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SOURCING BELIEF: USING OBSIDIAN SOURCING TO UNDERSTAND PREHISTORIC IDEOLOGY IN NORTHEASTERN CALIFORNIA, U.S.A.

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ABSTRACT

Large obsidian bifaces from northern California have long been known as non-utilitarian ceremonial and wealth objects. Despite their stylized form, bifaces were manufactured from several different obsidian sources. Glass Mountain in Siskiyou County, California was one source for black obsidian bifaces. The lithic assemblage at Glass Mountain and x-ray fluorescence data from the surrounding region indicate that Glass Mountain obsidian was used almost entirely for biface production, and was neglected as a source for utilitarian objects. Just as obsidian objects fulfilled utilitarian or non-utilitarian functions, obsidian sources retained special roles within the context of prehistoric culture and belief systems.

KEYWORDS: obsidian, prehistory, California, bifaces

INTRODUCTION

Glass Mountain is a large, tool-quality obsidian flow located within the Medicine Lake Highland of Siskiyou County, California (fig. 1). Archaeological survey and excavation at the quarry suggest that Glass Mountain obsidian was used primarily for the manufacture of value objects, specifically large ceremonial bifaces. These bifaces were exchanged from the Medicine Lake Highland region to the California coast, located over 200 miles distant. X-ray fluorescence, used to characterize and source ceremonial bifaces from the coast and utilitarian assemblages from within 50 miles of the quarry, has indicated that Glass Mountain obsidian was neglected as a material for common tools. Potential criticisms suggesting that the paucity

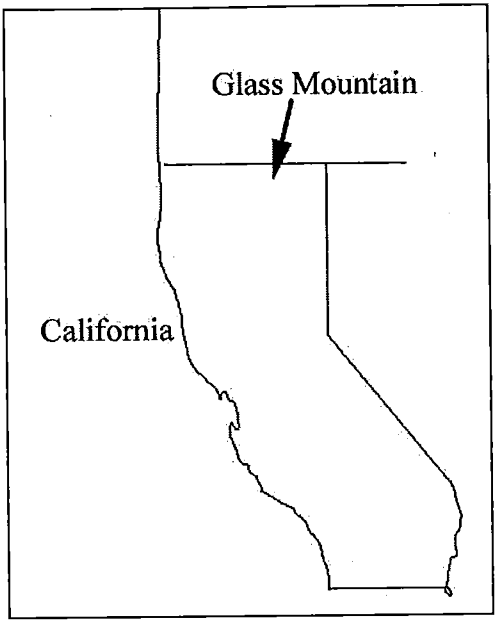

Fig. 1: Glass Mountain location map.

of Glass Mountain obsidian in utilitarian assemblages may be the result of heterogeneity of the trace element composition of the Glass Mountain obsidian flow are addressed here through thorough geologic sampling of the Glass Mountain flow, and these data are used to support arguments about differential use of Glass Mountain obsidian prehistorically (fig. 2). This paper traces the formation of Glass Mountain obsidian and its use, and proposes that recent eruptive phenomena may have contributed to the unusual archaeological patterns of obsidian consumption in northeastern California. Just as obsidian objects fulfilled utilitarian or non-utilitarian functions, obsidian sources retained special roles within the context of prehistoric culture and belief systems.

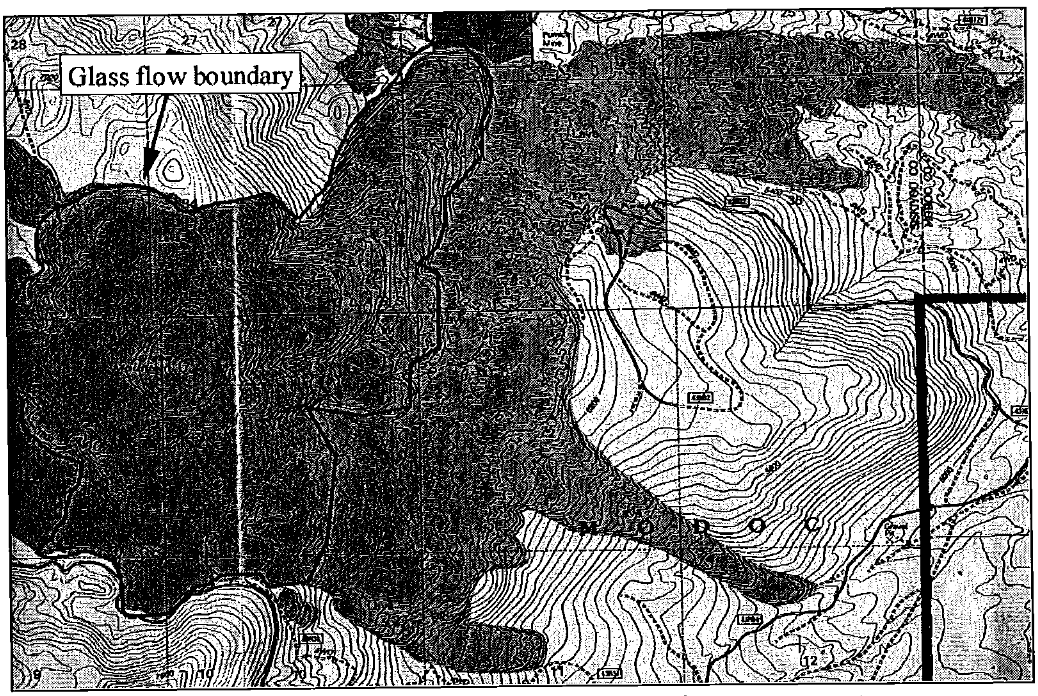

Fig. 2: USGS Topographic Map of Glass Mountain and vicinity.
Glass Mountain obsidian flow outlined in black.

FORMATION OF GLASS MOUNTAIN OBSIDIAN

Obsidian is a natural volcanic glass, which commonly forms in two ways: first, it occurs when high silica lavas cool so rapidly that crystal formation is minimal or non-existent. Second, it can be the product of welding and compaction of silica-rich pumice and ash (Blatt and Tracy 1996, 29). In both scenarios, the original magma is rhyolitic in composition, containing concentrations of silica (SiO_2) as high as 70%-75% and aluminum (Al_2O_3) concentrations between 10%-15% (Glascock *et al.* 1998, 18). Rhyolite lava is extremely viscous, and as a result, obsidian flows generally appear as steep-sided domes.

The Glass Mountain obsidian flow represents the most recent eruption of the Medicine Lake Highland, a large shield volcano exhibiting seventeen different eruptive events throughout the Holocene (Donnelly-Nolan *et al.* 1990, 19, 693). The Medicine Lake Highland is located at the eastern edge of the Cascade Range in northern California, and like other parts of the Cascades, remains seismically and volcanically active (USGS 2000). Glass Mountain sits along the eastern rim of the Medicine Lake caldera, and the obsidian flow extends down the steep eastern flank. The Glass Mountain eruption formed multiple rhyolite and rhyodacite domes on a fissure trending N30°W (Anderson 1933). Ten small domes extend to the north of the main flow, and one small dome lies to the south (Grove *et al.* 1997, 206) (fig. 2). Tool-quality obsidian, largely free of phenocrysts and inclusions is available around much of the perimeter of the main flow, as well as on parts of the surface of the flow. Tool-quality obsidian is also available at many of the smaller domes. However, some domes and some parts of the main flow are dominated by lower-silica compositions, by inclusion-bearing or porphyritic glass, and by pumiceous or vesicular facies.

