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BONE CAVE: A SEVERELY DISTURBED CAVE SITE IN CENTRAL OREGON

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ABSTRACT

The presence of obsidian artifacts available for hydration and sourcing analysis, a high concentration of well-preserved faunal remains, a limited time span of occupation, and a wealth of obsidian research in the region, make Bone Cave an ideal example of an often ignored class of archaeological site. Although highly disturbed, analysis of the excavation results allowed us to determine that Bone Cave served as a probable pre-Mazama (prior to 6850 B.P.) rabbit processing site during the Early Holocene. The disturbed site of Bone Cave shows that field research is possible even in a region or political environment in which the excavation of intact sites is not.

INTRODUCTION

In many areas of the arid western United States, the presence of lava tube caves in flows of basalt offer a unique natural setting often associated with archaeological remains. As attractive as these tubes sometimes were as a prehistoric environment, providing a combination of shelter and late season or perennial water, they have proven equally compelling in their ability to attract historic and modern-day amateur archaeologists and looters. Here we discuss our experiences with a lava tube near Bend, Oregon, and describe obsidian and faunal analyses aimed at recovering information about the time of occupation, raw material procurement patterns, and subsistence practices from this severely disturbed site.

The primary objectives were to assess the extent of damage and disturbance caused by several decades of looting activity, to locate undisturbed deposits, and to determine the function and chronology of the site. Looting at the site not only destroyed the context of all sediments encountered in the excavation but also likely resulted in the removal of all culturally and chronologically diagnostic tools and tool fragments. Although many lava tube caves are known to exist in the region surrounding the town of Bend, Oregon, only a few of them—Young's Cave, Charcoal Cave, and the caves of Lava Top Butte—have received even the briefest archaeological attention (Cressman and Perry, 1938; Simmons, 1983, 1984; Skinner, 1983).

Severely disturbed sites, whether the result of cultural or natural processes, often receive little attention from archaeologists. These may be occasionally ignored or deemed unworthy of study, particularly in cultural resource management projects (Talmage et al., 1977). While intact sites certainly contain significant contextual information and diagnostic artifacts that are often missing from looted or disturbed locales, a great deal of information may still be salvageable from these sites. This is especially important in regions where archaeological research is limited by Indian tribes and government agencies to eminently threatened or previously disturbed sites. Varieties of different analytical techniques have been employed in disturbed site archaeology and will almost certainly constitute an increasing portion of future research (Talmage et al., 1977).

BACKGROUND

Bone Cave is located immediately east of the city of Bend in the northwestern portion of the High Lava Plains province of central Oregon, a transitional region between the Great Basin and the Columbia Plateau (see Figure 1). The area in which the cave is found consists of late Pleistocene to early Holocene basalt flows, cinder cones, and extensive lava tube systems (MacLeod, Sherrod, Chitwood, and Jensen, 1995) and is mantled by volcanic tephra from the 6,850 year-old eruption of Mt. Mazama (Bacon, 1983). The lava tube under study is associated with the Horse Lava Tube System, a complex group of tube segments and collapse depressions ranging in length from a few meters to over a kilometer that are found in basalt flows originating on the northern slopes of nearby Newberry Volcano (Greeley, 1971; Larson, 1982). Access to Bone Cave is through an opening in the roof of the cave created when a portion of the previously intact underground tube collapsed.

Excavation of the cave was carried out in the summer of 1998 and included six 1 × 2 meter excavation units distributed in an effort to sample a large area of the site and to avoid large looter backdirt piles (see Figure 2). No natural stratigraphy was evident and excavations proceeded using 10 cm arbitrary levels with all recovered fill screened through 1/8 inch mesh.

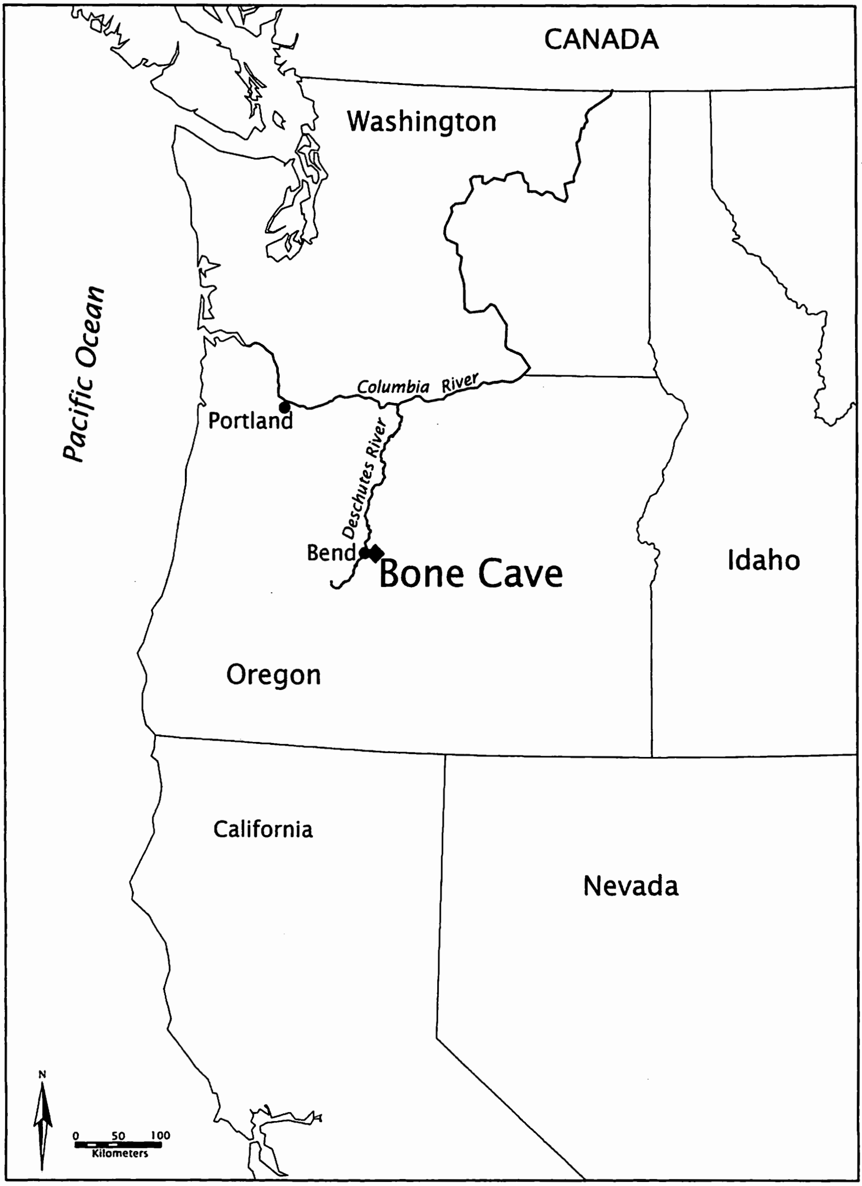

Figure 1. Location of Bone Cave (35-DS-1469).

