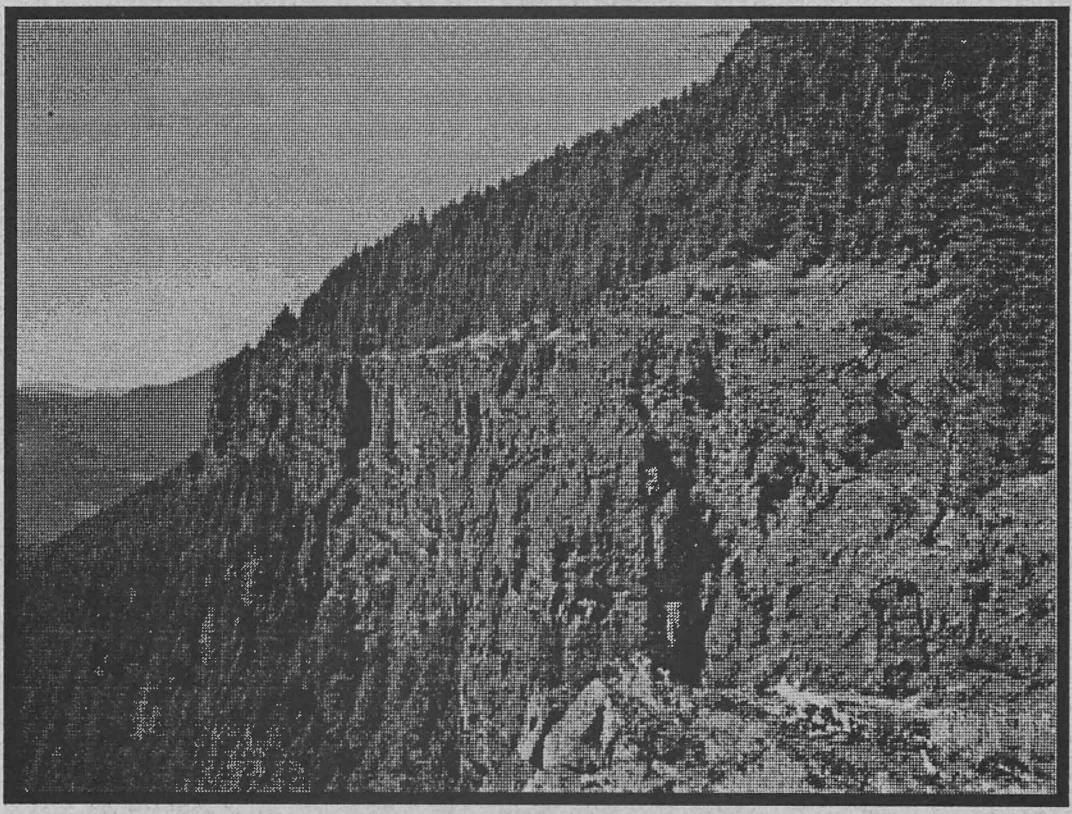
Obsidian Source Sampling Survey, Oakridge Ranger District: Results of Reconnaissance Field Investigations in the Mt. David Douglas Area