The Glass Mountain eruption formed two arms of an extensive dacite/rhyodacite flow and a massive, steep-sided obsidian flow at the higher elevations (Anderson 1933; Eichelberger 1981, 183). In addition, there are extensive pumice deposits associated with Glass Mountain. These pumice-forming eruptive events may have preceded the lava flows by only a few hours or by as much as 150 years based on stratigraphic associations with other Medicine Lake Highland tephras (Donnelly-Nolan *et al.* 1990, 19,699; Chesterman 1955). These pumice deposits contain pronounced banding, indicating a vulcanian-type eruption (Anderson 1941, 375), which are traditionally characterized by "discrete explosions at intervals varying from minutes to hours, caused by repeated build-up of pressure beneath a plug" (Fisher and Schmincke 1984, 82). Also, pumice deposits are lightest to the southwest of Glass Mountain, probably indicating that the wind was blowing from that direction when it erupted (Anderson 1941, 375).

The Glass Mountain eruption has been radiocarbon dated to 885 ± 40 years B.P. from a wood sample obtained from a dead cedar tree preserved in the distal margin of the dacite flow. This date may actually be several years too old, since some of the exterior of the tree was missing at the time when the sample was collected. An early date of 1050 B.P. is also available based on radiocarbon samples, paleomagnetic dates, and geomorphological data from tephra originating from Little Glass Mountain located eight miles to the west of Glass Mountain. Little Glass Mountain tephra directly underlies the Glass Mountain tephra (Donnelly-Nolan *et al.* 1990, 19, 699).

OBSIDIAN BIFACES

Large obsidian bifaces from Northern California have long been known as non-utilitarian ceremonial and wealth objects. Despite their stylized form, bifaces were manufactured from several different obsidian sources (fig. 3). The Glass Mountain obsidian flow was one source used prehistorically for black obsidian bifaces. The lithic assemblage at Glass Mountain and x-ray fluorescence data from the surrounding region indicate that Glass Mountain obsidian was used almost entirely for biface production, and was neglected as a source for utilitarian objects.

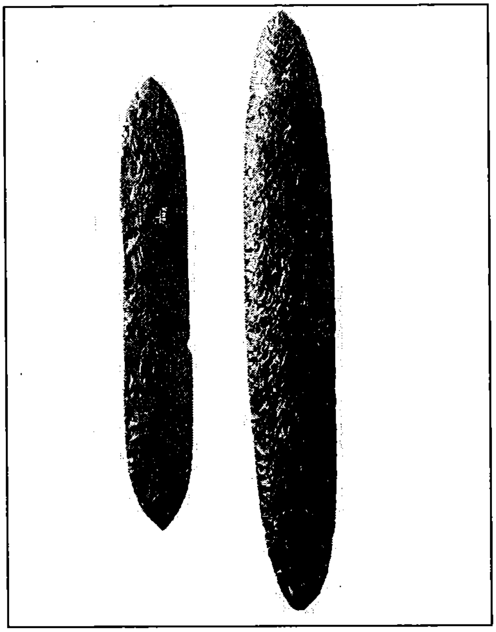

Fig. 3: Ceremonial bifaces (from Kroeber 1925).

Large obsidian bifaces from ethnographic and archaeological contexts in northern California and coastal Oregon have long been objects of interest for archaeologists and antiquarians. Their unique beauty and superlative craftsmanship makes them desirable acquisitions for museums and collectors. However, these objects are much more than merely beautiful things. Bifaces have and continue to serve essential functions in the ceremonial and wealth traditions of the northwest California coast. These artifacts are also important family heirlooms, whose ownership lineage is traceable far back into the past.

The morphology of northern California obsidian bifaces varies somewhat, perhaps as a result of raw material quality, nodule size, and knapping ability. Length was one reflection of value, and some biface specimens were up to 90cm long. In fact, one historic specimen measured 118cm in length (Heflin 1982, 124). Most of the obsidian bifaces recorded archaeologically and ethnographically are bipointed with parallel or slightly concave margins (Heflin 1982, 126), however straight-based bifaces have also been found.

Obsidian bifaces were traditionally part of a matched pair of one black and one red. Red obsidian was often mined from sources in the Warner Mountains of northeastern California, where nodules of red obsidian are large enough to be made into sizeable obsidian bifaces. Black obsidian was obtained from a variety of sources, including Glass Mountain (Hughes 1990, 51), though the presence of nodules large enough to be manufactured into large bifaces obviously limited potential obsidian sources.

Ethnographies noted the use of obsidian bifaces among peoples of the Northwestern California coast, approximately 200 miles west of Glass Mountain. Obsidian bifaces were recorded as important regalia displayed during the White Deerskin Dance among the Yurok, Hupa, Tolowa, and Karok (fig. 4). Additionally, ethnographic references mention the use of bifaces by the Shasta, Wiyot, and Wintu, though for these peoples, bifaces were not part of the White Deerskin Dance (Kroeber 1925).

The White Deerskin Dance was an opportunity for wealthy individuals to display their wealth, including obsidian bifaces, white

Fig. 4: White deerskin dance (from Kroeber 1925).

deerskins, and woodpecker scalps (Kroeber 1925, 54). However, this dance was more than just a chance to exhibit valuables, for it functioned as an important ceremony for world renewal and maintenance (Heflin 1982, 123). During the dance, bifaces were displayed by special "flint-carriers", who held a matched pair of red and black obsidian bifaces. The bifaces were sometimes tied to the carrier's wrist, to prevent potential breakage if dropped. The flint-carriers danced back and forth in front of a line of men carrying white deerskins and held the matched bifaces out in front so as to be readily visible (Goldschmidt and Driver 1940, 109). This dance was one means to reinforce social status; however, the spiritual nature of the White Deerskin ceremony should not be neglected. It was part of a system of world renewal and was important for the cohesion and continuation of the community (Kroeber 1957, 405).

Archaeological data indicate that large bifaces played an additional role as grave goods and burial items. At CA-Hum-67, obsidian bifaces were found in direct association with human remains. The site was excavated in 1913 by Llewellyn Loud, and is located within the ethnographic territory of Wiyot peoples along the coast of northern California, near the present city of Eureka (Hughes 1978, 56). It contained twenty-two burials, with thirteen associated obsidian bifaces (Loud 1918, 357-358). Five black obsidian bifaces were found and ranged in length from 27.2 cm to 41.0 cm (Loud 1918, 357). All of the black obsidian bifaces were bipointed, and all were associated with burned human remains. Loud refers to these as cremations, but Hughes specifies that this actually represented grave-pit burning (1978,56). Hughes geochemically characterized many of the obsidian bifaces recovered in Loud's excavations. The results for the black bifaces indicated that two were made of obsidian from the Medicine Lake Highland region [Glass Mountain], two of Vya obsidian, and one of Glass Buttes obsidian (1978, 58). In terms of distance, the obsidian sources are far from CA-Hum-67. Medicine Lake is the closest, at about 175 miles from the site, Glass Buttes is about 300 miles distant, and Vya is about 250 miles away (Hughes 1978, 60-61).

Loud also excavated eight red obsidian bifaces found in direct association with human remains. Hughes also geochemically characterized the red bifaces, and determined that all eight originated from the Warner Mountains, located 220 miles from the site (1978, 58). The bifaces range in length from 17.1 cm to 30.5 cm (Loud 1918, 358). All exhibited the same bipointed morphology as the black bifaces, though neither Loud nor Hughes discusses the presence or absence of paired specimens.

The bifaces from this site have not been dated directly using obsidian hydration. However, radiocarbon dates from a basal peat layer at the site yield a date of 1050±200 years B.P. (Hughes 1978, 56), which provides an earliest date for the site. Hughes further speculates that the burials themselves and the associated bifaces are approximately 600 years old.

Archaeological evidence from other northern California sites indicates that obsidian bifaces occur in similar contexts throughout northern California and also in southern Oregon. Bifaces that have been dated using obsidian hydration or through association with datable materials indicate that they are a relatively recent phenomenon, and bifaces were still in use in historic times, as wealth and an important part of ceremonies. This represents a late prehistoric ceremonial system, which perhaps may have older antecedents to the north (Hughes 1990, 55). Bifaces are generally associated with burials, and often with burned human remains. Interestingly, obsidian sources, particularly the obsidian sources preferred for ceremonial bifaces such as Glass Mountain, were far from the archaeological sites where bifaces have been found.