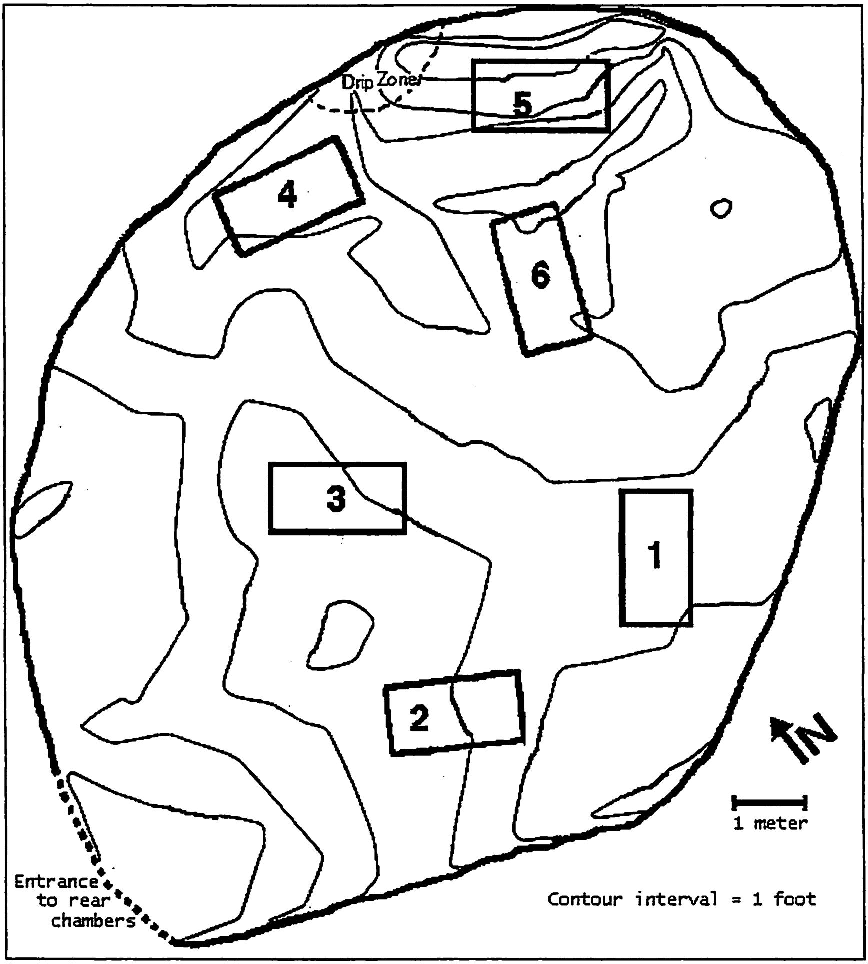

Figure 2. Map of the interior of the front chamber of Bone Cave showing excavation unit locations.

Excavation was halted after faunal remains questionably determined to be human were recovered and immediately reburied in two units; at that time, only Unit 1 had been excavated to bedrock (or at least a very large roof-fall) at a depth of 130 cm below the original surface. Although more than 10 cu m were removed from the site before excavation was discontinued, no undisturbed deposits were encountered. The assortment of recent materials found intermixed with prehistoric artifacts throughout the deposits included 22 caliber bullet casings, cigarette butts and cartons, boards, beer bottles and bottle caps, and soft drink cans. Much of the historic debris is less than 15 years old and, given the extent of the disturbance, it is likely that the looters have occasionally excavated (or at least relocated) the same material more than once.

In general, the faunal, lithic, and historic artifacts maintained a consistent distribution throughout the site. Bone and lithic debris were concentrated in the upper levels in the center of the chamber, yet almost all excavation levels yielded all three classes of artifacts. The only features noted during the excavation were small pockets of loose rock and bone over 1/4 inch that probably resulted from looters dumping the larger material that did not fall through their screens.

In addition to the historic debris, the excavations produced nearly 3,000 lithic artifacts, all of them chipped stone tools and debitage. Only ten lithic tool fragments were recovered—eight small biface fragments, one retouched flake, and one possible bifacial core (see Figure 3). Only a sample of the faunal material was counted and analyzed, but a conservative estimate of more than 25,000 individual bones and bone fragments were recovered from the site.

Overall, the degree of disturbance found at the site was considerably greater than anticipated, and the presence of modern debris in the lowest levels of all excavated units points to extensive looting as recent as the 1980s. The next task in the investigation of the Bone Cave Site was to choose analytical and interpretive methods that would allow us to recover significant information about the site, even in its obviously disturbed condition. Given the abundance of debitage, obsidian, and faunal material, we decided to use these materials to approach the questions of site function and chronology.

LITHIC ANALYSIS

The condition of the assemblage necessitated a shift away from the analysis of formal tools, a probable quarry of the pothunters, to the debitage that was left behind (Gaston, 1983). Lithic debitage analysis is capable of revealing tool-use and production behavior that is often not evident in the complementary assemblage of curated tools, and debitage is also least subject to both modern and prehistoric collection (Shott, 1994). Archaeological analyses generally examine differences between artifact assemblages in different areas and excavation levels at a site. Given the disturbed nature of the Bone Cave deposits, analysis by intra-site provenience was impossible and potentially misleading. Archaeological and ethnological data on rockshelter occupations demonstrate that individuals and groups inhabiting closed sites often differentiate activity areas based on the availability of outside light and other physical features of the shelter (Walthall, 1998). Given the differential light distribution within the front chamber (very light near the entrance and near complete darkness in the rear), it seemed possible that some activity differences exhibited in the debitage may have still been preserved between the front, middle, and rear of the front chamber (assuming the material was redeposited in the same general area by the looters). Similar volumes were excavated from each of the areas, resulting in less than a 13%

