sedentary communities, and higher quality materials, non-local obsidian and silicates, are easily accessible because of the use of horses. The assemblage dynamics at Tree Frog resemble a sedentary or semisedentary community, yet the people that utilized this site were extremely mobile. These factors suggest that the composition of short-term occupation sites that were utilized by mobile groups in the Late Prehistoric differ from short-term occupation sites in the Protohistoric. Tree Frog is an example of this change in lithic procurement and use strategies as the Protohistoric time period begins.

Material Quality and Availability at Tree Frog

In addition to the European trade items, particularly metal, non-local obsidian and non-obsidian lithic raw materials, the group(s) that occupied Tree Frog utilized the local, on-site source of HR/ML obsidian. These local cobbles are a low quality material yet they are extremely abundant and effective for use as simple tools. The poor quality of the material may have limited the amount of refinement necessary for the production of well-defined formal tools: poor quality and abundance seem to have contributed to the expedient use of this material. The mass flake analysis supports this assumption and is further explained below

The mass flake analysis revealed that while three of my expectations for the HR/ML obsidian were confirmed, the following expectations were not: (1) a high proportion of large flakes with cortex; and (2) a high ratio of large flakes to small flakes.

First, large flakes of local obsidian, while great in number did not have cortex as frequently as expected. These large flakes also demonstrate more formal flake characteristics than expected. Perhaps these results occurred because this material was extensively tested and therefore many large flakes—still in the initial stages of reduction—without cortex were used as flake tools or simply discarded. Elston (1992:3) states that in relation to prehistoric lithic quarries, "assemblages of adjacent workshop, campsites," and the quarry itself, "are dominated by debitage from processing and manufacturing." It appears, because of the type of small HR/ML obsidian flakes recovered, that further reduction of large flakes was extremely difficult due to occlusions within the material. The small HR/ML flakes were less likely to have cortex and less likely to display formal characteristics than expected. Perhaps as a cobble of local material was tested for use, shatter or chunk material resulted (Ahler 1989). Shatter/chunk material is defined as, "cubical or irregularly shaped chunks that frequently lack any well-defined bulbs of percussion or systematic alignment of cleavage scars on various faces" (Binford and Quimby 1963:278). Ahler (1989:210) elaborates on the previous definition by stating that "these pieces cannot be oriented, distally or proximally, dorsally or ventrally, with reference to the direction of force application or the position in the core."

Perhaps because of the abundance of shatter/chunk material, large, local flakes are more likely to have formal characteristics than small, local flakes. In general, flakes of all sizes of local obsidian are less likely than flakes of all sizes of non-local material to possess formal flake characteristics, most likely due to the quality of the material as described.

As discussed previously, it appears that non-local materials were also used for tools of expediency and in general were not conserved as expected. While the number of local obsidian flakes recovered was greater in number than the total amount of non-local materials recovered, the manner in which the materials were used seems very similar Because of these results, I infer that the quality of the lithic material used at Tree Frog needed only the potential for a cutting edge rather than an excellent quality material with the capability for extensive refinement. As Parry and Kelly (1986) stated, after the tool is created and resharpened, the edge of a tool is not as sharp as an unretouched edge.

Citing another ethnographic example, Ahler et al. (1991) states that the composition of Mandan village stone tools had been remarkably altered by 1830. Tool composition consisted of the following (Ahler et al. 1991 75):

> Recycling of older tools was common. Stone arrow points and cutting tools were largely replaced by metal counterparts. Little emphasis was placed on procuring high quality stone raw material. Whereas Knife River Flint was sought out in previous times, local cherts and sandstones often sufficed after 1830. Hide scrapers. had been replaced in part by tools with metal bits and in part by crude, hand-held stone scrapers made by chipping a rough edge on a slab of flint or a fire-split cobble. These crude scrapers may have been used for rapid processing of hides destined for the fur trade.

This example (Ahler et al. 1991) applies to the Tree Frog assemblage as another possible explanation of why a change in procurement (curated verses expedient) and use of lithic raw materials occurred at the site.

My interpretation of the inferred cultural activities that occurred at Tree Frog, based on the flake assemblage and associated artifacts recovered, is composed of multiple factors: (1) settlement mobility; (2) the presence of European trade items; (3) the presence of horses; and (4) material availability and quality As described above, these four factors (and probably unrecognized factors as well) equally contribute to the change or shift in settlement and procurement strategies that occurred at the site in the Protohistoric period.

Chapter V: Conclusion

This study, the mass flake analysis of lithic material collected during the 1997 and 1998 excavations at Tree Frog and the examination of associated artifacts, provides another source of information for the interpretation of Protohistoric sites in western North America and additional examples of the utility of geo-chemical and mass flake analyses used to facilitate the interpretation of cultural processes at and between archaeological sites. The lithic materials recovered from Tree Frog were subjected to a mass flake analysis where the presence or absence of formal flake characteristics was tested for independence in relation to material type, presence or absence of cortex, and size of flakes. The composition of flake assemblages, such as that recovered from Tree Frog, can be used to investigate the extent to which these characteristics reflect inferred cultural activities that occurred in the past. This study also demonstrates the complexity of the Protohistoric period and the utility of cautiously applying ethnographic accounts when interpreting the results of a lithic analysis.

As established previously, technological changes are evident at Tree Frog. A combination of factors may account for this change: (1) the acquisition of horses which facilitated increased contact between native groups and created a relative ease in procurement of non-local lithic materials due to an increase in mobility as well as passing the burden of transport to horses; (2) the introduction of European trade items which have replaced some lithic tools as curated items allowing for the expedient use of lithic materials; and (3) the presence of a vast amount of local, poor quality obsidian that was used in an expedient manner along with non-local lithic materials.

Throughout prehistory, "technological changes emerge when particular clusters of traits are substituted for previously existing modes" (Montet-White and Anta 1968:22). These technological changes occurred in conjunction with various factors, such as environmental changes or perhaps an increase or decrease in options available at that point in time (Arkush 1990). For example, the shift from Paleo-Indian to terminal Paleo-Indian or Early Archaic settlement/subsistence patterns are often associated with the disappearance of mega-fauna and climatic changes (the beginning of the Altithermal) and are often expressed in the archaeological record as changes in projectile point types (a shift in technology) (Frison 1991). Another North American example is the shift from using larger dart/spear points in the Late Archaic to the use of smaller arrow points with the introduction of the bow and arrow (Frison 1991). While some technologies were altered, such as projectile point styles, other technologies/strategies remained effective and were, therefore, retained. One example of strategy retention is the use of corrals, arroyo traps, jumps or dune/snow traps while hunting herds of animals (Frison 1991).

The above examples illustrate how differing and usually multiple factors prompt technological change or perhaps retention of a technology. The occupation at Tree Frog occurred during another period of profound change in cultural environment (direct or indirect contact with Europeans) and the increase and also decrease of certain options available to this group occurred (perhaps forced to use a different geographic area, loss of population due to disease, the introduction of European trade items, etc.). This period of technological change is reflected in the assemblage recovered from Tree Frog.

Steward (1997:6) wrote "This early period of contact seems to have had little cultural or economic effect on the Indians except in the East where they traded with the whites." This mass flake analysis and analyses of associated artifacts recovered from Tree Frog, however, adds to the growing number of sources (Pyszczyk 1997; Roper 1985; Toom 1979; Ahler et al. 1991, Hudson 1993; and Lohse and Holmer 1990) that describe the economic and cultural effects which occurred during the Protohistoric time period as ranging from subtle to profound depending upon the group in question. Also, these economic and cultural changes may seem subtle in the archaeological record, yet this may not wholly reflect the behaviors that occurred at these sites. This period of time, while brief, is a distinct and critical era where, "groups acquired elements of Euroamerican material culture and became aware of Anglo presence though communication with other native groups, and/or brief contacts with Euroamerican traders, trappers, or explorers" (Arkush 1990:28). Researchers must identify, analyze, and interpret Protohistoric resources, such as Tree Frog, while recognizing subtle yet distinct artifact types and cultural developments (Arkush 1990). The use of traditional analysis, such as a mass flake analysis, augmented with geo-chemical analyses and ethnographic accounts will facilitate future interpretation of these distinct Protohistoric site types.

Bibliography

Ahler, S.A.

1989a Mass Analysis of Flaking Debris: Studying the Forest Rather Than the Tree. In *Alternative Approaches to Lithic Analysis,* edited by D.O. Henry and G.H. Odell, pp. 85-118. Archaeological Papers of the American Anthropological Association No.1

1989b Experimental Knapping with KRF and Midcontinent Cherts: Overview and Applications. In *Experiments in Lithic Technology,* D.S. Amick and R.P Mauldin, editors. BAR International Series 528.