GLASS MOUNTAIN ARCHAEOLOGICAL PROJECT

Archaeological fieldwork was conducted during the summers of 1999, 2000, and 2001 at the Glass Mountain obsidian quarry under the auspices of the Glass Mountain Archaeological Project[1]. Production debitage at the Glass Mountain quarry, in combination with archaeological and ethnographic data from other parts of northern California revealed a pattern of biface manufacture and specialized use that was intertwined with cultural ideology and belief systems.

In order to more fully understand these mechanisms of procurement and production at Glass Mountain, the stages of biface manufacture present at the quarry were recorded and quantified for each reduction locus. Furthermore, these data revealed decreasing numbers of biface fragments with each successive stage of production, suggesting that either bifaces were removed from the quarry site at increasingly advanced stages of production, or that bifaces in which knappers had already invested a great deal of time and energy were reworked into smaller objects.

In studies of biface manufacture, is usually assumed that biface reduction at the quarry was designed to minimize both material bulk and time, and that knappers would remain at the quarry only long enough to produce easily transportable preforms that could then be completed later (Ozbun 1991, Kelly 1988, Bamforth 1986, Binford 1979). This implies that artifactual material found away from the quarry would include retouch or biface reduction debitage from larger bifaces initially reduced at quarry sites. However, it appears that at Glass Mountain, bifaces were knapped beyond the stage at which mass is sufficiently reduced for easy transport. Instead, evidence in the form of tertiary biface thinning flakes and final-stage biface fragments suggests that at least some bifaces were knapped to completion, or near-completion, at the Glass Mountain quarry. Furthermore, as will be discussed below, obsidian debitage at sites away from the immediate quarry locale do not contain evidence of retouch or biface thinning of Glass Mountain obsidian objects.

BIFACE REDUCTION STAGES

The bifacial reduction sequence is divided into five stages, based on amount of retouch (Callahan 1979; Andrefsky 1998) (fig. 5, 6). These stages are constructed purely for the sake of description and analysis, and do not necessarily represent any accurate divisions of the prehistoric reduction process. Biface production was instead a continuum of thinning and shaping. Despite the use of five reduction stages in the description and analysis of bifaces at Glass Mountain, there is no indication that such stages have any validity for prehistory. Instead, they are purely a tool for recording and describing the continuum of reduction evidenced through

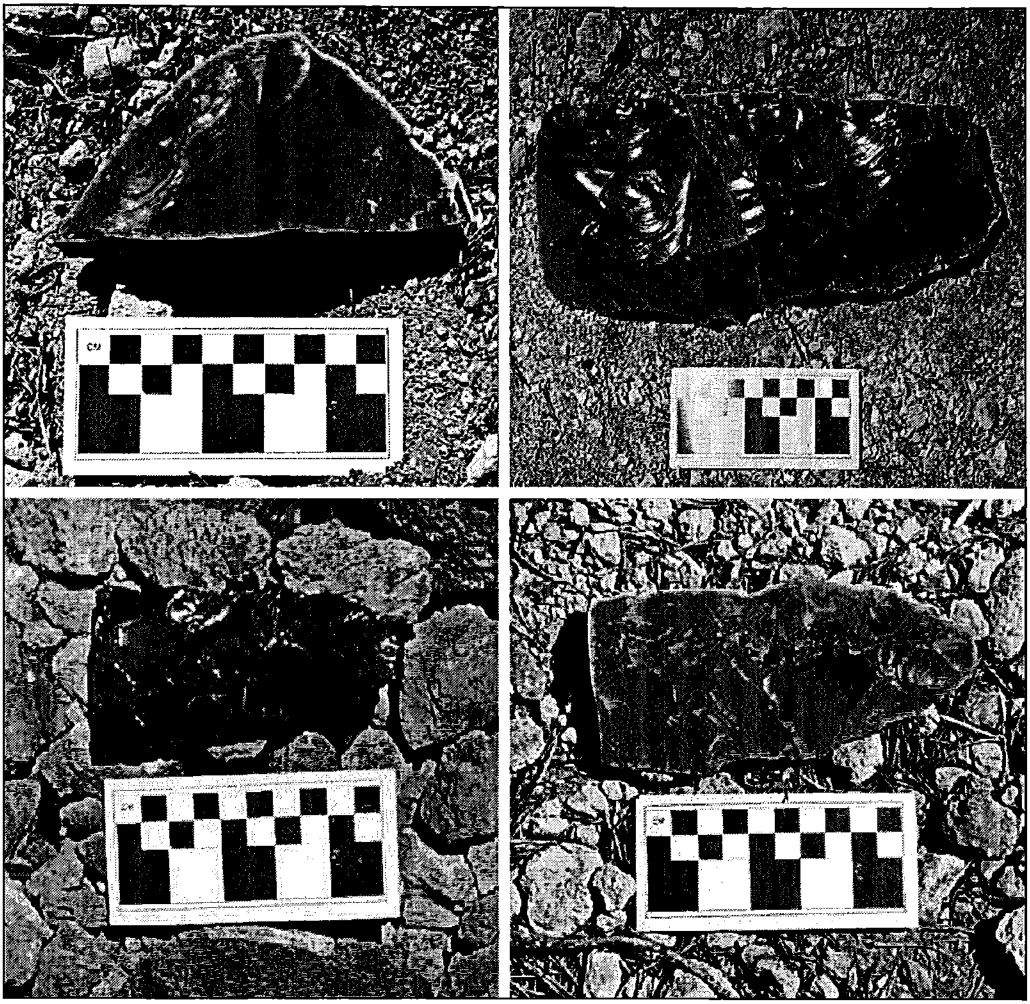

Fig. 5: Clockwise from upper left: Stage 1, Stage 2, Stage 3, and Stage 4 biface fragments recovered during survey for the Glass Mountain Archaeological Project (see Dillian 2002).

biface fragments and debitage. Furthermore, bifaces were functionally variable tools, and their utility for different activities fluctuated with the reduction continuum (Kelly 1988; Andrefsky 1998, 30). For example, bifaces were efficient cores for the production of flake blanks and expedient tools. Large bifaces were used as chopping tools, while smaller bifaces could be used as knives, scrapers, or projectiles. Thinning and reducing a biface potentially changed the function of the specimen, suggesting that a small bifacial point may have been used previously as a knife or core or chopper. Despite these many prospective uses, Glass Mountain bifaces show no evidence of use in any stage of reduction.

Biface reduction was apparent at Glass Mountain through the presence of biface thinning flakes and biface fragments in all stages of production. In addition, large hammerstones of non-local material were also present and appear to have been used to

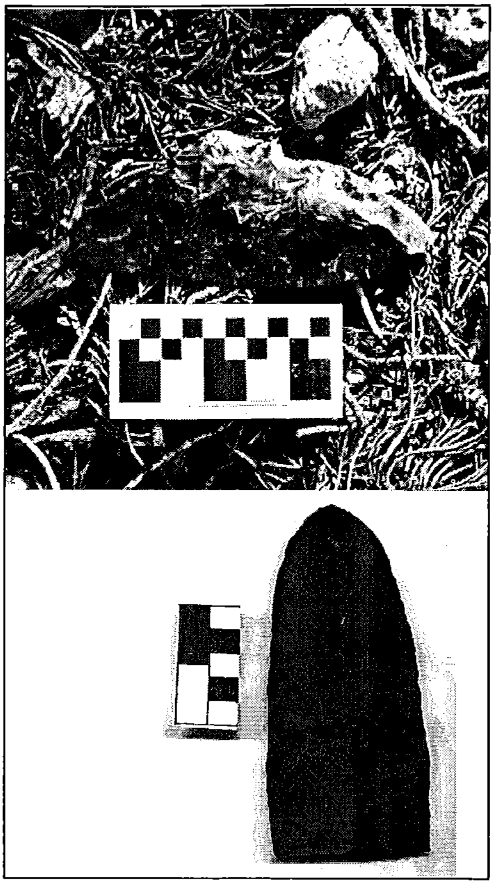

Fig. 6: Stage 5 obsidian bifaces recovered during survey for the Glass Mountain Archaeological Project (see Dillian 2002).

remove extremely large flakes from obsidian boulders. These flakes were then also manufactured into large bifaces.