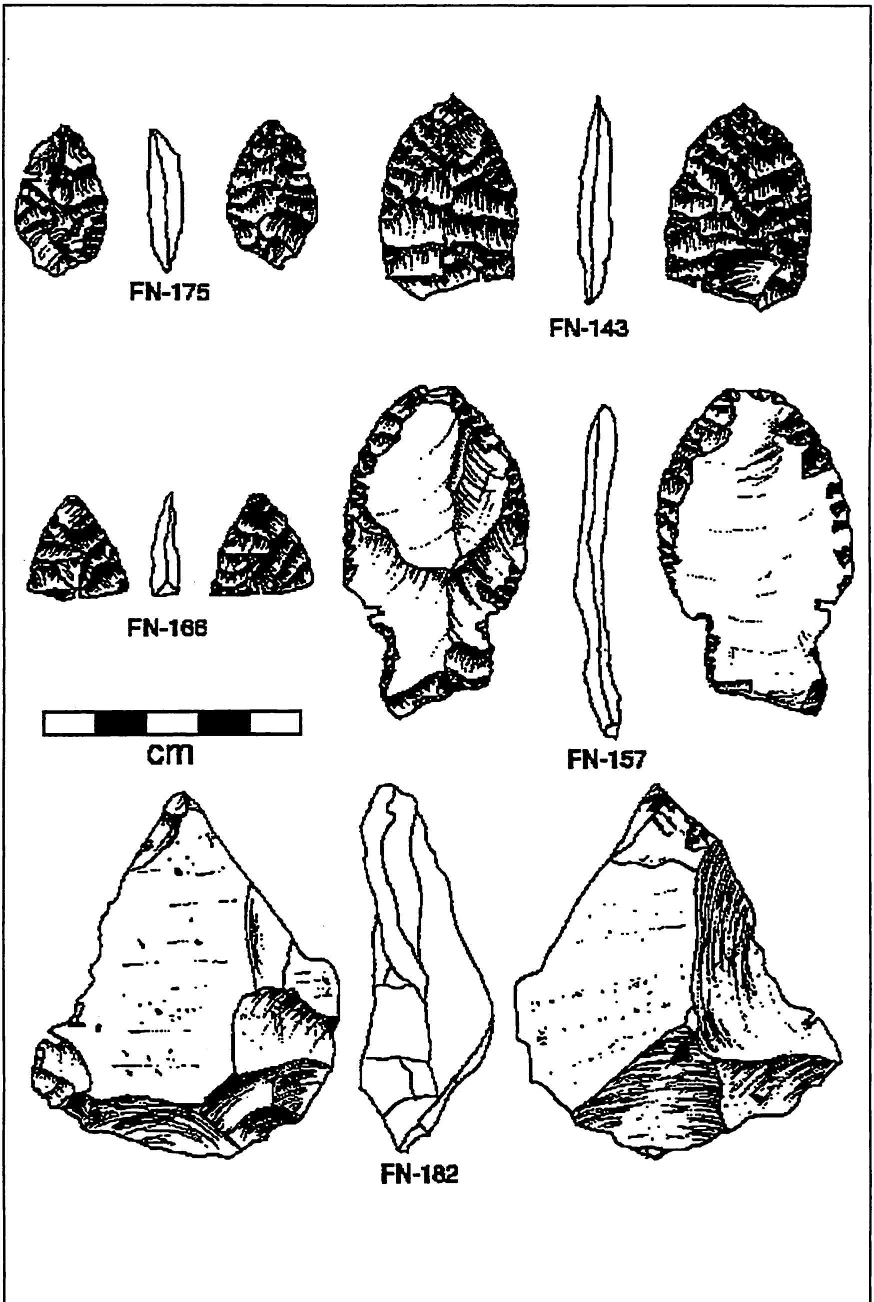

Figure 3. Complete assemblage of obsidian tools recovered from Bone Cave.

difference in total flake count or total weight between the three areas. The most direct method to detect major differences in the general stage of reduction is the comparison of flake size frequency distributions (Shott, 1994) which resulted in no more than a 7% difference for the three areas. With no substantial differences between the front, middle and rear of the site with regard to reduction stage, the entire debitage assemblage was pooled for further analysis. This is further supported by the limited site occupation described later in the discussion of the obsidian hydration results.

Obsidian comprises more than 92% (n = 2756) of the debitage, with other materials comprising the remaining portion of the assemblage (see Figure 4). The material types differ in physical qualities that can affect many aspects of lithic reduction and tool production (Amick and Mauldin, 1997; Ingbar, 1994). If particular materials were utilized for the production of expedient flake tools, this should produce a larger average flake size class when compared to material that was used for specialized and/or curated tools that would require later stage reduction and repeated maintenance. Surprisingly, the fine-grained materials such as obsidian and chalcedony showed a similar size class distribution to the

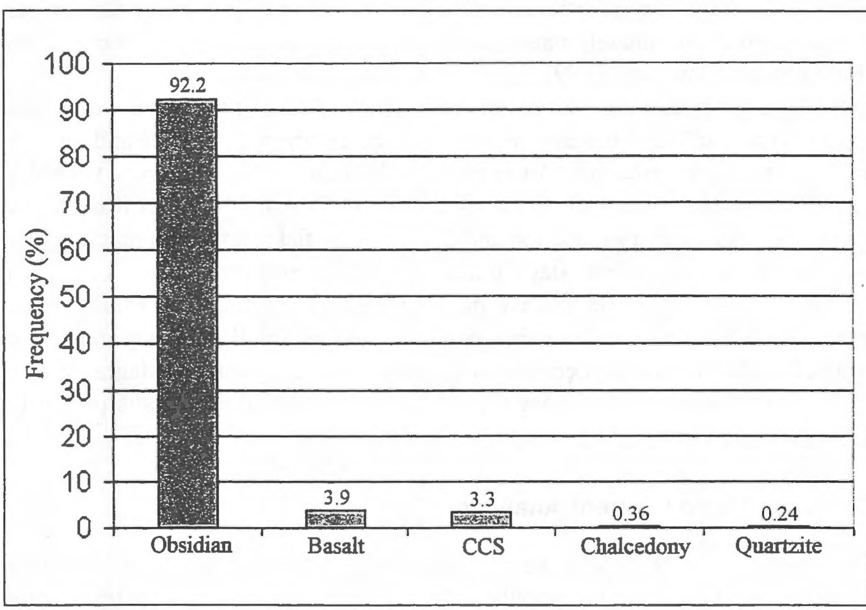

Figure 4. Percentage by count of various chipped stone raw materials.

coarse-grained basalt and quartzite assemblages, suggesting that the various raw materials at Bone Cave were used for similar tool production activities that produced similar debitage assemblages.