Ahler, S.A., T.D. Thiessen, and M.K. Trimble

1991 *People of the Willows: The Prehistory and Early History of the Hidatsa Indians.* University of North Dakota Press, Grand Forks.

Bamforth, D.B

1986 Technological Efficiency and Tool Curation. *American Antiquity* 51(1):38-50.

Baumler, M.F

1997 A Little Down the Trail: Prehistoric Obsidian Use On The Flying D Ranch, Northern Gallatin-Madison River Divide, Southwestern Montana. *Tebiwa* 26(2):141-161.

Beta Analytic, Inc.

1997 Results of radiocarbon dating, Tree Frog Site, Centennial Valley, Montana. Sample #112986. Letter submitted to Dr. Thomas A. Foor, the University of Montana, Missoula.

1999 Results of radiocarbon dating, Tree Frog Site, Centennial Valley, Montana. Sample #135577 Letter submitted to Dr Thomas A. Foor, the University of Montana, Missoula.

Bettinger, R.L.

1991 *Hunter-Gatherers. Archaeological and Evolutionary Theory.* Plenum Press, New York.

Binford, L.R.

1977 General Introduction. In *For Theory Building in Archaeology.* L.R. Binford, editor Academic Press, New York, pp.1-10.

1979 Organization and Formation Processes: Looking at Curated Technologies. *Journal of Anthropological Research* 35:255-273.

1980 Willow Smoke and Dogs' Tails: Hunter-Gatherer Settlement Systems and Archaeological Site Formation. *American Antiquity* 45(1):4-20.

Binford, L.R. (continued)

1982 The Archaeology of Place. In *Journal of Anthropological Archaeology*, Robert Whallon, editor 1(1):5-31 Academic Press, New York.

Binford, L.R. and G.I Quimby
1963 Indian Sites and Chipped Stone Materials in the Northern Lake Michigan Region. *Fieldiana Anthropology* 36(12):277-307

Butler, B.R.
1981 When Did the Shoshoni Begin to Occupy Southern Idaho?· Essays on Late Prehistoric Cultural Remains From the Upper Snake and Salmon River Country. In *Occasional Papers of the Idaho Museum of Natural History* No. 32. Pocatello, Idaho.

Conner, M. and R. Kunselman
1997 Mobility, Settlement Patterns, and Obsidian Source Variation in Jackson Hole, Wyoming. *Tebiwa* 26(2):162-185.

Crabtree, D. E.
1972 *An Introduction to Flintworking.* Occasional Papers, Idaho State University Museum, No. 28.

Crum, B. and J.P Dayley
1997 Shoshoni Texts. *Occasional Papers and Monographs in Cultural Anthropology and Linguistics* Vol. 2. Boise State University, Boise.

D'Azevedo, W.L.
1986 *Handbook of North American Indians: Great Basin*, Vol.11. Smithsonian Institution, Washington.

Dundas, R.
1998 Results of faunal analysis, excavation at Tree Frog 1997, Centennial Valley, Montana. Letter submitted to Dr. Thomas A. Foor, the University of Montana, Missoula.

1999 Results of faunal analysis, excavation at Tree Frog 1998, Centennial Valley, Montana. Letter submitted to Dr Thomas A. Foor, the University of Montana, Missoula.

Earle, B.J
1980 *Centennial Mountains Cultural Resource Inventory.* Centennial Mountains Timber Compartment Management Plan, Continental Divide National Scenic Trail, Centennial Mountains Instant Wilderness Study Area. Beau of Land Management, Butte District: Dillon Resource Area, Dillon, MT

Elston, R.G. and C. Raven (editors)
1992 *Archaeological Investigations at Tosawihi A Great Basin Quarry.* Report on file Bureau of Land Manangement, Elko District, Elko, Nevada, pp.1-70.

Embree, E.R.
1939 *Indians of the Americas.* Houghton Mifflin Company, Boston.

Ericson, J.E.

1984 Toward the Analysis of Lithic Production Systems. In *Prehistoric Quarries and Lithic Production*, edited by J.E. Ericson and B.A. Purdy, pp.1-9. Directions in Archaeology, Cambridge University Press, Cambridge.

Espenshade, E.B. (editor)

1986 *Goode's World Atlas.* Rand McNally & Company, Chicago.

Foor, T.A.

1997 Research design for the Tree Frog Site. Submitted to the Bureau of Land Management, Dillon Resource Area, Dillon, MT

1999 [Professor, University of Montana]. Personal communication.

Frison, G.C.

1971 Shoshonean Antelope Procurement in the Upper Green River Basin, Wyoming. *Plains Anthropologist* 16(54)258-284.

1991 *Prehistoric Hunters of the High Plains.* Academic Press, New York.

Gould, R.A., D.A. Koster, and A.H.L. Sontz

1971 The Lithic assemblage of the Western Desert Aborigines of Australia. *American Antiquity* 36:149-69.

Greater Yellowstone Coalition (The)

No Date *A Model for Integration and Management for the Centennial Ecosystem.* unpublished Master's thesis on file, Department of Anthropology, University of Montana, Missoula.

Hodges, H.

1989 *Artifacts: An Introduction to Early Materials and Technology.* Gerald Duckworth and Company Ltd., London.

Holmer, R.N.

1997 Volcanic Glass Utilization in Eastern Idaho. *Tebiwa* 26(2):186-204.

Hudson, L.

1993 Protohistoric Pawnee Lithic Economy *Plains Anthropologist* 38-146:265-277

Hughes, R.E.

1986 *Diachronic Variability in Obsidian Procurement Patterns in Northeastern California and Southcentral Oregon.* University of California Publications in Anthropology Vol.17 University of California Press, Berkeley

1998a Results of obsidian sourcing, Tree Frog Site, Centennial Valley, Montana. Letter submitted to Dr Thomas A. Foor, the University of Montana, Missoula, MT, May 5, 1998.

1998b Results of obsidian sourcing, Tree Frog Site, Centennial Valley, Montana. Letter submitted to Dr Thomas A. Foor, the University of Montana, Missoula, MT, December 16, 1998.

Jennings, J.D. and E. Norbeck, editors
1964 *Prehistoric Man in the New World.* The University of Chicago Press, Chicago.

Johnson, J.K.
1989 The Utility of Production Trajectory Modeling As a Framework for Regional Analysis. In *Alternative Approaches to Lithic Analysis,* edited by D.O. Henry and G.H. Odell, pp. 119-138. Archaeological Papers of the American Anthropological Association No.1.

Johnson, J.K.
1996 Lithic Analysis and Questions of Cultural Complexity· The Maya. In *Stone Tools: Theoretical Insights into Human Prehistory,* edited by G.H. Odell, pp.159-174. Plenum Press, New York.

Kelly, R.L.
1988 The Three Sides of a Biface. *American Antiquity* 53(4):717-731.

Kopper, P
1986 *The Smithsonian Book of North American Indians: Before the Coming of the Europeans.* Smithsonian Books, Wahsington.

Kunselman, R. and W.M. Husted
1997 Prehistoric High Altitude Obsidian Selection in the Beartooth Mountains of Montana. *Tebiwa* 26(2):205-215.

Lohse, E.S. and Holmer, R.N., editors
1990 *Fort Hall and The Shoshone-Bannock.* Idaho State University Press, Moscow

Lowie, R.H.
1954 *Indians of the Plains: Anthropological Handbook, No. 1* The American Museum of Natural History, McGraw-Hill Book Company, Inc. New York.

Marshall, Lorna
1976 *The !Kung of Nyae Nyae.* Harvard University Press, Cambridge, Massachusetts.

Masten, R., T.K. Eller, D. Massengale
1981 A Cultural Resources Overview of the Bonneville Power Administration's Flathead Valley Reinforcement Project in Northwestern Montana. Bonneville Cultural Resources Group report number 100-18. Eastern Washington University Reports in Archaeology and History, Cheney

McKee, D. F
1988 A Faunal Analysis of the River Bend Site (48NA202): Evidence of Protohistoric Subsistence on the Northwest Plains. Unpublished Master's Thesis, Department of Anthropology, University of Wyoming, Laramie.

Metcalf, M.D.
1987 Contributions to the Prehistoric Chronology of the Wyoming Basin. In *Perspectives on Archaeological Resources Management in the "Great Plains",* edited by Alan J Osborn and Robert C. Hassler I & O Publishing Company, Omaha. Pp. 233-261

Montet-White, A.
1968 *The Lithic Industries of the Illinois Valley in the Early and Middle Woodland Period.* Anthropological Papers #35, Museum of Anthropology, University of Michigan, Ann Arbor.

Mulloy, W T
1958 A Preliminary Historical Outline for the Northwestern Plains. *University of Wyoming Publications.* 22(1):1-235.