Stage 1: According to Callahan (1979) and Andrefsky (1998) stage 1 is represented by the procurement of a flake blank or nodule. Archaeologically, this would be visible as an unmodified or partially modified piece of raw material. At Glass Mountain, and other quarry sites, it would be difficult to distinguish a stage 1 preform from unused raw material. Therefore, for the sake of this study, a stage 1 biface preform required some evidence that the knapper intended to make it into a biface. This was apparent through the presence of flake scars on both dorsal and ventral surfaces of a nodule or large flake of obsidian, and some initial shaping. The procurement and initial shaping of large bifaces is represented at Glass Mountain by minimally flaked, bifacial preforms. Stage 1 bifaces were common at Glass Mountain, and were observed on 10 of the 18 sites recorded. Many stage 1 bifaces were found in fragmentary condition, suggesting that this stage was also the point at which raw material flaws and impurities were most noticeable. Furthermore, stage 1 biface preforms represented a minimal time investment, so in many cases, it was more efficient to discard a broken biface than it would have been to try to reshape the broken piece into a smaller object.

Stage 2: This stage is characterized by bifacial working that is limited to the margins of the nodule or flake. Callahan (1979, 10) describes this stage as appearing "Abbevillian handaxe-like" with a width/thickness ratio of 2.00 or more. At Glass Mountain, a stage 2 biface was generally twice as long as it was wide, and possessed flake scars on both dorsal and ventral surfaces. However, flake scars did not extend into the center of either surface. Stage 2 biface fragments were also very common on Glass Mountain sites; 88 stage 2 bifaces were recorded within Glass Mountain site loci. These specimens were thinner and flatter, yet dorsal and ventral flake scars rarely intruded into the center of each face. Flakes were instead limited to the margins of the biface preform. As was common with stage 1 bifaces, stage 2 bifaces were also often fragmentary. There was no evidence to suggest that broken stage 2 bifaces were reworked into other objects. In some cases, both halves of a fragmentary biface were found within a single locus.

Stage 3: Bifaces of this stage were characterized by flake scars that extend into the center of each surface, removing any remaining cortical material. Stage 3 bifaces begin to achieve their final shape, with a lenticular cross section, and in the case of Glass Mountain bifaces, a narrow and bi-pointed morphology. During stage 3, bifaces were considerably reduced in thickness, though flake scars may still be large and randomly oriented. Flake scars on stage 3 bifaces extend into the center of the specimen, distinguishing them from stage 2 preforms. These items are thinner in profile, and begin to approach the final biface morphology. At Glass Mountain, 10 out of 18 sites contained stage 3 bifaces, making them still fairly common. All stage 3 bifaces recorded were in fragmentary form. Stage 3 bifaces represent an increased time and labor investment, and large fragments may have been reworked into smaller bifaces.

Stage 4: During this stage, bifaces were thinned and shaped further, creating a flattened cross-section. In some cases, flakes were removed in a parallel pattern across the surface. Callahan (1979, 10) refers to this stage as comprising the secondary thinning of the biface, while Andrefsky (1998, 31) associates this stage with the creation of a biface or point preform. At Glass Mountain, stage 4 bifaces were complete in all aspects except for final retouch around the lateral margins. Bifaces at this stage of reduction are almost complete. They may have parallel flake scars across the surface of the piece and have achieved the final thin and bipointed morphology. Stage 4 bifaces were rarer than earlier preforms, and were only found on 8 out of the 18 recorded sites. All of the stage 4 bifaces recorded at Glass Mountain were fragmentary and small. It seems likely that large stage 4 fragments were reworked into smaller bifaces, given the time and labor already invested in the object.

Stage 5: This stage is the final edge retouch and shaping of a biface. In manufacturing projectile points, knives, or other hafted bifaces, stage 5 includes haft preparation and notching (Callahan 1979; 10, Andrefsky 1998, 31). However, at Glass Mountain, stage 5 biface reduction was characterized by the removal of small retouch flakes along the lateral margins. The final reduction stage for Glass Mountain bifaces involved retouch of the lateral margins of the piece. Only three stage 5 bifaces were observed at Glass Mountain, and both specimens were collected and are now curated at Modoc National Forest. Yet it was surprising that any stage 5 fragments were recovered at all. Models of lithic material procurement and production suggest that minimal time investment occurred at the quarry, and that once reduction of the mass of the original obsidian nodule had already occurred, preforms were removed to be finished at the knappers' leisure. This did not appear to be the case at Glass Mountain. However, to some degree, antiquities collectors may be responsible for the low numbers of stage 5 fragments recovered at sites with easy public access. One project visitor pointed out a location where a large biface fragment had been observed in the past (Forrest 1999: personal communication), but after thorough searching, it was not relocated.

Hammerstones and Large Flakes: Large, rounded cobbles and boulders used as hammerstones were also recorded during survey. These hammerstones were made of non-local material including rhyolite or granite and exhibit water or glacially worn surfaces, which would not occur naturally at Glass Mountain, given its recent geologic origin. The closest possible natural occurrence of these boulders may be the Tule Lake area 20 miles to the northeast. Hammerstones all show evidence of battering, including the spall fracture clearly visible in figure 7. It is quite

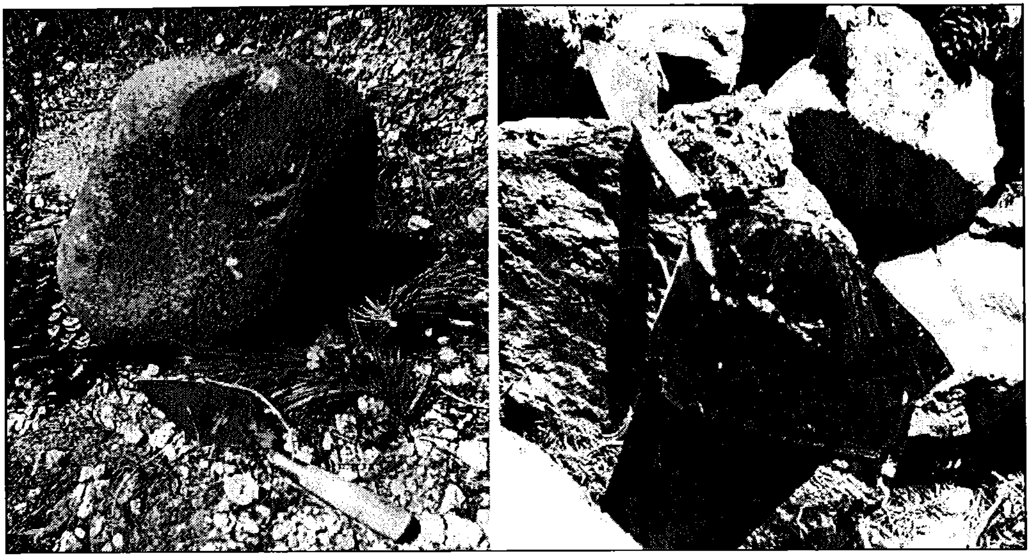

Fig. 7: Large rhyolite hammerstone and large obsidian flake recorded during Glass Mountain Archaeological Project survey (see Dillian 2002).

likely that hammerstones were deliberately left for future use at the Glass Mountain quarry, since they weighed up to 40 pounds and were difficult to transport. Hammerstones were likely used to remove large flakes from massive obsidian boulders in the glass flow. Large flakes were found adjacent to hammerstones and obsidian boulders, though refitting to boulders in the flow was not successful. Flakes were also found as stage 1 and stage 2 biface preforms, suggesting they were part of the biface reduction process. However, it appears that bifaces were more commonly made on nodules rather than flakes, as evidenced by numerous stage 1 and stage 2 preforms which retain original nodule cortex or surface morphology.