Size class distributions can provide information about the general stage of lithic reduction that occurred at the site (Mauldin and Amick, 1989). The size class frequency of the Bone cave assemblage is skewed toward smaller flakes, with more than 95% smaller than 2 cm and more than 65% less than 1 cm in maximum dimension. Shott (1994) suggests that assemblages skewed toward small debitage often result from late stage lithic reduction, tool repair, rejuvenation, and recycling, although the validity of forming a conclusion from only the flake size frequency distribution is questionable (Baumler and Downum, 1989). Though unlikely, it is possible that a significant number of the larger flakes were collected either by other prehistoric occupants or by the looters.

The conditions of the flakes from Bone Cave further support the idea that the dominant lithic reduction activities at the site involved late stage bifacial reduction and/or tool rejuvenation. When compared with the assemblages analyzed by Sullivan and Rozen (1985, recalculated to exclude tools) the Bone Cave assemblage closely matches the frequency of flake types (complete, proximal, fragments, and debris) for the tool production, and differs considerably from the distribution for core reduction (see Figure 5). Baumler and Downum (1989) disagree with the analysis of all flake types, and claim that the frequency of debris is the most diagnostic attribute in a debitage assemblage. The frequency of debris in the Bone Cave sample (8%) is well within the experimental range for scraper retouch, and approximately one-third the expected frequency for core reduction (Baumler and Downum, 1989).

Nearly all debitage analyses incorporate some measure of the amount of cortex on the dorsal surface of flakes in an attempt to determine the presence and relative amount of primary reduction (Andrefsky, 1994; Shott, 1994). Numerous variables can influence the amount of cortex (Sullivan and Rozen, 1985), yet it is clearly established that primary reduction and decortication flakes exhibit a much higher cortex frequency than late stage bifacial reduction and tool repair. Less than 4% of the flakes from Bone Cave have cortex and less than 2% exhibit more than 10% dorsal cortex. Assemblages dominated by small debitage and a low cortex frequency typically occur at logistical or emergency camps (Magne, 1989), which would be the case if Bone Cave was utilized as a logistical site primarily for processing game.

Obsidian Trace Element Analysis

The abundance of obsidian sources in the Northwestern Great Basin and their intensive use by prehistoric populations has resulted in frequent obsidian trace element characterization studies throughout the region. Most studies of North American hunter-gatherer lithic technology assume a direct access model of

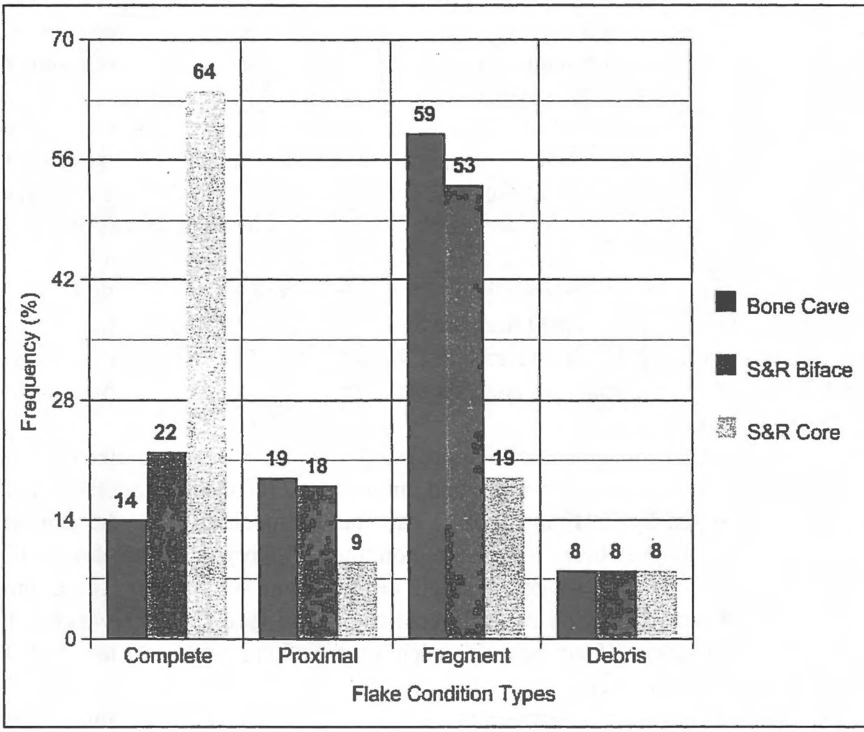

Figure 5. Frequency distribution of flake types from the Bone Cave debitage assemblage compared to Sullivan and Rozen's (1985) biface and core assemblages. The Sullivan and Rozen data has been recalculated to exclude tools and tool fragments.

raw material procurement unless otherwise indicated (Bouey and Basgall, 1984; Ingbar, 1994; Shackley, 1996). There is little evidence from the Northern Great Basin of extensive lithic raw material exchange systems. On the contrary, there is a general assumption of predominantly direct procurement (Minor and Toepel, 1989). The spatial distribution of lithic sources may indicate the extent of seasonal migration of a single group or multiple groups. Studies of obsidian procurement patterns often view the site as the center of occupation, and then examine lithic source use as movements away from the site to procure lithic and other embedded materials (Molyneaux, 2002). If Bone Cave served as a logistical site the source locations of obsidian artifacts may indicate the areas of the residential bases for the groups that utilized the site. Aikens (1993) notes that some Great Basin ethnographic groups traveled more than two hundred miles in a seasonal migration and groups traveling from Malheur, Harney, and Fort Rock Basins to the east and south may have used Bone Cave. Knowledge of the sources represented within an obsidian assemblage potentially provides information about seasonal movements, trade patterns, territorial boundaries, and the organization of lithic technology (Bettinger et al., 1984; Hughes, 1984; Shackley, 1996, Skinner, 1995a).