Murray, A.L.
1974 Obsidian Quarries of the Centennial Valley of Southwestern Montana. Paper presented at the Plains Anthropological Conference. Copies on file at the University Of Montana, Missoula.

Newman, J.R.
1994 The Effects of Distance on Lithic Material Reduction Technology. *Journal of Field Archaeology,* 21(4):491-501

Odell, G.H.
1994 Prehistoric Hafting and Mobility in the North American Midcontinent: Examples from Illinois. *Journal of Anthropological Archaeology,* 13:51-73.

1996 Economizing Behavior and the Concept of "Curation" In *Stone Tools: Theoretical Insights into Human Prehistory,* edited by G.H. Odell, pp.51-80. Plenum Press, New York.

Origer, T.M.
1999 Obsidian hydration analysis report of Tree Frog Site obsidian samples. Anthropological Studies Center, Sonoma State University, Rohnert Park, California. Submitted to Thomas Foor, The University of Montana, Missoula, January 7, 1999.

Parry, W.J. and R.L. Kelly
1986 Expedient Core Technology and Sedentism. In *The Organization of Core Technology.* J.K. Johnson and C.A. Morrow, editors. Westview Press, Boulder, Colorado, pp. 285-304

Pavesic, M.G.
1985 Cache Blades and Turkey Tails: Piecing Together the Western Idaho Archaic Burial Complex. In *Prehistoric Quaries and Lithic Production,* edited by J.E. Ericson and B.A. Purdy, pp.55-90. University of Cambridge Press, Cambridge.

Pyszczyk, H.W
1997 The Use of Fur Trade Goods by the Plains Indians, Central and Southern Alberta, Canada. In *Canadian Journal of Archaeology,* 21:45-84

Quimby, G.I.
1966 *Indian Culture and European Trade Goods. The Archaeology of the Historic Period in the Western Great Lakes Region.* University of Wisconsin Press, Madison.

Ray, V.F
1939 *Cultural Relations in the Plateau of Northwestern America.* Southwest Museum, Los Angeles. Reprint of Vol. 13 of Publications of the Frederick Webb Hodge Anniversary Publication Fund.

Renfrew, C. and P Bahn
1996 *Archaeology: Theories, Methods, and Practice.* Thames and Hudson, Ltd., London.

Renfrew, C.
1977 Alternative Models for Exchange and Spatial Distribution. In *Exchange Systems in Prehistory,* T.K. Earle and J.E. Ericson, editors. Academic Press, New York.

Ritchie, D. and R.A. Gould
1985 Back to the Source: A Preliminary Account of the Massachusett Hill Quarry Complex. In *Stone Tool Analysis: Essays in Honor of Don E. Crabtree*, edited by M.G. Plew, J.C. Woods, and M.G. Pavesic, pp.35-54. University of New Mexico Press, Albuquerque.

Sappington, R.L.
1981 A Progress Report on the Obsidian and Vitorphyre Sourcing Project. *Idaho Archaeologist.* Spring Issue: pp.4-8.

1984 Procurement Without Quarry Production: Examples from Southwestern Idaho. In *Prehistoric Quarries and Lithic Production: Directions in Archaeology,* edited by J.E. Ericson and B.A. Purdy, pp.23-34. Cambridge University Press, Cambridge.

Sant, M.B.
1992 Site form for 24BE1639—"The Tree Frog Site" Montana State Office Site Form: Bureau of Land Management, Dillon Resource Area. Copies available from The University of Montana Archaeological Records Office, Missoula, Montana.

Schoen, J.R.
1997 As Clear As Opaque Obsidian: Source Locations In Jackson Hole, Wyoming. *Tebiwa* 26(2):216-224.

Shott, M.J.
1986 Technological Organization and Settlement Mobility· An Ethnographic Examination. *Journal of Anthropological Research* 42(1):15-52.

Spence, M.W., J. Kimberlin, and G. Harbottle
1984 State Controlled Procurement and the Obsidian Workshops of Teotihuacan, Mexico. In *Prehistoric Quaries and Lithic Production*, edited by J.E. Ericson and B.A. Purdy, pp.97-106. University of Cambridge Press, Cambridge.

Steward, J.H.
1997 *Basin-Plateau Aboriginal Sociopolitical Groups.* The University of Utah Press, Salt Lake City Reprint of the Smithsonian Institution Bureau of American Ethnology, Bulletim 120, 1938.

Stocker, T.L. and R.H. Cobean
1984 Preliminary report on the Obsidian Mines at Pico de Orizba, Veracruz. In *Prehistoric Quaries and Lithic Production*, edited by J.E. Ericson and B.A. Purdy, pp.83-96. University of Cambridge Press, Cambridge.

Summerhayes, G.R., J.R. Bird, R. Fullagar, C. Gosden, J. Specht, and R. Torrence
1998 Application of PIXE-PIGME to Archaeological Analysis of Changing Patterns of Obsidian Use in West New Britain, Papua New Guinea. In *Archaeological Obsidian Studies: Method and Theory*, edited by M.S. Shackley Plenum Press, New York.

Swanson, E.H., Jr., C. King, and J. Chatters
1969 A Settlement Pattern in the Foothills of East-Central Idaho. *Tebiwa* 12(1):31-38.

Thompson, K.W., J.V Pastor, S.D. Creasman
1997 Wyoming Basin-Yellowstone Plateau Interaction: A Study of Obsidian Artifacts from Southwestern Wyoming. *Tebiwa* 26(2):241-254.

Toom, D.L.
1979 *The Middle Missouri Villagers and the Early Fur Trade: Implications for Archaeological Interpretation.* Unpublished M.A. Thesis, Department of Anthropology, University of Nebraska, Lincoln.

Torrence, R.
1984 Monopoly or Direct Access? Industrial Organization at the Melos Obsidian Quarries. In *Prehistoric Quaries and Lithic Production*, edited by J.E. Ericson and B.A. Purdy, pp.49-64. University of Cambridge Press, Cambridge.

Tykot, R.H.
1998 Mediterranean Islands and Multiple Flows: Sources and Exploitation of Sardinian Obsidian. In *Archaeological Obsidian Studies: Method and Theory*, edited by M.S. Shackley Plenum Press, New York.

Walker, D.E., Jr.
1998 Handbook of North American Indians: Plateau, Vol.12. Smithsonian Institution, Washington.

Weisler M.I. and D.A. Clague
1999 Characterization of Archaeological Glass from Oceania: The Utility of Three Techniques. In *Archaeological Obsidian Studies: Method and Theory*, edited by M.S. Shackley Plenum Press, New York.

White, A., L.R. Binford, and M.L. Papworth
1963 Miscellaneous Studies in Typology and Classification. In *Anthropological Papers, Museum of Anthropology, The University of Michigan*, No. 19, pp.1-221, Ann Arbor

Wissler, C.
1970 Population Changes Among the Northern Plains Indians. In *Yale University Publications in Anthropology*, No. 1 Reprinted by Human Relations Area Files Press, New Haven.

Yellen, J.E.
1977 *Archaeological Approaches to the Present.* Academic Press, New York.

Yohe, R.M. II, M.G. Pavesic
1997 Olivella Beads from the Braden Site (10-WN-117), Southwestern Idaho. *Tebiwa* 26(2):225-229

Feature 4 Northern Excavation Area

Feature 4. Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	1	1	1	0.9
No Cortex	3	34.85	2	2.15

Feature 4: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	1	22.9	1	0.9
No SP&BP	3	12.95	2	2.15

Feature 4. Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	2	7.45	4	4.05
No Cortex	2	8.45	17	5.55

Feature 4: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	2	7.45	13	5.65
No SP&BP	2	8.45	8	3.95

Feature 4. Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	1	4.8	4	2.4
No Cortex	7	15.5	39	16.35

Feature 4: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	4	8.9	7	6
No SP&BP	4	11.4	36	12.75

Feature 7 Northern Excavation Area

Feature 7: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	7	76.8	14	5
No Cortex	2	5.15	24	4.85

Feature 7: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	6	13.25	15	5.4
No SP&BP	3	68.7	23	4.45

Feature 7: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	32	786.7	35	19
No Cortex	16	115.8	152	35.05

Feature 7: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	29	571	46	28.35
No SP&BP	19	331.5	141	25.7

Feature 7: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	77	1380	113	69.1
No Cortex	70	335.9	457	166.6

Feature 7: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	51	746.2	66	28.2
No SP&BP	96	969.7	504	207.5

Feature 8   Northern Excavation Area

Feature 8: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	0	0
No Cortex	0	0	0	0

Feature 8: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	0	0
No Cortex	1	1.1	0	0

Feature 8: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	0	0
No Cortex	0	0	0	0

Feature 8: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	0	0	0	0
No SP&BP	0	0	0	0

Feature 8: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	0	0	0	0
No SP&BP	0	0	0	0