Biface fragments in all stages of production were common on Glass Mountain sites. Interestingly, stage 5 bifaces were also recovered, suggesting that at least some bifaces were knapped to completion at the quarry, and not removed for completion elsewhere. Biface fragments were the only formed objects observed at Glass Mountain. Projectile points, projectile point preforms, knives, crescents, or other chipped stone tools were not found. This is counter to the expected assemblage if generalized retooling were performed at the quarry. Instead, it reveals that bifaces were the only objects manufactured at Glass Mountain, supporting the hypothesis that this quarry was part of a belief system that reserved particular quarries for specific types of objects.

X-RAY FLUORESCENCE OF GLASS MOUNTAIN OBSIDIAN

Obsidian samples were collected throughout the duration of the Glass Mountain Archaeological Project. Geologic sampling and geochemical sourcing were important aspects of this research. Samples were obtained from the surface and edges of the glass flow; drilling or boring into the obsidian flow was not performed. Select samples were analyzed using X-ray fluorescence to assess the variability in trace element concentrations throughout the flow. As will be discussed further, sampling revealed a remarkable uniformity in trace element concentrations, which bodes well for the efficacy of X-ray fluorescence as a means of identifying Glass Mountain obsidian in the archaeological record.

Random (probabilistic) and judgmental (non-probabilistic) sampling strategies were performed. Obsidian specimens were collected using a random sampling methodology along the edge of the glass flow and on top of the flow. Obsidian specimens were also collected in a judgmental pattern, whenever surveyors observed unusual color, texture, or geographic variations in the obsidian flow. In particular, any red obsidian was sampled, as were occasional obsidian spires located away from the main body of the glass flow. Any visual or flow abnormalities were recorded at the time of collection. All obsidian specimens were mapped using the Trimble Geoexplorer 3 Global Positioning System.

Samples from Glass Mountain were analyzed on the Phillips PW 2400 wavelength X-ray fluorescence spectrometer in the Department of Geology and Geophysics at the University of California, Berkeley. Geologic source standard RGM-1 was analyzed simultaneously to ensure comparability and machine accuracy. Table 1 presents the published values for these standards and the results obtained during this study, showing a high degree of comparability between the values obtained here and accepted values for RGM-1 elemental concentrations.

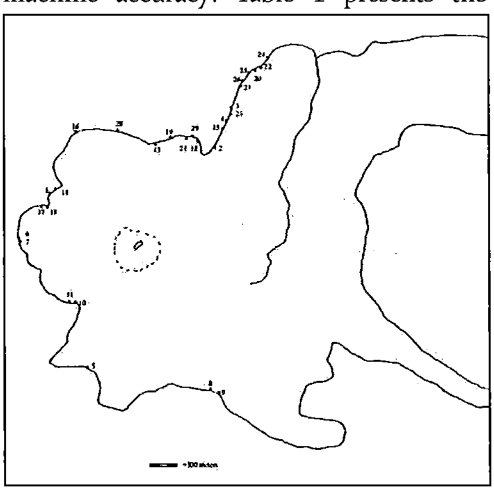

Fig. 8: Geologic sample locations for x-ray fluorescence characterization of the Glass Mountain obsidian flow.

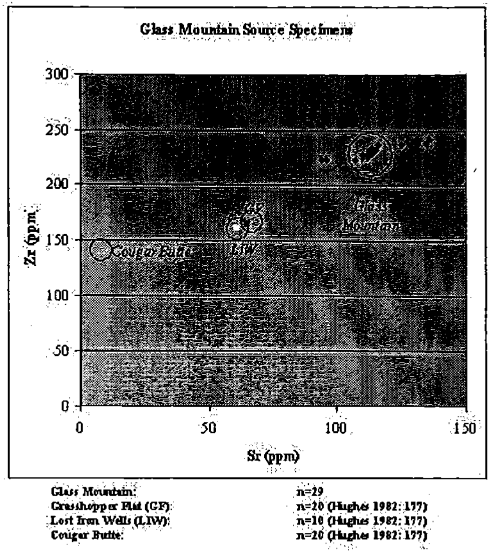

Fig. 9: Zr and Sr concentrations (ppm) for Glass Mountain source samples, and mean values for other Medicine Lake Highland sources. Circles indicate one standard deviation from the mean.

Previous characterization studies at Glass Mountain have revealed that the trace elements Zirconium (Zr) and Strontium (Sr) are the most effective identifying elements for this source, particularly when used to distinguish Glass Mountain from other Medicine Lake Highland obsidian such as Grasshopper Flat, Lost Iron Wells, and Cougar Butte (Hughes 1982). Therefore, variability within Sr and Zr trace element concentrations within the Glass Mountain obsidian source is of the most concern in characterization analyses used as a comparative database for archaeological obsidian.

A total of 29 source samples were selected for analysis from the geologic specimens collected during the Glass Mountain Archaeological Project. Of the analyzed specimens, four were judgmentally collected samples (#10, #11, #15, #8) that were selected based on anomalies in appearance or location. Twenty-five of the analyzed specimens were selected as random grab samples from the population of specimens collected at the source using a random sampling methodology. The results of the X-ray fluorescence analysis of these specimens are presented in fig. 9. Sample numbers correlate with numbers indicated on the map in fig. 8.

X-ray fluorescence analysis revealed a high degree of uniformity in Zr and Sr concentrations in the Glass Mountain source samples. Interestingly, two visually anomalous source specimens (sample #10 and #11) and a sample from an obsidian spire away from the flow (sample #15) also did not reveal any significant variation in Sr and Zr concentrations. Five specimens fell outside the first standard deviation for Zr and Sr concentrations, of these samples #8 and #9 were collected from the south side of the glass flow, where rhyolitic obsidian grades into coarser-grained rhyodacite. However, even these five minor outliers would be easily identifiable geochemically as Glass Mountain obsidian, based on the Sr and Zr concentrations, when compared to other Medicine Lake Highland obsidian sources. Fig. 9 presents a plot of Zr and Sr concentrations in parts per million for the 29 Glass Mountain specimens analyzed here. In addition, mean Zr and Sr concentrations for other Medicine Lake Highland sources are plotted for comparison. As can be seen in this figure, Glass Mountain obsidian does not overlap with any other Medicine Lake Highland obsidian source at one standard deviation.

Geologic sampling and analysis of the Glass Mountain obsidian source indicated that this source is extremely uniform in the concentrations of elements used to discriminate between Medicine Lake Highland sources. Parts per million measurements of Zr and Sr showed little variability, suggesting that there exist few erroneous source assignments in geochemical analyses of archaeological specimens. Any errors in the assignment of archaeological obsidian artifacts to the Glass Mountain source therefore are likely the result of operator error and errors in interpreting trace element concentrations, rather than due to variations in the geochemical composition of Glass Mountain obsidian.

X-RAY FLUORESCENCE IN CULTURAL RESOURCE MANAGEMENT CONTEXTS

Many of the cultural resource management (CRM), or contract archaeology, projects conducted in the Northern California region contain accompanying obsidian sourcing analyses, since a large portion of the artifactual lithic material often consists of obsidian debitage and formed tools. These gray-literature data are rarely synthesized on a regional level or used to address questions of patterns in long-distance obsidian procurement and use. This study will use a sample of archaeological sites with firmly dated late-period components to ascertain the distribution of Glass Mountain obsidian artifacts in the area immediately surrounding the source (Table 2).