All of the obsidian tool and tool fragments as well as all of the debitage large enough for accurate X-ray fluorescence (XRF) analysis were subjected to trace element analysis, resulting in a sample of 221 artifacts. The samples were analyzed at the Northwest Research Obsidian Studies Laboratory using a Spectrace 5000 energy dispersive X-ray fluorescence spectrometer. Additional details about specific analysis methods for the XRF and obsidian hydration as well as all of the data presented here are available at www.obsidianlab.com. An additional sample of 53 of the smallest flakes recovered from the site was randomly selected for sourcing analysis using Instrumental Neutron Activation Analysis (INAA).

Seventeen geochemical obsidian sources, 12 of which were correlated with known geologic sources, were identified among the 274 obsidian artifacts that were characterized by XRF and INAA. The sources are located in the central High Cascades, the Newberry Volcano region, the periphery of the northwestern Great Basin, and, in the case of the single artifact from Whitewater Ridge, the Strawberry Mountains region of north-central Oregon (see Figure 6). Table 1 presents the numbers of artifacts for each source along with any associated hydration rim measurements.

The obsidian procurement pattern that emerges at Bone Cave is a combination of local (Big Obsidian Flow, East Lake Flow, McKay Butte, Quartz Mountain, Unknown X) and nonlocal (Brooks Canyon, Cougar Mountain, Glass Buttes, Whitewater Ridge, Obsidian Cliffs, Silver Lake/Sycan Marsh, Burns Butte, Rimrock Spring) acquisition. A particularly striking aspect of the characterized artifact collection is the minimal amount of obsidian from the Newberry Volcano chemical source in Newberry Crater. This composite geochemical source consists of several geochemically indistinguishable (using XRF methods) post-Mazama flows of obsidian that erupted in or near the Newberry Volcano caldera (MacLeod et al., 1995). Prehistoric use of the Newberry Volcano sources in the region to the west and north of the volcano following their eruption beginning about 6,500 years ago was both intensive and almost immediate. At numerous sites along the western slopes and margins of Newberry Volcano, the post-Mazama period is dominated by use of glass from the Newberry Volcano sources while obsidian from the McKay Butte and Unknown X sources decreases markedly (Skinner, 1995a). With the presence of the Buried Obsidian Flow, McKay Butte, and Unknown X sources, the overall obsidian source pattern at Bone Cave closely resembles a typical pre-Mazama source assemblage (Skinner, 1995a). The five small flakes correlated with the East Lake Flow are the only evidence of any post-Mazama occupation of the site and most likely represent a chance use of the site after the eruption of Mt. Mazama that did not significantly contribute to the accumulation of faunal material. The possibility that almost all of the

Table 1. Summary of XRF, INAA, and Obsidian Hydration Analyses

Source	No. from INAA Analysis	No. from XRF Analysis	Total characterized artifacts	Percent of total	Obsidian Hydration Rim Measurements
McKay Butte	15	67	82	29.9	2.9, 3.4, 3.5, 3.7, 4.8, 4.8, 5.4, 5.5, 5.5, 5.7
Newberry Crater: Big Obsidian Flow	9	67	76	27.7	3.0, 3.3, 3.3, 3.3, 3.4, 3.4, 3.5
Obsidian Cliffs	7	23	30	10.9	3.2, 3.3, 3.3, 3.3, 3.9, 4.2
Quartz Mountain	6	15	21	7.7	3.2, 3.2, 3.7, 4.4, 4.6
Silver Lake/Sycan Marsh	2	15	17	6.2	4.6, 4.6
Unknown X	0	12	12	4.4	1.4, 3.2, 3.3, 3.3, 3.7
Newberry Crater: East Lake Flow	5	0	5	1.8	
Brooks Canyon	3	0	3	1.1	
Glass Buttees	3	0	3	1.1	
Whitewater Ridge	1	2	3	1.1	
Burns Butte	2	0	2	0.7	
Cougar Mountain	0	2	0	0.7	3.7, 3.7
Rimrock Spring	0	1	1	0.4	
Other Unknowns	0	17	14	6.2	3.2, 3.4, 3.5, 3.9, 4.4, 4.6, 5.2
Totals	53	221	274	99.9	

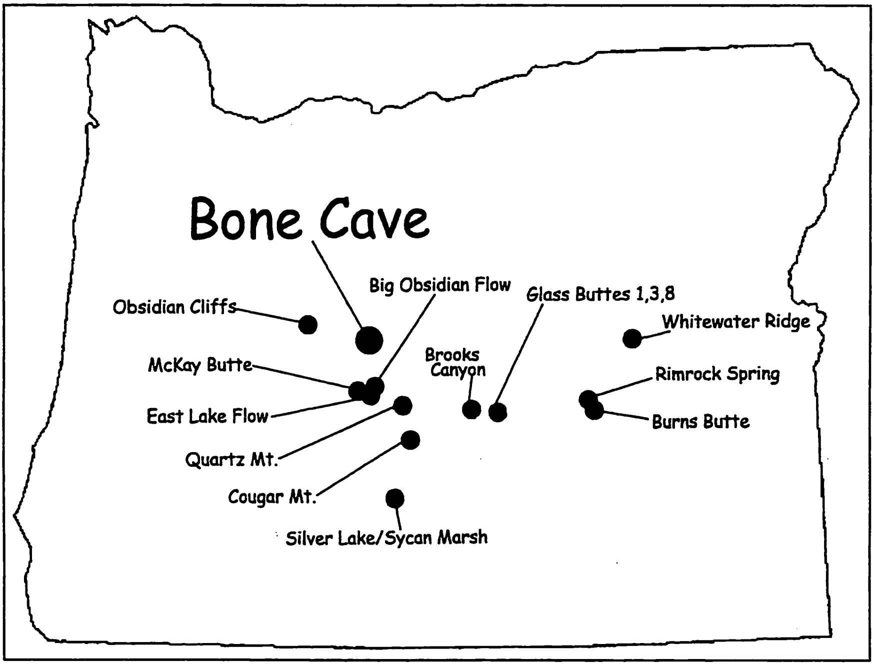

Figure 6. Map of Oregon showing locations of obsidian sources recovered in Bone Cave, including both tools and debitage.

Bone Cave collection may date from prior to the 6,850 year old eruption of Mt. Mazama was a hypothesis that we were able to explore through obsidian hydration analysis of the artifacts (see below).