Feature 8: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	0	0	0	0
No SP&BP	0	0	0	0

Feature 12 Northern Excavtion Area

Feature 12: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	0	0
No Cortex	2	7.45	7	1.6

Feature 12: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	1	1.1	0	0
No SP&BP	1	6.35	7	1.6

Feature 12: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	3	15.6	1	0.2
No Cortex	4	3.9	12	5.15

Feature 12: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	3	10.3	2	1.15
No SP&BP	4	9.2	11	4.2

Feature 12: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	0	0
No Cortex	3	7	23	8.5

Feature 12: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	1	2.6	4	1.6
No SP&BP	2	4.4	19	6.9

Appendix A Feature Contingency Tables

Feature 14 Northern Excavation Area

Feature 14. Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	1	1.22	0	0
No Cortex	1	1.4	2	0.6

Feature 14: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	1	1.4	0	0
No SP&BP	1	1.22	2	0.6

Feature 14: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	1	2.6	0	0
No Cortex	0	0	32	5.35

Feature 14: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	1	2.6	13	3.05
No SP&BP	0	0	19	2.3

Feature 14. Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	0	0
No Cortex	0	0	8	1.2

Feature 14: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	0	0	3	0.4
No SP&BP	0	0	5	0.8

Feature 16 Northern Excavation Area

Feature 16: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	1	0.85
No Cortex	1	1.45	7	3.35

Feature 16: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	0	0	2	1.45
No SP&BP	1	1.45	6	2.75

Feature 16: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	2	1.75
No Cortex	2	4.2	27	8.6

Feature 16: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	1	1	7	3.8
No SP&BP	1	3.2	22	6.55

Feature 16: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	6	33.9	4	2
No Cortex	8	24.8	40	14.3

Feature 16: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	6	27.8	5	0.7
No SP&BP	8	30.9	39	15.6

Feature 20 Northern Excavation Area

Feature 20: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	0	0
No Cortex	0	0	3	0.6

Feature 20: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	0	0	0	0
No SP&BP	0	0	3	0.6

Feature 20: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	1	1.8	0	0
No Cortex	3	9.8	27	9.6

Feature 20: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	1	3.6	7	1.8
No SP&BP	3	8	20	7.8

Feature 20: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	2	10.7	5	1.7
No Cortex	9	34.6	29	17.1

Feature 20: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	6	28.8	6	3.9
No SP&BP	5	16.5	28	14.9

Feature 21 Northern Excavation Area

Feature 21. Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	1	0.9
No Cortex	1	8.4	3	1.1

Feature 21. Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	1	8.4	1	0.5
No SP&BP	0	0	3	1.5

Feature 21. Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	1	0.3
No Cortex	0	0	16	5.4

Feature 21. Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	0	0	6	2.5
No SP&BP	0	0	11	3.2

Feature 21. Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	1	1
No Cortex	2	8.7	12	4.7

Feature 21. Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	0	0	2	0.8
No SP&BP	2	8.7	11	4

Feature 22 Northern Excavation Area

Feature 22: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	2	5.5	3	1.7
No Cortex	3	37.1	38	15

Feature 22: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	1	23.1	11	3.3
No SP&BP	4	19.5	30	13.4

Feature 22: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	7	100.1	12	9.8
No Cortex	23	67.6	140	37.6

Feature 22: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	12	117	51	15.4
No SP&BP	18	50.7	101	32

Feature 22: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	38	793.9	46	17.35
No Cortex	34	154.5	247	76.35

Feature 22: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	28	344.5	66	26.5
No SP&BP	44	603.9	227	67.2

Feature 32 Northern Excavation Area

Feature 32: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	1	3.6	1	0.1
No Cortex	1	1.8	26	6.75

Feature 32: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	0	0	9	1.85
SP & BP	2	5.4	18	5

Feature 32: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	7	21.4	13	9.1
No Cortex	10	35.6	79	18.45

Feature 32: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	10	35.4	35	10.9
No SP&BP	7	21.6	57	16.65

Feature 32: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	9	72.7	28	15.95
No Cortex	7	12.6	68	24.35

Feature 32: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	6	17.9	14	6.5
No SP&BP	10	67.4	82	33.8

Appendix A Feature Contingency Tables

Feature 33 Northern Excavation Area

Feature 33: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	2	23.6	3	1.6
No Cortex	19	86.6	68	24.25

Feature 33: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	4	82.1	24	8.75
SP & BP	7	28.1	47	15.1

Feature 33: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	9	56.8	23	15
No Cortex	22	72.8	205	64.1

Feature 33: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	11	57.9	81	28.55
No SP&BP	20	71.7	147	50.55

Feature 33: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	19	180.8	36	27.2
No Cortex	25	129.1	209	74.5

Feature 33: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	18	177.3	48	16.9
No SP&BP	26	132.6	197	84.8

Feature 41 Northern Excavation Area

Feature 41. Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	0	0
No Cortex	0	0	0	0

Feature 41. Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	0	0	0	0
SP & BP	0	0	0	0

Feature 41. Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	0	0
No Cortex	0	0	0	0

Feature 41: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	0	0	0	0
No SP&BP	0	0	0	0

Feature 41. Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	0	0
No Cortex	1	17.4	0	0

Feature 41. Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	1	14.4	0	0
No SP&BP	0	0	0	0

Feature 42 Northern Excavation Area

Feature 42: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	5	105.2	3	2.8
No Cortex	9	41.6	75	27.65

Feature 42: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	5	37.3	25	9.5
SP & BP	9	109.5	53	20.95

Feature 42: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	5	18.9	15	6.25
No Cortex	22	86.3	204	57.35

Feature 42: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	12	57	61	18.5
No SP&BP	15	48.2	158	45.1

Feature 42: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	19	231.8	36	29.3
No Cortex	22	95.2	188	66.3

Feature 42: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	15	220.6	39	15.9
No SP&BP	26	106.4	185	79.7

Feature 43 Northern Excavation Area

Feature 43: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	3	0.7
No Cortex	6	18	19	9.2

Feature 43: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	1	4.1	8	2.7
SP & BP	5	13.9	14	7.2

Feature 43: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	4	107.4	4	2.4
No Cortex	11	24.4	78	20.9

Feature 43: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	9	116.3	39	10.95
No SP&BP	6	15.5	43	12.35

Feature 43: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	6	38.5	17	8.1
No Cortex	10	50.1	75	22

Feature 43: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	8	39.8	16	4.25
No SP&BP	8	48.8	76	25.85

Feature 47/19 Northern Excavation Area

Feature 47/19: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	0	0
No Cortex	1	6.3	0	0

Feature 47/19: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	1	6.3	0	0
SP & BP	0	0	0	0

Feature 47/19: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	1	1.9	0	0
No Cortex	0	0	3	2.3

Feature 47/19: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	1	1.9	2	1.9
No SP&BP	0	0	1	0.4

Feature 47/19: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	2	0.5
No Cortex	0	0	3	1.25

Feature 47/19: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	0	0	1	0.05
No SP&BP	0	0	4	1.7

Feature 48 Northern Excavation Area

Feature 48: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	1	2.6	5	0.31
No Cortex	7	12.4	16	3.5

Feature 48: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	6	11.6	7	1.2
SP & BP	2	3.4	14	5.4

Feature 48: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	9	38.8	25	13.1
No Cortex	41	176.3	266	77.35

Feature 48: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	22	123.5	80	18.85
No SP&BP	28	91.6	211	71.6

Feature 48: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	4	15.1	12	4.7
No Cortex	7	33.6	98	28.4

Feature 48: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	2	17.7	21	8.4
No SP&BP	9	31	89	24.7

Appendix A Feature Contingency Tables

Feature 49   Northern Excavation Area

Feature 49: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	1	2.1	6	4.7
No Cortex	8	47.2	27	15.2

Feature 49: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	2	12.6	10	7.2
SP & BP	7	36.7	23	12.7

Feature 49: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	4	96.4	10	6.7
No Cortex	23	85.4	138	45.5

Feature 49: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	18	146.6	36	13.3
No SP&BP	9	35.2	112	38.9

Feature 49: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	5	134.4	8	6.2
No Cortex	16.1	90	31.95	28.4

Feature 49: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	3	87.3	21	6.4
No SP&BP	7	63.2	77	31.75

Feature 5 Southern Excavation Area

Feature 5: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	19	423.6	8	7.55
No Cortex	4	92.1	22	10.55

Feature 5: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	2	11.6	5	3.55
No SP&BP	21	504.1	25	14.55

Feature 5: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	16	109.9	21	12.4
No Cortex	43	97.15	508	158.9

Feature . Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	27	134	50	36.8
No SP&BP	32	73.05	479	134.5

Feature 5: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	7	110.4	12	6.3
No Cortex	15	65.8	44	15.15

Feature 5: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	4	22.6	14	6.6
No SP&BP	18	153.6	42	14.85