Temporal control forms the biggest challenge to utilizing gray-literature data for Glass Mountain obsidian use patterns. Because the Glass Mountain eruption occurred only approximately 900 years ago, it is imperative that sites used for this study date to within the appropriate time frame. Many sites in Northern California have been dated using diagnostic projectile point types, which is insufficient to achieve the level of temporal control needed here. Therefore, only securely dated, post-900 BP components will be included in this discussion. The sites included

Sample name	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Ba
RGM-1 (this study)	2727	375	18814	145	102	24	217	9	809
RGM-1 (Govindaraju 1994)	1600	279	12998	149	108	25	219	8.9	807
RGM-1 (Glascock and Anderson 1993)	1800+200	323+7	12400+300	145+3	120+10	n/a	150+7	n/a	826+31

Table 1: Published RGM-1 concentration values in parts per million (ppm).

Map Number	Site	Reference	Glass Mountain	Total Obsidian	Percent Glass Mtn.	Other Medicine Lake	Percent Other Medicine Lake	Object Type
1	35-KL-818	Site record on file at Modoc NF	1	52	1.9	0	0.0	Flake Tool
2	CA-Mod-77	Site record on file at Modoc NF	4	73	5.5	0	0.0	Debitage
3	CA-Mod-2574	Site record on file at Modoc NF	18	44	40.9	15	34.1	Debitage
4	CA-Mod-2566/2567	Site record on file at Modoc NF	3	129	2.3	0	0.0	P.P./Deb.
5	CA-Mod-1206/1207	Site record on file at Modoc NF	29	90	32.2	52	57.8	Debitage
6	CA-Mod-2560	Site record on file at Modoc NF	19	155	12.3	126	81.3	Debitage
7	Nightfire Island (CA-Mod-27)	Hughes 1986, Sampson 1985	0	34	0.0	27	79.4	P. Points
8	CA-Mod-2562	Site record on file at Modoc NF	1	179	0.6	0	0.0	Multiple
9	OTH-B (05-09-56-1206, 05-09-56-1235)	Busby et al. 1990	2	45	4.4	31	68.9	P. Point
10	CA-Sha-68/H	Site record on file at Modoc NF	1	169	0.6	0	0.0	Debitage
11	Lake Britton	Kelly et al. 1987	2	387	0.5	271	70.0	P. P./Deb.
12	CA-Tri-1019	Nilsson 1990	0	15	0.0	9	60.0	Debitage
13	CA-Mod-1023	Gates 1991	1	1	100.0	0	0.0	P. Point
14	05-09-56-2413	Gates et al 2000	0	16	0.0	16	100.0	Debitage
15	CA-Sis-332	Shackley 1987	1	7	14.3	6	85.7	Multiple
16	CA-Sis-1267	McAlister 1988	0	25	0.0	25	100.0	Multiple
		Total:	82	1421	5.8		46.1	
		Mean:	*5.1*	*88.8*	*13.5*	*36.1*	*46.1*	
		Median:	*1.0*	*48.5*	*2.1*	*12.0*	*58.9*	
		Std. Dev.:	*8.7*	*99.1*	*26.1*	*70.3*	*40.0*	

Table 2: Cultural Resource Management x-ray fluorescence data summary.

in this discussion were chosen based on the availability of X-ray fluorescence data and securely dated components within 50 miles of Glass Mountain. Because of the paucity of such sites in the region, all available and accessible data were used.

Site records and lithic analysis reports for sixteen sites were examined, yielding data for 1421 obsidian artifacts. Artifacts were selected only from post-900 BP components, as determined by obsidian hydration or radiocarbon dating of associated material. None of the components examined dated to the historic period. Sites were selected to cluster around Glass Mountain (fig. 10), and all except for one are within 50 miles of the source. These sites represented a variety of prehistoric activities, and include small camp sites and larger village sites. None of the selected sites were quarry locales.

X-ray fluorescence data reveal that 5.8% of the obsidian debitage and tools are made up of Glass Mountain obsidian. Meanwhile, other obsidian sources in the Medicine Lake Highland such as Grasshopper Flat/Lost Iron Well/Red Switchback, Cougar Butte, and East Medicine Lake comprise 73.7% of these same assemblages. The remaining 20% of obsidian sources represented include sources in the Warner Mountains (Buck Mountain or South Warners), Blue Mountain, or other Northern California and Southern Oregon sources (Busby *et al.* 1990; Kelly *et al.* 1987; Hughes 1986; Sampson 1985; Nilsson 1990; McAlister 1988; Gates 1991; Shackley 1987, Gates *et al.* 2000).

The paucity of Glass Mountain obsidian in these sites is unexpected, given the size, accessibility, and quality of Glass Mountain obsidian available after 900 BP. Interestingly,

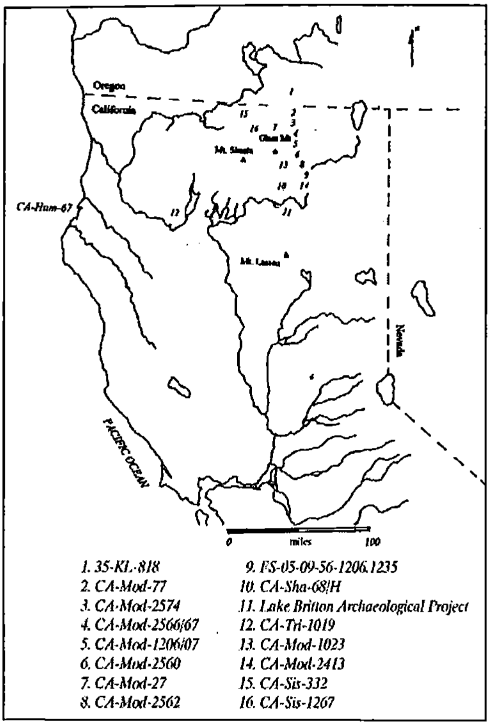

Fig. 10: Mapped locations of Cultural Resource Management sites presented in Table 2.

the Medicine Lake Highland sources that comprise a majority of the obsidian assemblage at these same sites are located only a short distance from Glass Mountain. This implies that northern California peoples were obtaining obsidian in the Medicine Lake Highland near Glass Mountain. Yet Glass Mountain was effectively ignored as a major obsidian source for local peoples during this time. In fact, the true percentage of Glass Mountain obsidian in post-900 B.P. sites in the region may actually be lower than that represented here. Some sites that did not contain Glass Mountain obsidian were excluded from this study due to questionable chronological assessments based on diagnostic projectile point types or stratigraphic associations.

X-RAY FLUORESCENCE OF VALUE OBJECTS

The most comprehensive obsidian sourcing study of large ceremonial bifaces in northern California was conducted twenty-five years ago (Hughes 1978). This study performed rapid scan semi-quantitative X-ray fluorescence analysis on thirteen bifaces and biface fragments, as well as twenty-eight projectile points and drills, all from burial contexts from site CA-Hum-67.

CA-Hum-67 is a late-prehistoric and ethnographic period site, also known as *Dulawo't*, located on Gunther Island near the city of Eureka on the northwest coast of California. As discussed above, L. L. Loud (1918) of the University of California, Berkeley excavated twenty-two burials from the site in 1913. Chronological estimates suggest that the burials date to approximately 600 years ago, based on a radiocarbon date from the basal peat layer of 1050±200 B.P. and a relatively constant rate of sedimentation (Hughes 1978, 56; Heizer and Elsasser 1964, 35; Elsasser and Heizer 1966, 2). Occupation by the Wiyot continued until historic times, and the site was abandoned around 1860 (Nomland and Kroeber 1936).

Hughes's analyses of the obsidian artifacts from the burials excavated by Loud at CA-Hum-67 were conducted using rapid scan semi-quantitative X-ray fluorescence analysis on a Norelco/Phillips Universal Vacuum Spectrograph in the Department of Geology and Geophysics at the University of California, Berkeley (Hughes 1978, 62). His analyses were sensitive enough to discriminate obsidian source groups, such as Medicine Lake and Warner Mountains, yet were not able to distinguish individual Medicine Lake sources, such as Glass Mountain, Grasshopper Flat/Lost Iron Wells/Red Switchback, or Cougar Butte (Hughes 2001: *personal communication*).