The significant presence of Unknown X and McKay Butte material (combining for 34.3% of the total characterized assemblage) provides a clue as to site chronology. The Unknown X source is estimated to be somewhere in the vicinity of the Newberry and McKay Butte sources and is almost certainly located somewhere in the upper Deschutes Basin. Use of the Unknown X and McKay Butte sources drops off dramatically in the High Lava Plains and regions to the north and south after the Mazama ashfall (Skinner, 1995a) and the presence of artifacts from these sources in the Bone Cave assemblage suggests a significant pre-Mazama occupation. Accumulation of Mazama ash may have blocked or seriously reduced access to the Unknown X and McKay Butte sources, as well reduced the appeal of Bone Cave. The current floor in the front chamber of the site averages less than one meter from the ceiling, and much of the sediment in the site results from accumulation of Mazama tephra, explaining possible site abandonment after the Early Holocene.

Another unusual occurrence is the representation of several unknown obsidian sources among the analyzed collection. Obsidian sources in the Bone Cave region are very well known and artifacts from unknown sources are relatively uncommon. We are currently unable to explain why 6.2% of the characterized Bone Cave artifacts are from unknown obsidian sources (not including the Unknown X source).

Although groups from the Southern Columbia Plateau occasionally utilized a similar suite of sources, the obsidian source distribution heavily favors Northern Great Basin sources, and suggests a Great Basin association of Bone Cave occupants (Skinner, 1995a). Without diagnostic artifacts it is difficult to distinguish between an occupation by groups from the Northern Great Basin, southern Columbia Plateau, or a group(s) permanently occupying the Western High Lava Plains, although the dominance of Northern Great Basin sources suggests that region as a portion of a seasonal round.

Obsidian Hydration Analysis

The chemical characterization data from Bone Cave provide some evidence for the dating of the site, and the obsidian hydration analysis further supports the estimated pre-Mazama period of occupation. Since it was first proposed as an archaeological dating method (Friedman and Smith, 1960), obsidian hydration analysis has undergone periods of intense use and heightened skepticism. Although the potential for absolute, and even relative, dating by hydration analysis has been seriously questioned due to a wide array of factors (Jackson, 1984; Stevenson et al., 1998; Tremaine, 1989), the technique remains reliable for relative dating, particularly when comparing sites in the same region (Green, 1998; Hockett, 1995; Layton, 1972).

Inter-site comparison of hydration values requires the assumption of similar environmental conditions, the most important of which is temperature variability since hydration rates are correlated with temperature in a non-linear manner (Beck and Jones, 1994; Friedman, 1976; Jones et al., 1997; Tremaine, 1993). The hydration studies used for comparison with the Bone Cave analysis are from open sites which are subject to daily, seasonal, and longer temperature changes. The internal temperature conditions of Bone Cave are consistent and lower than the average temperature outside the cave. Obsidian in open sites experiences a highly variable temperature pattern and would likely yield slightly higher hydration values than pieces from the same source initially exposed at the same time.

The presence of ash derived from the eruption of Mt. Mazama (6850 B.P.) provides an excellent time marker for hydration analysis. Extensive trace element and hydration studies of Deschutes Basin artifacts were carried out in the early 1990s as part of the PGT-PG&E Pipeline Expansion Project (Skinner, 1995a, 1995b). Over 1,800 obsidian artifacts from several Deschutes County sites were recovered from stratigraphically defined post- or pre-Mazama contexts.

In an effort to examine the regional obsidian procurement patterns and to develop an obsidian hydration chronology, these artifacts were selected for trace element and hydration studies. Forty-five obsidian artifacts, including all of the tools and a random sample of debitage, were selected for obsidian hydration analysis (see Table 1). Figure 7 plots the hydration range and mean for the five dominant sources recovered at Bone Cave along with the pre- and post-Mazama sample from the INFOTEC PGT-PG&E pipeline project. The dominant presence of McKay Butte and Unknown X obsidian and the minimal presence of East Lake Flow material in itself (none of the East Lake Flow artifacts were large enough for XRF analysis), suggests a predominantly pre-Mazama occupation. A source specific comparison of the hydration measurements of the Bone Cave assemblage and other regional pre- and post-Mazama assemblages supports this conclusion.

In addition to the sources described above, two Bone Cave artifacts made from Silver Lake/Sycan Marsh glass yielded readings within 0.04 microns of the estimate of the Mazama ashfall (Skinner, 1995b). Specimens representing five other sources were recovered from Bone Cave without an associated estimate of the Mazama ash deposition. The hydration values for these artifacts vary from

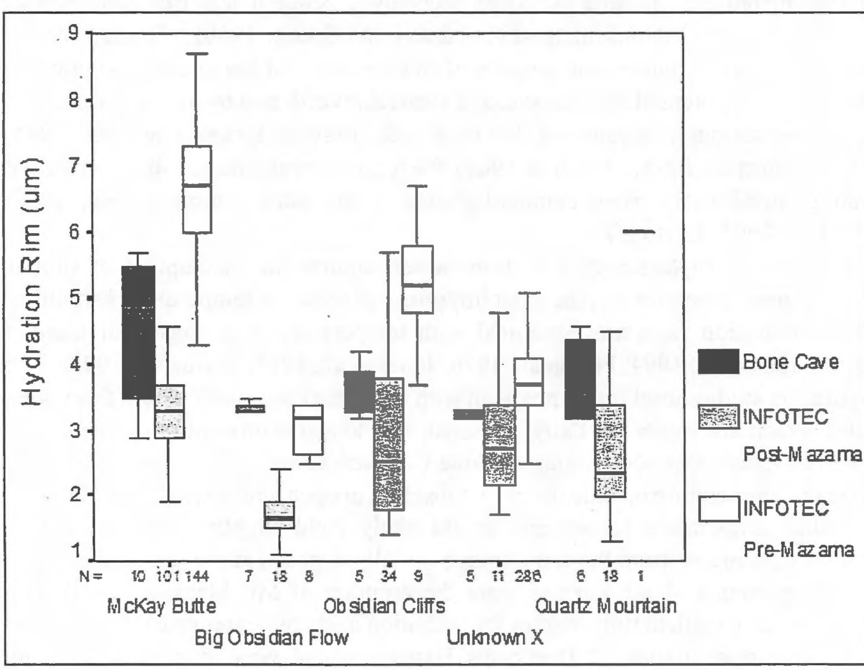

Figure 7. Boxplots of obsidian hydration rim measurements by source for Bone Cave and INFOTEC project.