Appendix A Feature Contingency Tables

Feature 25 Southern Excavation Area

Feature 25: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	1	8.7	2	2.1
No Cortex	3	12.2	4	2.55

Feature 25: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	4	20.9	3	2.35
No SP&BP	0	0	3	2.3

Feature 25: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	0	0
No Cortex	1	0.9	7	1.3

Feature 25: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	1	0.9	3	0.5
No SP&BP	0	0	4	0.8

Feature 25: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	2	2.3
No Cortex	4	8	16	4.9

Feature 25: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	0	0	2	0.8
No SP&BP	4	8	16	6.4

Feature 26 Southern Excavation Area

Feature 26: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	4	16.5	4	2.25
No Cortex	6	12.75	39	12.1

Feature 26: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	4	13.85	13	3.9
No SP&BP	6	15.4	30	8.45

Feature 26: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	1	5.1	1	0.3
No Cortex	3	8.3	56	8.55

Feature 26: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	2	7.3	25	5.25
No SP&BP	2	6.1	32	4.6

Feature 26: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	8	95.5	2	0.9
No Cortex	19	66.2	91	27.9

Feature 26: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	8	37.8	15	6.1
No SP&BP	19	123.9	78	22.7

Feature 29 Southern Excavation Area

Feature 29: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	0	0
No Cortex	0	0	4	1.1

Feature 29: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	0	0
No Cortex	0	0	2	0.1

Feature 29: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	0	0
No Cortex	0	0	5	0.3

Feature 29: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	0	0	0	0
No SP&BP	0	0	4	1.1

Feature 29: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	0	0	0	0
No SP&BP	0	0	2	0.1

Feature 29: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	0	0	0	0
No SP&BP	0	0	5	0.3

Feature 30   Southern Excavation Area

Feature 30: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	4	0.9
No Cortex	4	7.3	28	8.15

Feature 30: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	3	5.4	8	1.6
No SP&BP	4	11.3	24	7.45

Feature 30: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	3	1.65
No Cortex	1	6.4	23	5.25

Feature 30: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	0	0	12	2.55
No SP&BP	1	6.4	13	4.3

Feature 30: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	1	7.2	6	5.1
No Cortex	4	8.2	37	4.7

Feature 30: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	3	6.6	10	1.7
No SP&BP	2	8.8	33	8.1

Appendix A   Feature Contingency Tables

Feature 35 Southern Excavation Area

Feature 35: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	0	0
No Cortex	3	15.4	12	2.75

Feature 35: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	0	0	5	0.6
No SP&BP	3	15.4	7	2.15

Feature 35: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	0	0
No Cortex	1	0.4	14	2.5

Feature 35: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	1	0.4	6	1.75
No SP&BP	0	0	8	0.75

Feature 35: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	0	0
No Cortex	1	1.7	15	4.95

Feature 35: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	1	1.7	4	1.4
No SP&BP	0	0	11	3.55

Feature 36 Southern Excavation Area

Feature 36: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	1	1.5	1	0.7
No Cortex	1	1.7	15	4.95

Feature 36: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	0	0	10	2
No SP&BP	2	2.8	9	6.9

Feature 36: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	3	1.7
No Cortex	2	14.5	22	4.5

Feature 36: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	0	0	10	2.7
No SP&BP	2	14.5	15	3.5

Feature 36: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	2	7.5	3	3.1
No Cortex	1	7.6	16	7.6

Feature 36: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	1	3.2	4	3.5
No SP&BP	2	11.9	15	6.2

Feature 37 Southern Excavation Area

Feature 37: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	0	0
No Cortex	1	1.9	6	1.5

Feature 37: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	0	0	3	0.9
No SP&BP	1	1.9	3	0.6

Feature 37: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	0	0
No Cortex	0	0	1	0.6

Feature 37: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	0	0	0	0
No SP&BP	0	0	2	0.8

Feature 37: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	1	1.6	0	0
No Cortex	1	3.8	2	0.6

Feature 37: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	1	3.8	1	0.1
No SP&BP	1	1.6	1	0.5

Feature 39 Southern Excavation Area

Feature 39: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	2	3.9	3	1
No Cortex	2	6.3	9	18

Feature 39: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	0	0	4	1.2
No SP&BP	4	10.2	8	2.5

Feature 39: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	2	6.5	0	0
No Cortex	0	0	24	5.8

Feature 39: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	1	3.6	10	2.4
No SP&BP	1	2.9	15	3.9

Feature 39: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	3	47.8	4	2.1
No Cortex	7	55.3	27	7

Feature 39: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	6	53.1	6	1.5
No SP&BP	4	40	26	7.6

Feature 40 Southern Excavation Area

Feature 40: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	0	0
No Cortex	1	6.3	6	1.25

Feature 40: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	1	6.3	2	0.2
No SP&BP	0	0	4	1.05

Feature 40: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	0	0
No Cortex	2	2.4	10	2.6

Feature 40: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	0	0	2	0.2
No SP&BP	2	2.4	8	2.4

Feature 40: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	1	5.5	0	0
No Cortex	2	1.6	6	0.7

Feature 40: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	2	6.6	6	0.7
No SP&BP	1	0.5	0	0

Feature 45 Southern Excavation Area

Feature 45: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	0	0
No Cortex	0	0	7	2.1

Feature 45: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	0	0	2	0.6
No SP&BP	0	0	5	1.5

Feature 45: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	1	1.5	0	0
No Cortex	1	2.4	6	1.05

Feature 45: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	1	1.5	4	0.95
No SP&BP	1	2.4	2	0.1

Feature 45: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	0	0	2	0.15
No Cortex	2	4.6	7	3.55

Feature 45: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	0	0	1	0.1
No SP&BP	2	4.6	8	3.6

Feature 46 Southern Excavation Area

Feature 46: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	1	2.2	5	5.4
No Cortex	2	11.2	12	5.3

Feature 46: Other Raw Material

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	1	7.8	6	2.9
No SP&BP	1	3.4	11	7.8

Feature 46: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	1	64	0	0
No Cortex	1	22.6	25	6.8

Feature 46: Non-Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	2	86.6	12	1.5
No SP&BP	0	0	13	5.3

Feature 46: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
Cortex	2	39	4	22
No Cortex	2	2.1	30	6.15

Feature 46: Local Obsidian

	G1 & G2	weight	G3, G4, & G5	weight
SP & BP	1	1.9	8	1
No SP&BP	3	41	26	7.35

Tree Frog XRF Results and Source Designation

Values in parts per million (ppm) except total iron (in weight percent) and Fe/Mn; +/- =estimate (in ppm and weight %) of x-ray counting uncertainty and regression fitting error at 300 and 600 (*) livetime; nm=not measured (Hughes 1998b. 1).

Values in parts per million (ppm) except total iron (in weight percent) and Fe/Mn; +/- =estimate (in ppm and weight %) of x-ray counting uncertainty and regression fitting error at 300 and 600 (*) livetime; nm=not measured (Hughes 1998a:1-2).

Values in parts per million (ppm) except total iron (in weight percent) and Fe/Mn; +/- =estimate (in ppm and weight %) of x-ray counting uncertainty and regression fitting error at 300 and 600 (*) livetime; nm=not measured (Hughes 1998a:3).

Tree Frog XRF Results and Source Designation (Hughes 1998a)