Despite the technological limitations at the time and the very small sample size of black obsidian bifaces (n=5), these analyses revealed that black bifaces in the assemblage were comprised of three different obsidian source groups: 40% from Medicine Lake in Northeastern California, 40% from Vya in Western Nevada, and 20% from Glass Buttes in South-central Oregon. The red obsidian bifaces in the assemblage were traced exclusively to the Warner Mountains of Northeastern California, one of the few sources of large red obsidian nodules (fig. 11, 12).

Based on visual inspection of the black bifaces assigned to the Medicine Lake source group by Hughes, it appears that they are likely made of Glass Mountain obsidian. Glass Mountain obsidian is one of the few sources that occurs in nodules large enough to be knapped into extravagant bifaces, which can approach one meter in length (Heflin 1982, 124). Glass Mountain obsidian also generally appears as a dusky black with gray swirling bands of varying thickness and opacity, which is distinctive from the clearer black with occasional parallel banding found in other Medicine Lake Highland sources. Visually, the bifaces sourced to the Medicine Lake Highland source group appear to be manufactured from Glass Mountain obsidian[2].

According to the ethnographic record, obsidian used in bifaces for the Hupa White Deerskin Dance came from outside the region: "red obsidian that presumably comes from the south, and a black obsidian that comes from the Shasta region in northeastern California" (Goldschmidt and Driver 1940, 120). X-ray fluorescence and visual sourcing data strongly support the hypothesis that Glass Mountain was a significant source for large, ceremonial bifaces used by coastal Nations. It is also apparent from the ethnographies that at least in historic times, these artifacts were being exchanged as finished bifaces, rather than as nodules or preforms. The archaeological evidence also supports this, in that Glass Mountain obsidian is only minimally represented in the debitage assemblages of late-prehistoric archaeological sites in Northern California, yet makes up 40% of the black biface assemblage at CA-Hum-67.

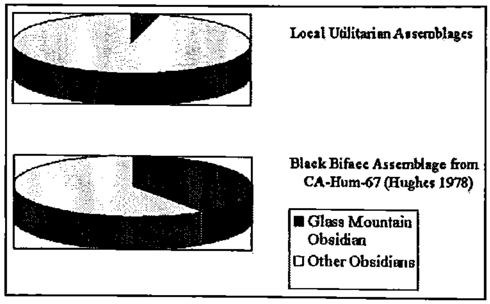

Fig. 11: Percentage of Glass Mountain obsidian in utilitarian and biface assemblages.

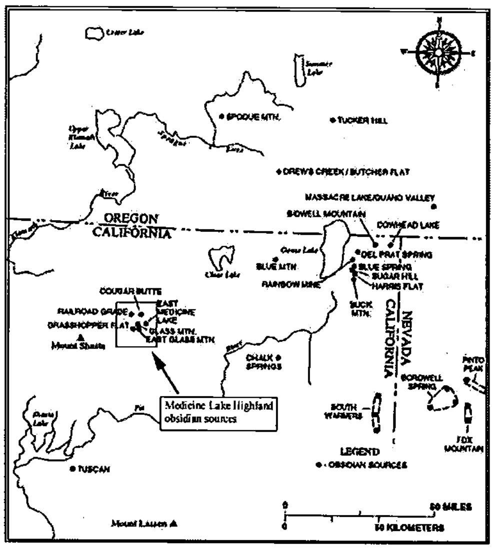

Fig. 12: Northern California, western Nevada, and southern Oregon obsidian sources (Schalk 1995).

CONCLUSION

An intriguing dichotomy is revealed by the geochemical characterization data from archaeological sites in the vicinity of Glass Mountain and large ceremonial bifaces recovered from burial contexts at CA-Hum-67. Glass Mountain obsidian makes up only approximately 5% of the obsidian assemblage in sites close to the source, while other Medicine Lake obsidian sources located merely one or two miles away are dominant. Yet it has a significant presence in the biface assemblage from CA-Hum-67 along the Northwestern California Coast. From these data, it is apparent that Glass Mountain obsidian was utilized in the past, albeit very selectively. What is most remarkable however, is the fact that Glass Mountain was effectively ignored for utilitarian purposes in the immediate vicinity of the source while other Medicine Lake Highland obsidian was preferred for utilitarian things. Archaeological survey indicates that prehistoric lithic production at the Glass Mountain quarry consisted exclusively of large, ceremonial biface production. What is important here is not just that Glass Mountain was one source used for black ceremonial bifaces, but that it was *only* used for biface production and not for common tools.

Fieldwork conducted at Glass Mountain revealed a singular pattern of raw material procurement and production at the quarry. Field reconnaissance, surface sampling, and subsurface testing indicated that biface production was the primary activity performed at Glass Mountain. High percentages of identifiable biface thinning flakes as well as biface fragments in all stages of production attest to this fact. In addition, retooling activities were conspicuously absent in the debitage and tool assemblages at the sites recorded along the base of the Glass Mountain obsidian flow. Though a handful of utilized flakes were found, no projectile points, projectile point fragments, knives, formed scrapers, drills, or other formed tools were observed. The only formalized objects recorded were large bifaces and biface fragments.

There exist few economic explanations for the lack of Glass Mountain obsidian in utilitarian assemblages in the sites within 50 miles of the quarry, particularly given that it is a high quality, easily procured obsidian. Indeed, prehistoric flintknappers traveled to nearby obsidian sources in the Medicine Lake Highland to obtain their toolstone, as evidenced by the 73% proportion of other Medicine Lake Highland obsidians in late-prehistoric assemblages. These data indicate that cultural factors held a substantial role in influencing the procurement and use of Glass Mountain obsidian in late prehistory. There was a pattern of selection of Medicine Lake Highland obsidian for a multitude of uses, yet Glass Mountain obsidian, arguably the largest and most spectacular obsidian flow in the Medicine Lake Highland, was neglected for utilitarian purposes. Instead, Glass Mountain obsidian was used for large, ceremonial bifaces. As such, the archaeological record strongly supports the hypothesis that Glass Mountain was a special obsidian source, reserved for the production of ceremonial and high value objects, and deemed inappropriate for the manufacture of utilitarian tools. The Glass Mountain obsidian source retained a special place in the worldview of local peoples. It was perceived as a location for the production of ceremonial and high value objects, yet cultural prohibitions prevented its use for utilitarian tools. Given the recent date for the eruption of Glass Mountain obsidian, it is highly likely that local peoples witnessed this eruption and the formation of the obsidian flow. Stories of the eruption entered into oral histories and legends, and contributed to the special status of this obsidian source in the local cosmology. It is possible that because of its fabled eruptive phenomena, Glass Mountain obsidian was thus used exclusively for ceremonial and high status objects, such as large bifaces, and neglected for utilitarian purposes. Thus the cultural context of the prehistoric belief system and oral histories about Glass Mountain's eruption underlie selective procurement and use of this obsidian source. The Glass Mountain eruption played an active role in the creation and transformation of value of this source and for the large bifaces made from it.

REFERENCES

Anderson, C. A. (1941) Volcanoes of the Medicine Lake Highland, California. *University of California Publications, Bulletin of the Department of Geological Sciences,* vol. 25, 347-422.

Anderson, C. A. (1933) Volcanic History of Glass Mountain, Northern California. *American Journal of Science,* vol. 26, 485-506.

Andrefsky, W. (1998) *Lithics: Macroscopic Approaches to Analysis.* Cambridge University Press, Cambridge.

Bamforth, D. (1986) Technological Efficiency and Tool Curation. *American Antiquity,* vol. 51, No. 1, 38-50.

Binford, L. R. (1979) Organization and Formation Processes: Looking at Curated Technologies. *Journal of Anthropological Research,* vol. 35, No. 3, 255-272.