3.2 to 5.2 microns. While this does not directly support the pre-Mazama date for the site occupation(s), it does not provide contrary information.

Although there is no direct correlation between the Bone Cave hydration results and those of the pre-Mazama sample from the Pipeline Expansion Project, Figure 7 reveals a pattern of matching with the upper limits of the post-Mazama assemblages and the lower limits of the pre-Mazama components for most sources. The correlation may be better than this if environmental factors that influence hydration rates are considered. Hydration rates increase exponentially with increased temperature, and obsidian artifacts experiencing the same yearly mean temperature but exposed to a more variable temperature setting (such as sites in open environments) will likely hydrate at a more rapidly than those held nearly constantly at the same mean temperature. All of the sites from the Pipeline Expansion Project were open sites and would potentially yield larger hydration rim measurements compared to the Bone Cave artifacts that remained at a much more constant temperature.

A study of the hydration measurements from pre-Mazama contexts in sites in the Newberry Crater (Connolly, 1999) further supports the pre-Mazama dates proposed for the primary occupation of Bone Cave. Connolly (1999) reports identical means (4.85 microns) for artifacts from the McKay Butte source for pre-Mazama Newberry Crates contexts as for Bone Cave. Hydration rim measurements from three other common sources (Big Obsidian Flow, Unknown X, and Quartz Mountain) reveal greater, and thus probably older, dates for the occupation of Bone Cave versus the pre-Mazama artifacts from the Newberry Crater study.

Bone Cave serves as a rare instance in archaeology when a heavily, if not completely, disturbed site without perishable artifact preservation can still yield chronological data in the absence of temporally diagnostic artifacts. While some questions remain about the validity of comparing hydration rim measurements of samples from different sites, the pre-Mazama/Early Holocene source distribution pattern seen elsewhere in the upper Deschutes Basin is apparent in the Bone Cave assemblage. Based on the results of the hydration and the chemical characterization analyses, there is no indication of significant occupation of Bone Cave after the Mazama eruption.

FAUNAL ANALYSIS

The Bone Cave faunal assemblage was both the most deceptive and the most revealing with respect to site function. During excavation, it was noted that the faunal remains exhibited little weathering due to exposure or chemical dissolution and was initially interpreted as the possible remains of recent carnivore activity and natural deaths of rodents and rabbits occupying the site. The faunal assemblage from four alternate excavation levels of Unit 4 (levels 2, 4, 6, and 8) was analyzed. Given the disturbed nature of the deposits, the analyzed portions of the faunal as well as the lithic assemblages were pooled into a single analytical unit.

The sample of 3,877 identifiable bones and fragments consisted of 91.1% leporid (NISP = 3,534) (*Lepus* sp., *Sylvilagus nuttalli,* and *Brachylagus idahoesis*) by count, with over 57% (NISP = 2,233) of the remains identified to genus and 34.5% (NISP = 1,338) to family (see Table 2). The assemblage also included *Canis* sp. (NISP = 7), pronghorn antelope (NISP = 10) (*Antilocapra americana*), deer (NISP = 15) (*Odocoileus* sp.), a small number of unidentified rodent bones (NISP = 14), and a single humerus fragment from a duck (Anatidae family). The low species diversity and overwhelming presence of rabbit remains suggests human accumulation, and the lack of predator remains or other typical prey of non-human predators such as woodrat further implicates humans. In addition, 58 (1.5%) of the analyzed faunal elements exhibited direct cultural modification in the form of butchering cut marks, fractures associated with marrow removal, and one possible tool fragment. Of the 31 observed cut marks, the vast majority occurred on the long bone fragments of the larger species (deer and antelope).

Table 2. Results of Faunal Analysis[a]

Taxon	NISP	% NISP	Weight (gm)	% of weight
Rodent undetermined	14	0.4	0.2	0.01
Peromyscus sp. (deer mouse)	2	0.1	0.1	0.0
Perognathus parvus (pocket gopher)	1	0.0	0.0	0.0
Thomomys sp. (pocket gopher)	3	0.1	0.4	0.02
Leporidae (rabbit family)	1338	34.5	172.7	11.0
Sylvilagus sp. (cottontail rabbit)	1700	43.8	546.8	34.9
Lepus sp. (hare or jackrabbit)	496	12.8	359.9	22.9
Canis sp. (dog or coyote)	7	0.2	6.8	0.4
Antilocapra americana (pronghorn)	10	0.3	19.4	1.2
Odocoileus sp. (deer)	15	0.4	26.0	1.7
Other small mammal	6	0.2	2.8	0.1
Other medium mammal	184	4.7	392.9	25.0
Other medium/large mammal	83	2.1	39.4	2.5
Undetermined mammal	17	0.4	1.7	0.1
Anatidae (duck family)	1	0.0	0.1	0.0
Total	3877	100.0	1569.2	99.8

[a]NISP stands for number of individual specimens present.

The bone breakage patterns provide further evidence of cultural activity. The larger mammal bones exhibit spiral fractures as well as impact fractures and flake scars, possibly resulting from marrow extraction. Carnivore gnawing can occasionally produce similar features but none of the other attributes such as stained, polished, or pitted bones, or rounded and thinned fractured surfaces typical of non-human carnivore assemblages (Schmitt and Juell, 1994) are present. Limb bones comprise the majority of the charred bone and some long bones exhibit extreme distal or proximal burning, suggesting exposure to fire with meat intact. Natural fires within the site are unlikely due to the lack of organic debris accumulation. It appears that the site occupants focused their hunting activity on rabbits, possibly including some mass collection.

Communal hunting of rabbits, as well as antelope and other ungulates, is well represented in the ethnographic literature from the Great Basin, the Southwest, and the Great Plains (Fowler, 1992; Lubinski, 1999; Schmidt, 1999; Steward, 1938; Wheat, 1967), but archaeological evidence is relatively scarce (Lubinski, 1999; Schmidt, 1999; Shaffer and Gardner, 1995). Ethnographic accounts of rabbit drives differ on details of technology and technique such as dimensions of the net, number of people involved, and manner of selecting the leader, but the Great Basin descriptions are remarkably consistent as to general procedure and ultimate goals. The primary purpose of the drives was the procurement of rabbit hides, with secondary importance given to meat procurement although the meat was both eaten immediately and dried for storage (Wheat, 1967). The hides were woven into blankets used throughout the year to provide warmth during the cold desert nights. Blankets required between 40 and 100 rabbit skins making large-scale procurement necessary. Rabbits are not ideal for hunting individually, and, due to rapid reproduction rates, the local population can quickly rebound from significant population crashes (Shaffer and Gardner, 1995).