		Trace and Selected Minor Element Concentrations--Unworked Cobbles										Ratio	
Specimen #	Zn	Ga	Rb	Sr	Y	Zr	Nb	Ba	Ti	Mn	$Fe_2O_3^T$	Fe/Mn	Obsidian Source
Area B-1	72 +/-6	18 +/-3	165 +/-4	19 +/-3	62 +/-3	322 +/-4	49 +/-3	904 +/-14	1088+/-21	363 +/-8	1.99+/-.08	nm	Huckleberry Ridge?
Area B-2	75 +/-6	18 +/-3	172 +/-4	19 +/-3	58 +/-3	330 +/-4	45 +/-3	915 +/-14	1178+/-23	361 +/-8	2.04+/-.08	nm	Huckleberry Ridge?
Area B-3	76 +/-6	18 +/-3	175 +/-4	24 +/-3	64 +/-3	331 +/-4	49 +/-3	1002 +/-1	1196+/-24	375 +/-8	2.08+/-.08	nm	Huckleberry Ridge?
Area B-4	73 +/-5	19 +/-3	166 +/-4	20 +/-3	60 +/-3	327 +/-4	48 +/-3	901 +/-14	1113+/-20	343 +/-8	1.93+/-.08	nm	Huckleberry Ridge?
Area B-5	72 +/-5	21 +/-3	169 +/-4	22 +/-3	60 +/-3	315 +/-4	48 +/-3	854 +/-14	1042+/-20	345 +/-8	1.94+/-.08	nm	Huckleberry Ridge?
Area B-6	68 +/-6	20 +/-3	162 +/-4	20 +/-3	63 +/-3	355 +/-4	48 +/-3	943 +/-14	1210+/-22	396 +/-8	2.15+/-.08	nm	Huckleberry Ridge?
Area B-7	68 +/-6	17 +/-3	166 +/-4	20 +/-3	58 +/-3	317 +/-4	46 +/-3	866 +/-14	1077+/-22	342 +/-8	1.93+/-.08	nm	Huckleberry Ridge?
Area B-8	70 +/-5	15 +/-3	168 +/-4	21 +/-3	62 +/-3	328 +/-4	46 +/-3	860 +/-14	1124+/-20	350 +/-8	1.96+/-.08	nm	Hucklebery Ridge?
Area B-9	72 +/-5	14 +/-3	160 +/-4	19 +/-3	58 +/-3	317 +/-4	45 +/-3	888 +/-14	1073+/-20	359 +/-8	1.94+/-.08	nm	Huckleberry Ridge?
Area B-10	75 +/-5	14 +/-3	164 +/-4	19 +/-3	58 +/-3	314 +/-4	50 +/-3	891 +/-14	1117+/-21	344+/-8	2.0 +/-.08	nm	Huckleberry Ridge?
Area C-1	78 +/-5	17 +/-3	169 +/-4	20 +/-3	62 +/-3	324 +/-4	49 +/-3	915 +/-14	1165+/-20	352 +/-8	1.95+/-.08	nm	Huckleberry Ridge?
Area C-2	82 +/-5	24 +/-3	163 +/-4	19 +/-3	61 +/-3	352 +/-4	50 +/-3	958 +/-14	1224+/-22	381 +/-8	2.13+/-.08	nm	Huckleberry Ridge?
Area C-3	76 +/-6	18 +/-3	161 +/-4	21 +/-3	60 +/-3	339 +/-4	46 +/-3	945 +/-14	1188+/-22	382 +/-8	2.09+/-.08	nm	Huckleberry Ridge?
Area C-4	64 +/-6	16 +/-3	164 +/-4	21 +/-3	62 +/-3	347 +/-4	45 +/-3	931 +/-14	1186+/-23	392 +/-8	2.15+/-.08	nm	Huckleberry Ridge?
Area C-5	77 +/-5	16 +/-3	159 +/-4	19 +/-3	59 +/-3	336 +/-4	47 +/-3	961 +/-14	1071+/-20	364 +/-8	1.97+/-.08	nm	Huckleberry Ridge?
Area C-6	84 +/-5	18 +/-3	168 +/-4	22 +/-3	63 +/-3	366 +/-4	49 +/-3	1009+/-14	1271+/-23	399 +/-8	2.18+/-.08	61	Huckleberry Ridge?
Area C-7	74 +/-5	17 +/-3	167 +/-4	21 +/-3	63 +/-3	360 +/-4	46 +/-3	1029+/-15	1209+/-22	387 +/-8	2.13+/-.08	61	Huckleberry Ridge?
Area C-8	73 +/-6	18 +/-3	162 +/-4	19 +/-3	60 +/-3	347 +/-4	44 +/-3	949 +/-14	1132+/-22	375 +/-8	2.11+/-.08	60	Huckleberry Ridge?
Area C-9	72 +/-5	17 +/-3	164 +/-4	19 +/-3	64 +/-3	348 +/-4	45 +/-3	967 +/-14	1126+/-21	376 +/-8	2.07+/-.08	59	Huckleberry Ridge?
Area C-10	78 +/-5	18 +/-3	163 +/-4	18 +/-3	60 +/-3	351 +/-4	49 +/-3	1020+/-15	1040+/-21	365 +/-8	1.96+/-.08	61	Huckleberry Ridge?

Appendix B X-Ray Fluorescence Results

Tree Frog XRF Results and Source Designation (Hughes 1998b)

		Trace and Selected Minor Element Concentrations										Ratio	
Specimen #	Zn	Ga	Rb	Sr	Y	Zr	Nb	Ba	Ti	Mn	$Fe_2O_3^T$	Fe/Mn	Obsidian Source
S98-1	87 +/-6	26 +/-3	246 +/-4	6 +/-3	71 +/-3	158 +/-4	41 +/-3	nm	nm	nm	nm	nm	Obsidian Cliff, WY
S98-2	213 +/-7	24 +/-3	335 +/-4	5 +/-3	120 +/-3	1015+/-7	112 +/-3	nm	1279+/-20	491 +/-9	3.58+/-.08	nm	Unknown
S98-3	93 +/-6	20 +/-3	248 +/-4	5 +/-3	78 +/-3	167 +/-4	41 +/-3	nm	nm	nm	nm	nm	Obsidian Cliff, WY
S98-4	91 +/-8	20 +/-4	185 +/-4	20 +/-3	67 +/-3	398 +/-5	55 +/-3	1110+/-17	1371+/-25	370 +/-9	2.02+/-.08	64	Huckleberry Ridge?
S98-5	63 +/-6	19 +/-3	169 +/-4	43 +/-3	40 +/-3	272 +/-4	49 +/-3	nm	nm	nm	nm	nm	Bear Gulch, ID
S98-6	51 +/-6	19 +/-3	132 +/-4	74 +/-3	28 +/-3	88 +/-4	7 +/-3	1607+/-19	nm	nm	nm	nm	Malad, ID
S98-7	64 +/-5	16 +/-3	188 +/-4	18 +/-3	38 +/-3	58 +/-4	31 +/-3	nm	nm	713 +/-8	.53 +/-.08	nm	Timber Butte, ID
S98-8	69 +/-6	18 +/-3	184 +/-4	46 +/-3	41 +/-3	289 +/-4	50 +/-3	nm	nm	nm	nm	nm	Bear Gulch, ID
S98-9	295 +/-7	38 +/-3	318 +/-4	3 +/-3	238 +/-3	322 +/-4	307 +/-3	nm	nm	nm	nm	nm	Big Southern Butte, ID
S98-10	85 +/-6	19 +/-3	241 +/-4	4 +/-3	74 +/-3	160 +/-4	40 +/-3	nm	nm	nm	nm	nm	Obsidian Cliff, WY
S98-11	59 +/-6	17 +/-3	179 +/-4	46 +/-3	40 +/-3	282 +/-4	46 +/-3	nm	nm	nm	nm	nm	Bear Gulch, ID
S98-12	68 +/-6	17 +/-3	184 +/-4	46 +/-3	40 +/-3	282 +/-4	51 +/-3	nm	nm	nm	nm	nm	Bear Gulch, ID
S98-13	68 +/-5	16 +/-3	188 +/-4	24 +/-3	57 +/-3	215 +/-4	42 +/-3	976 +/-14	nm	327 +/-8	1.35+/-.08	45	Unknown
S98-14	66 +/-6	15 +/-3	161 +/-4	19 +/-3	60 +/-3	329 +/-4	49 +/-3	921 +/-14	1293+/-21	365+/-8	2.03+/-.08	61	Huckleberry Ridge?
S98-15	64 +/-6	17 +/-3	182 +/-4	43 +/-3	39 +/-3	287 +/-4	52 +/-3	nm	nm	nm	nm	nm	Bear Gulch, ID
S98-16	56 +/-6	13 +/-3	161 +/-4	41 +/-3	40 +/-3	263 +/-4	48 +/-3	689 +/-14	nm	nm	nm	nm	Bear Gulch, ID
S98-17	67 +/-5	15 +/-3	166 +/-4	18 +/-3	58 +/-3	317 +/-4	47 +/-3	nm	nm	nm	nm	nm	Huckleberry Ridge?