Blatt, H. and Tracy, R. J. (1996) *Petrology.* W. H. Freeman and Company, New York.

Busby, C. I., Bard, J. C., Dezzani, R. J., Nissen, K. M., Findlay, J. M., Harmon, R. M., and Fong, M. R. (1990) *OTH-B Cultural Resource Program Site Testing: Modoc National Forest.* Basin Research Associates. Prepared for U. S. Forest Service, Alturas, California. On file at Modoc National Forest.

Callahan, E. (1979) The Basics of Biface Knapping in the Eastern Fluted Point Tradition: A Manual for Flintknappers and Lithic Analysts. *Archaeology of Eastern North America,* vol. 7, 1-180.

Chesterman, C. W. (1955) Age of the Obsidian Flow at Glass Mountain, Siskiyou County, California. *American Journal of Science,* vol. 253, 418-424.

Dillian, C. D. (2002) *More than Toolstone: Differential Utilization of Glass Mountain Obsidian, Siskiyou County, California.* Unpublished Ph.D. dissertation, Department of Anthropology, University of California, Berkeley.

Donnelly-Nolan, J. M., Champion, D. E., Miller, C. D., Grove, T. L., and Trimble, D. A. (1990) Post-11,000-Year Volcanism at Medicine Lake Volcano, Cascade Range, Northern California. *Journal of Geophysical Research,* vol. 95, No B12, 19,693-19,704.

Eichelberger, J. C. (1981) Mechanism of Magma Mixing at Glass Mountain, Medicine Lake Highland Volcano, California. *Guides to Some Volcanic Terranes in Washington, Idaho, Oregon, and Northern California, U.S. Geological Survey Circular,* vol. 838, 183-189.

Fisher, R. V. and H.-U. Schmincke (1984) *Pyroclastic Rocks.* Springer-Verlag, Berlin.

Forrest, Nathaniel "Chief" (1999) Personal communication. Pit River Tribal member and seasonal archaeologist, Modoc National Forest, Alturas, California.

Gates, Gerald R. (1991) *Fairchild Rip-Rap Quarry Site Damage Assessment [Supplement to ASR 05-09-700].* Report on File at Modoc National Forest.

Gates, G. R., Bevill, R., and Dillian, C. D. (2000) *Archaeological Investigations at FS-05-09-56-2413: A Sparse Lithic Scatter on the Modoc Plateau of Northeastern California.* Report Prepared for U.S. Forest Service, Alturas, California. On file at Modoc National Forest.

Glascock, M. D., Braswell, G. E., and Cobean, R. H. (1998) A Systematic Approach to Obsidian Source Characterization. In M. Steven Shackley (ed.) *Archaeological Obsidian Studies: Method and Theory,* Plenum Press, New York, 15-66.

Glascock, M. D. and Anderson, M. P. (1993) Geological Reference Materials for Standardization and Quality Assurance of Instrumental Neutron Activation Analysis. *Journal of Radioanalytical and Nuclear Chemistry,* vol. 174, No 2, 229-242.

Goldschmidt, W. R. and Driver, H. E. (1940) The Hupa White Deerskin Dance. *University of California Publications in American Archaeology and Ethnology,* vol. 35, 103-142.

Govindaraju, K. (1994) Compilation of Working Values and Sample Descriptions for 383 Geostandards. *Geostandards Newsletter,* vol. 18.

Grove, T. L., Donnelly-Nolan, J. M., and Housh, T. (1997) Magmatic Processes that Generated the Rhyolite of Glass Mountain, Medicine Lake Volcano, N. California. *Contributions to Mineral Petrology,* vol. 127, 205-223.

Heflin, E. (1982) The Huge Obsidian Ceremonial Blades of the Pacific Northwest. *Central States Archaeological Journal,* vol. 29, No 3, 122-129.

Hughes, R. E. (2001) Personal Communication.

Hughes, R. E. (1990) The Gold Hill Site: Evidence for a Prehistoric Socioceremonial System in Southwestern Oregon. In N. Hannon and R. Olmo (eds.) *Living with the Land: The Indians of Southwest Oregon,* 48-55. Southern Oregon Historical Society, Medford.

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.

Hughes, R. E. (1982) Age and Exploitation of Obsidian from the Medicine Lake Highland, California. *Journal of Archaeological Science,* vol. 9, 173-185.

Hughes, R. E. (1978) Aspects of Prehistoric Wiyot Exchange and Social Ranking. *Journal of California Anthropology,* vol. 5, No. 1, 53-66.

Kelly, R. L. (1988) The Three Sides of a Biface. *American Antiquity,* vol. 53, No. 4, 717-734.

Kelly, M. S., Nilsson, E. and Cleland, J. H. (1987) *Archaeological Investigations at Lake Britton, California.* WIRTH Environmental Services, San Diego. Prepared for PG&E, San Francisco. On file at Modoc National Forest.

Kroeber, A. L. (1957) The World Renewal Cult of Northwest California. In R. F. Heizer and M. A. Whipple (eds.) *The California Indians.* University of California Press, Berkeley, 404-411.

Kroeber, A. L. (1925) *Handbook of the Indians of California, Volume 1.* Bureau of American Ethnology, Bulletin 78.

Loud, L. (1918) Ethnogeography and Archaeology of the Wiyot Territory. *University of California Publications in American Archaeology and Ethnology,* vol. 14, 221-436.

McAlister, J. (1988) *Kwatuk.* Paper prepared for Winema National Forest. On file at Modoc National Forest.

Nilsson, E. (1990) *Archaeological Test Excavations at CA-Tri-1019: A Late Prehistoric Site in the Upper Trinity River Region of Northern California.* Mountain Anthropological Research. Prepared for PG&E, San Francisco. On file at Modoc National Forest.

Ozbun, T. (1991) Boulders to Bifaces: Initial Reduction of Obsidian at Newberry Crater, Oregon. *Journal of California and Great Basin Anthropology,* vol. 13, No 2, 147-159.

Sampson, C. G. (1985) *Nightfire Island: Later Holocene Lakemarsh Adaptation on the Western Edge of the Great Basin.* University of Oregon Anthropological Papers, vol. 33.

Schalk, R. (ed.) (1995) *Archaeological Investigations PGT-PG&E Pipeline Expansion Project. Idaho, Washington, Oregon, and California. Volume IV: Synthesis of Findings.* Infotec Research Inc. Fresno, California.

Shackley, M. S. (1987) *U.S. Sprint Fiber Optic Cable Project Oroville, California to Eugene, Oregon. Archaeological Testing of Four Sites in California: CA-But-5, Teh-1468, Sha-1684, Sis-332.* Dames and Moore, LLP. Prepared for U.S. Sprint. On file at Modoc National Forest.

U. S. Geological Survey (2000) *Description: Medicine Lake Shield Volcano, Medicine Lake Caldera.* USGS World Wide Web page. (http://vulcan.wr.usgs.gov/Volcanoes/MedicineLake/description_medlake.html)

Yurok Nation NAGPRA Committee (1999) *Personal Communication. Phoebe Hearst Museum of Anthropology,* University of California, Berkeley. November 11.

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[2] Ideally, it would be possible to re-analyze the obsidian bifaces from CA-Hum-67 using more precise, modern X-ray fluorescence technology to determine if they are indeed Glass Mountain obsidian. In addition, a larger sample size could be obtained through re-analysis. However, as burial items, bifaces are subjects of NAGPRA legislation and at this time are the objects of consultation and repatriation. The descendant Native American representatives have requested that no bifaces be re-analyzed for this study, and their wishes will be respected here. Therefore, Hughes's data and visual examination provide the only available source information. For this same reason, bifaces from other California sites in the collections at the Phoebe A. Hearst Museum of Anthropology and Archaeology at the University of California, Berkeley, have also not been analyzed using geochemical techniques.