Unlike other types of kill sites where animals are killed in mass by driving them into pits or off cliffs, rabbit drive sites would be difficult to distinguish from long-term occupation or reoccupied sites in which rabbit remains would be gradually accumulated. Isolated hunting episodes tend to produce specific age profiles of the prey, but most massive kill sites show an age structure similar to the living population because it would be difficult if not impossible to select the individuals driven off a cliff. Rabbit drives offer a different scenario. Young individuals may not provide desirable hides or sufficient meat yields and might be released, avoid detection by the drive line, or escape through the mesh designed to trap adults. In this case, a rabbit drive processing site may show similar age structure to accumulated isolated kills. In addition, the narrow seasonal pattern typical of massive kill sites could also be replicated by isolated kills during repeated occupation of the same area at the same point along seasonal movements. Rabbit drive nets would appear to provide a clear indicator of rabbit drive activity, but given the lack of perishable artifacts recovered from the site (other than bone) if there were nets or net fragments they either did not preserve in the relatively damp conditions within Bone Cave or they were removed by looters. Most archaeological examples of rabbit drive nets are from dry caves (Aikens, 1993), but it is not clear if this is fortuitous preservation or a prehistoric caching strategy.

Schmidt (1999) describes a rabbit drive faunal assemblage based on the appearance of intensive processing, low taxonomic diversity, and a similarity to other rabbit drive processing sites. The site is located in the San Simon Valley of Southeastern Arizona and dates between 1500 B.C. and 1050 A.D. The sample analyzed contained 2,390 faunal elements, and 814 identified to class. Over 98% (NISP = 802) were identified as rabbit, with 91% jackrabbit and almost 6% cottontail. Jackrabbits and cottontails exhibit different predator avoidance behavior that makes jackrabbits far more likely to be harvested in a communal rabbit drive; cottontails prefer heavier cover and tend to seek cover rather than flee from prey as jackrabbits are prone to do. The fleeing response makes jackrabbits ideal for driving into nets, and as expected, Schmidt's assemblage contains almost exclusively jackrabbits.

Oetting (1994) claims clear evidence of a rabbit drive dating to the Early Holocene (8000-9000 B.P.) at a site at Buffalo Flat in the Fort Rock Basin based on a buried feature containing dense charcoal and almost 1,000 variably identified faunal remains. He estimates that as much as 98% belong to Leporidae, with the majority identified as jackrabbit. Such a distinct feature could have resulted from a single butchering episode of a large harvest of rabbits. The site at Buffalo Flat fits well with the predicted assemblage for a rabbit drive processing site.

The Bone Cave assemblage matches well the faunal assemblage from Buffalo Flat except for the disturbed nature of the Bone Cave deposits and the different species prevalence within the Leporidae. More than 91% of the Bone Cave assemblage was identified as rabbit, and, among the rabbit remains, 14% of the NISP were identified as jackrabbit, 49% as cottontail, and 37% unidentifiable to species. Examining only those elements identifiable to species, cottontails account for 77.4% of the assemblage and jackrabbits for the remaining 22.6%. When examining the species percentages by weight it appears that the jackrabbits may not have been as extensively processed as the cottontails which is as expected if the cottontails were hunted individually and intensively processed while the jackrabbits were predominantly collected in mass and only minimally processed. Cottontails account for 60.3% of the assemblage by weight compared to 39.7% jackrabbit. This shift of more than 15% by examining NISP and weight may be a function different hunting and processing practices, but it may also be the result of a variety of taphynomic and identification factors.

CONCLUSIONS

A morphological analysis of the Bone Cave lithic assemblage provides some indications of site activities. The extremely low frequency of cortical flakes, as well as the small size of the debitage indicates the lack of primary lithic reduction at the site. Lithic reduction activities were limited to late-stage bifacial reduction and tool resharpening that are often associated with logistical or emergency camps.

Rabbit taxa account for more than 91% of the faunal collection. Only a small portion of the butchered bone fragments was rabbit, suggesting occasional, thorough butchering of the large mammals such as deer and antelope, in contrast to frequent collection and only limited butchering of rabbits. Excavations of two Early Holocene sites interpreted as rabbit drive processing sites in the Eastern Fort Rock Basin to the south of Bone Cave revealed a similar faunal assemblage (Oetting, 1994), yet these sites may be the remains of similar gradual accumulation of individual kills or a combination of individual and mass harvest as proposed for Bone Cave.

Food resources and fresh water sources are widely scattered in the High Lava Plains, and have likely remained so since at least the Early Holocene. The hunting and processing of large numbers of rabbits may have provided the resources required to support the population that inhabited Bone Cave. The sheltered site may have served as an ideal location for rabbit processing in the early spring when a small snow pack inside the front chamber could have provided the only significant water source in the immediate area.

Both the obsidian characterization and obsidian hydration analyses provide convincing evidence of a predominantly pre-Mazama (prior to 6850 B.P.) occupation of the site. McKay Butte and Unknown X obsidian is rarely recovered from post-Mazama sites in the upper Deschutes Basin (Skinner, 1995a), and these two sources account for exactly one-third of the XRF sample. The obsidian hydration rim measurements for all of the known sources are compatible with pre-Mazama measurements from the two well-documented sites with pre-Mazama components. The lack of any more recent hydration rims suggests that the site may have been abandoned prior to 6,800 B.P., with only rare later use.

Often, disturbed sites such as Bone Cave are ignored, or worse, insufficiently assessed prior to destructive activities. Without a concerted effort to extract information from the disturbed deposits of Bone Cave we would not have the information presented here about site chronology and regional hunting and lithic raw material procurement strategies. An early reviewer of this article wrote: "any archaeologist worth his or her salt can make any site significant." We are not arguing that heavily disturbed sites should always be given attention equal to their better-preserved counterparts, but we should not dismiss disturbed sites out of hand. There needs to be a balance between the costs of cultural resource management and our determination to study the past. Hopefully this study will serve as an example of the creative means in which to examine disturbed archaeological sites.

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