Tree Frog XRF Results and Source Designation (Hughes 1998a)

		Trace and Selected Minor Element Concentrations										Ratio	
Specimen #	Zn	Ga	Rb	Sr	Y	Zr	Nb	Ba	Ti	Mn	$Fe_2O_3^T$	Fe/Mn	Obsidian Source
S-1	84 +/-6	18 +/-3	184 +/-4	48 +/-3	44 +/-3	287 +/-4	50 +/-3	693 +/-15	nm	nm	nm	nm	Bear Gulch, ID
S-2	94 +/-6	17 +/-3	172 +/-4	22 +/-3	67 +/-3	385 +/-4	48 +/-3	1058+/-16	1195+/-24	361 +/-9	2.08+/-.08	nm	Huckleberry Ridge?
S-3	66 +/-6	20 +/-3	185 +/-4	47 +/-3	42 +/-3	288 +/-4	51 +/-3	676 +/-16	1501+/-24	326 +/-8	1.72+/-.08	nm	Bear Gulch, ID
S-4	65 +/-6	16 +/-3	177 +/-4	45 +/-3	40 +/-3	284 +/-4	47 +/-3	nm	nm	nm	nm	nm	Bear Gulch, ID
S-5	76 +/-6	20 +/-3	177 +/-4	47 +/-3	42 +/-3	289 +/-4	53 +/-3	nm	nm	nm	nm	nm	Bear Gulch, ID
S-6	81 +/-6	18 +/-3	190 +/-4	25 +/-3	57 +/-3	210 +/-4	39 +/-3	903 +/-15	1302+/-21	323 +/-8	1.36+/-.08	46	Unknown
S-7	62 +/-5	20 +/-3	165 +/-4	40 +/-3	38 +/-3	279 +/-4	49 +/-3	nm	nm	nm	nm	nm	Bear Gulch, ID
S-8	79 +/-5	19 +/-3	165 +/-4	19 +/-3	61 +/-3	356 +/-4	49 +/-3	nm	nm	nm	nm	60	Hucklebery Ridge?
S-9	61 +/-5	14 +/-3	170 +/-4	44 +/-3	39 +/-3	277 +/-4	49 +/-3	nm	nm	nm	nm	nm	Bear Gulch, ID
S-10	65 +/-5	18 +/-3	172 +/-4	44 +/-3	41 +/-3	282 +/-4	53 +/-3	nm	nm	nm	nm	nm	Bear Gulch, ID
S-11	79 +/-6	16 +/-3	171 +/-4	22 +/-3	64 +/-3	364 +/-4	51 +/-3	nm	nm	nm	nm	62	Huckleberry Ridge?
S-12	68 +/-6	20 +/-3	181 +/-4	47 +/-3	42 +/-3	293 +/-4	51 +/-3	nm	nm	nm	nm	nm	Bear Gulch, ID
S-13	80 +/-5	18 +/-3	177 +/-4	23 +/-3	65 +/-3	342 +/-4	51 +/-3	nm	nm	nm	nm	65	Huckleberry Ridge?
S-14	70 +/-6	15 +/-3	185 +/-4	45 +/-3	42 +/-3	291 +/-4	51 +/-3	nm	nm	nm	nm	nm	Bear Gulch, ID
S-15	67 +/-5	13 +/-3	181 +/-4	45 +/-3	40 +/-3	287 +/-4	53 +/-3	nm	nm	nm	nm	nm	Bear Gulch, ID
S-16													
S-17	75 +/-6	17 +/-3	188 +/-4	45 +/-3	44 +/-3	299 +/-4	52 +/-3	nm	nm	nm	nm	nm	Bear Gulch, ID
S-18	75 +/-6	18 +/-3	179 +/-4	22 +/-3	62 +/-3	332 +/-4	48 +/-3	nm	nm	nm	nm	64	Huckleberry Ridge?
S-19	66 +/-6	21 +/-3	173 +/-4	21 +/-3	62 +/-3	340 +/-4	49 +/-3	nm	nm	nm	nm	60	Huckleberry Ridge?
S-20	77 +/-6	14 +/-3	160 +/-4	20 +/-3	64 +/-3	322 +/-4	46 +/-3	nm	nm	nm	nm	61	Huckleberry Ridge?
S-21	59 +/-5	19 +/-3	172 +/-4	44 +/-3	42 +/-3	283 +/-4	49 +/-3	nm	nm	nm	nm	nm	Bear Gulch, ID
S-22	77 +/-6	24 +/-3	197 +/-4	17 +/-3	40 +/-3	53 +/-4	29 +/-3	nm	270 +/-12	737 +/-8	.55+/-.08	nm	Timber Butte, ID
S-23	60 +/-6	18 +/-3	186 +/-4	41 +/-3	41 +/-3	258 +/-4	49 +/-3	592 +/-14	nm	nm	nm	nm	Bear Gulch, ID
S-24	69 +/-6	24 +/-3	180 +/-4	48 +/-3	44 +/-3	297 +/-4	55 +/-3	750 +/-16	nm	nm	nm	nm	Bear Gulch, ID
S-25	82 +/-6	20 +/-3	172 +/-4	19 +/-3	61 +/-3	337 +/-4	48 +/-3	991 +/-15	nm	nm	nm	61	Huckleberry Ridge?
S-26	71 +/-6	25 +/-3	196 +/-4	17 +/-3	41 +/-3	52 +/-4	31 +/-3	2 +/-13	259+/-11	755+/-8	.56 +/-.08	nm	Timber Butte, ID
S-27	79 +/-6	19 +/-3	185 +/-4	48 +/-3	43 +/-3	293 +/-4	54 +/-3	733 +/-15	nm	nm	nm	nm	Bear Gulch, ID
S-28	66 +/-5	21 +/-3	167 +/-4	44 +/-3	41 +/-3	276 +/-4	49 +/-3	nm	nm	nm	nm	nm	Bear Gulch, ID
S-29	69 +/-5	18 +/-3	179 +/-4	46 +/-3	40 +/-3	287 +/-4	49 +/-3	nm	nm	nm	nm	nm	Bear Gulch, ID
S-30	66 +/-3	17 +/-3	184 +/-4	47 +/-3	43 +/-3	290 +/-4	50 +/-3	nm	nm	nm	nm	nm	Bear Gulch, ID
S-31	209 +/-6	23 +/-3	328 +/-4	4 +/-3	112+/-3	997 +/-6	111+/-3	0 +/-20	1017+/-18	510 +/-9	3.68+/-.08	nm	Unknown

Appendix B X-Ray Fluorescence Results

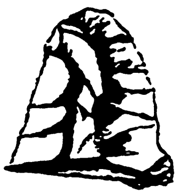
Tree Frog Obsidian Hydration Results (Origer 1999)

Lab #	Specimen #	Description	Feature Area	Measurements	Mean
1	S98-16	Debitage	North Half	1.4 1.4 1.5 1.5 1.5 1.6	1.5
2	S98-17	Debitage	North Half	1.4 1.4 1.4 1.4 1.5 1.5	1.4
3	S98-18	Debitage	North Half	3.9 3.9 3.9 4.0 4.1 4.2	4
4	S98-19	Debitage	North Half	1.2 1.2 1.2 1.3 1.3 1.3	1.3
5	S98-20	Debitage	North Half	1.0 1.1 1.1 1.1 1.1 1.1	1.1
6	S98-21	Debitage	North Half	3.3 3.4 3.4 3.4 3.4 3.5	3.4
7	S98-22	Debitage	North Half	3.4 3.4 3.4 3.4 3.5 3.5	3.4
8	S98-23	Debitage	North Half	1.3 1.3 1.4 1.4 1.4 1.5	1.4
9	S98-24	Debitage	North Half	1.1 1.1 1.1 1.1 1.1 1.1	1.1
10	S98-25	Debitage	North Half	1.1 1.1 1.1 1.2 1.2 1.2	1.2
11	S98-26	Debitage	North Half	1.4 1.4 1.4 1.5 1.5 1.5	1.5
12	S98-27	Debitage	North Half	1.0 1.0 1.1 1.1 1.1 1.1	1.1
13	S98-28	Debitage	North Half	1.1 1.1 1.1 1.2 1.2 1.2	1.2
14	S98-29	Debitage	North Half	1.8 1.8 1.9 1.9 1.9 2.1	1.9
15	S98-30	Debitage	North Half	1.3 1.4 1.4 1.4 1.4 1.5	1.4
16	S98-31	Debitage	North Half	1.1 1.1 1.1 1.1 1.1 1.1	1.1
17	S98-32	Debitage	North Half	3.0 3.0 3.0 3.0 3.2 3.2	3.1
18	S98-33	Debitage	North Half	1.5 1.5 1.5 1.6 1.6 1.6	1.6
19	S98-34	Debitage	North Half	1.9 2.0 2.0 2.0 2.0 2.0	2
20	S98-35	Debitage	North Half	1.1 1.1 1.1 1.2 1.2 1.2	1.2
21	S98-36	Debitage	North Half	1.1 1.1 1.2 1.2 1.2 1.3	1.2
22	S98-37	Debitage	North Half	1.3 1.3 1.3 1.3 1.3 1.3	1.3
23	S98-38	Debitage	North Half	No visible hydration	n/a
24	S98-39	Debitage	North Half	1.8 1.8 1.9 2.0 2.0 2.1	1.9
25	S98-40	Debitage	North Half	1.3 1.3 1.3 1.4 1.4 1.4	1.4
26	S98-41	Debitage	South Half	1.0 1.0 1.1 1.1 1.1 1.1	1.1
27	S98-42	Debitage	South Half	1.1 1.1 1.1 1.1 1.1 1.1	1.1
28	S98-43	Debitage	South Half	No visible hydration	n/a
29	S98-44	Debitage	South Half	1.0 1.1 1.1 1.1 1.1 1.1	1.1
30	S98-45	Debitage	South Half	1.1 1.1 1.1 1.1 1.2 1.2	1.1
31	S98-46	Debitage	South Half	5.6 5.6 5.7 5.7 5.7 5.9	5.7
32	S98-47	Debitage	South Half	1.0 1.0 1.0 1.1 1.1 1.1	1.1
33	S98-48	Debitage	South Half	0.9 0.9 1.0 1.0 1.0 1.0	1
34	S98-49	Debitage	South Half	No visible hydration	n/a
35	S98-50	Debitage	South Half	1.0 1.0 1.0 1.0 1.0 1.1	1
36	S98-51	Debitage	South Half	1.1 1.1 1.2 1.2 1.3 1.3	1.2
37	S98-52	Debitage	South Half	0.9 0.9 0.9 1.0 1.0 1.0	1
38	S98-53	Debitage	South Half	0.8 0.9 0.9 0.9 1.0 1.0	0.9
39	S98-54	Debitage	South Half	1.0 1.0 1.1 1.1 1.1 1.1	1.1
40	S98-55	Debitage	South Half	1.0 1.0 1.0 1.0 1.0 1.0	1
41	S98-56	Debitage	South Half	0.9 0.9 0.9 1.0 1.0 1.0	1
42	S98-57	Debitage	South Half	1.1 1.1 1.1 1.2 1.2 1.2	1.2
43	S98-58	Debitage	South Half	1.1 1.2 1.2 1.2 1.2 1.3	1.2
44	S98-59	Debitage	South Half	1.4 1.4 1.5 1.6 1.6 1.6	1.5
45	S98-60	Debitage	South Half	1.0 1.1 1.1 1.1 1.1 1.2	1.1
46	S98-61	Debitage	South Half	No visible hydration	n/a
47	S98-62	Debitage	South Half	No visible hydration	n/a
48	S98-63	Debitage	South Half	1.2 1.3 1.3 1.3 1.3 1.3	1.3
49	S98-64	Debitage	South Half	1.2 1.2 1.2 1.2 1.2 1.3	1.2
50	S98-65	Debitage	South Half	0.9 1.0 1.0 1.0 1.0 1.1	1

Appendix C Obsidian Hydration Results

Northern Area
Non-local Obsidian

Southern Area
Silicate

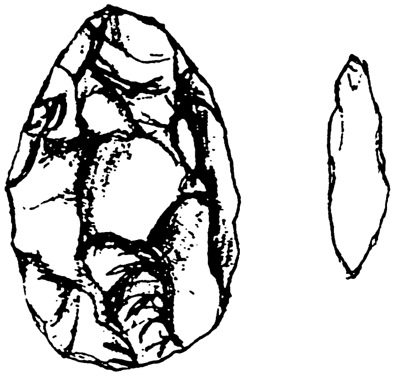


Northern Area
Silicate

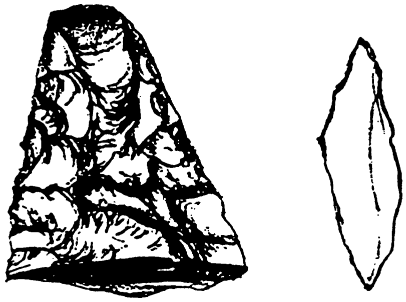
Southern Area
Non-local Obsidian

Northern Area
Non-local Obsidian

Northern Area
Non-local Obsidian



Southern Area
Silicate



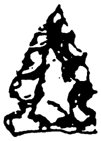
Surface Collection
Non-local Obsidian
S98-5

0 cm 2

Appendix D Formal Tool Illustrations

Southern Area
Silicate

Northern Area
Silicate



Northern Area
Non-local Obsidian
S98-1

Southern Area
Non-local Obsidian
S98-2

Southern Area
Non-local Obsidian
S98-4

Southern Area
Non-local Obsidian
S98-6

Southern Area
Non-local Obsidian
S98-7

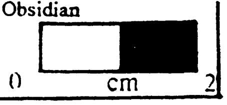
Southern Area
Non-local Obsidian
S98-9

Southern Area
Non-local Obsidian
S98-10

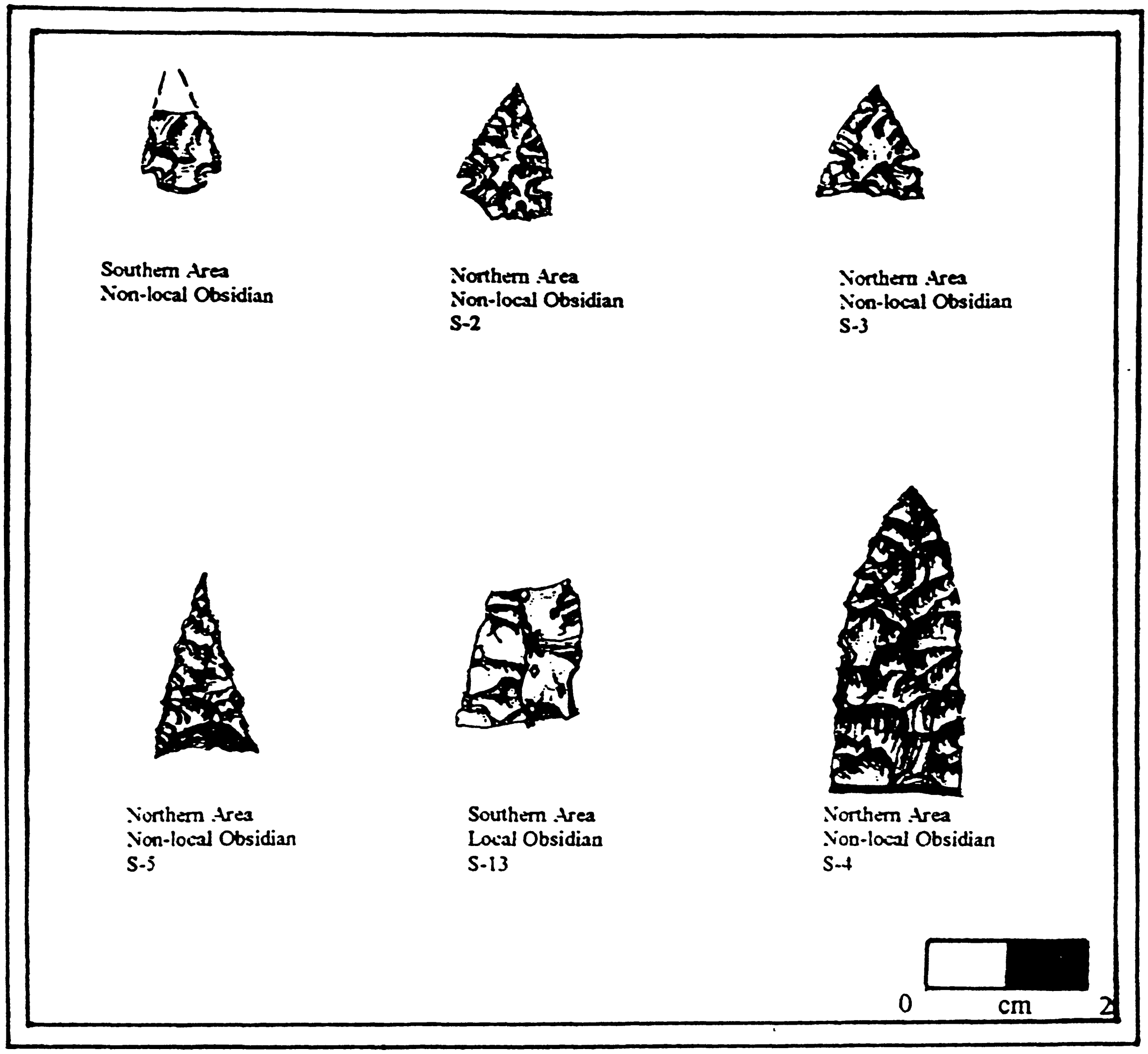
Northern Area
Non-local Obsidian
S98-11

Southern Area
Non-local Obsidian
S98-12

Northern Area
Non-local Obsidian
S98-13



Appendix D Formal Tool Illustrations



Southern Area
Non-local Obsidian

Northern Area
Non-local Obsidian
S-2

Northern Area
Non-local Obsidian
S-3

Northern Area
Non-local Obsidian
S-5

Southern Area
Local Obsidian
S-13

Northern Area
Non-local Obsidian
S-4

Appendix D Formal Tool Illustrations

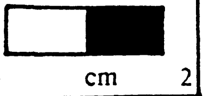
Southern Area
Iron

Surface Collection
Iron

Southern Area
Brass

Surface Collection
Iron

Surface Collection
Wire-wound Glass Bead



Appendix D Formal Tool Illustrations