Craig E. Skinner

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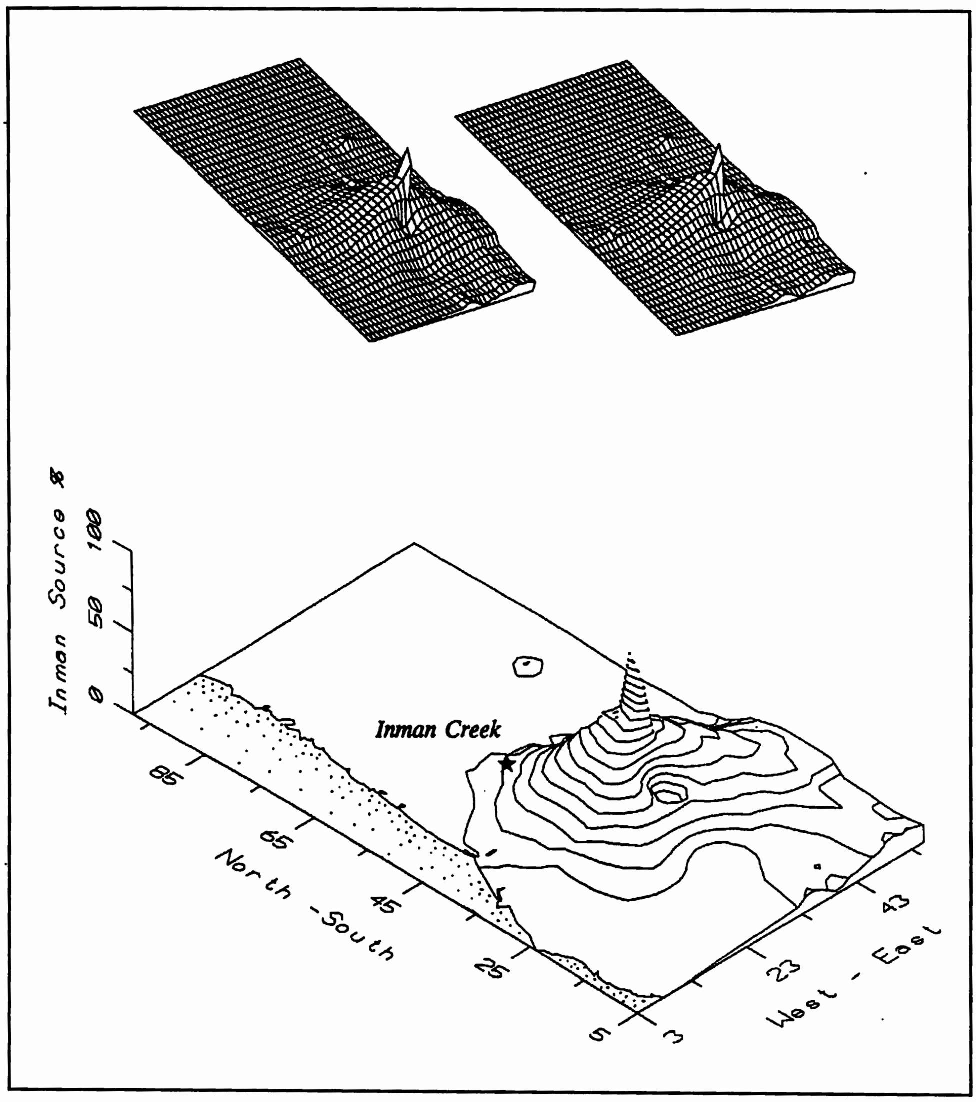

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Introduction

This report documents the results of a two-day field investigation conducted in October, 1993, under the auspices of the Oakridge Ranger District, Willamette National Forest. The objectives of this field reconnaissance investigation were to:

1. Examine known and suspected locations of naturally-occurring nodules of obsidian in the Mt. David Douglas Area, Lane County. Several U.S. Forest Service site descriptions recorded in the 1980's contained descriptions of obsidian source material which suggested the possibility of primary or secondary obsidian source localities.

2. Investigate the secondary extent of obsidian in the Mt. David Douglas region. Obsidian nodules have been found and reported in drainages in the Mt. David Douglas area and an objective of this investigation was to examine stream drainages and roadcuts for the presence of obsidian.

At least two prehistorically utilized and archaeologically significant sources of obsidian are known or are suspected to lie within the Middle Fork drainage of the Willamette River in the Oakridge Ranger District of western Oregon. While these two sources, referred to here as the Inman A and Inman B sources, have been geochemically identified at several archaeological and geologic localities, details about their primary and secondary source boundaries remain incompletely known. The primary location of the Inman A source, determined through geochemical studies of the glass, appears to be located within the upper Salt Creek drainage near Mt. David Douglas. Obsidian correlated with this source is widely distributed in geologic outcrops in the Western Cascades, southern Willamette Valley, and central Oregon Coast, although the secondary boundaries of the source are not well known. The location of the primary Inman B source remains unknown, although geochemical, geological, and spatial evidence strongly suggests that it lies in the same region as the Inman A source. The geographic distribution of the Inman B source is similar to that of the Inman A source, and the two groups often co-occur in both archaeological and geologic contexts. Glass from the Inman B source is almost always found in significantly smaller quantities than the Inman A material.

Considering the importance of obsidian characterization studies in the investigation of prehistoric studies of raw material procurement and the potential of obsidian hydration dating in the western Cascades, a clearer understanding of the location of these two sources of glass must be considered a regional archaeological priority. Without an accurate measure of the geographic boundaries of availability of the glass, the secondary source distribution, and the primary locations of all available sources, studies of obsidian procurement patterns must remain incomplete.

The Salt Creek-Inman Creek Connection

To understand the enigmatic geographic distribution of natural glasses correlated with the Inman Creek chemical groups, it is necessary to examine the relationship of obsidian sources in the Mt. David Douglas area with those found in the southern Willamette Valley of Oregon.

For many years, archaeologists took it for granted that the only natural indigenous sources of obsidian available to the prehistoric inhabitants of the Willamette Valley were in the gravels of the McKenzie and Willamette Rivers. Small nodules of glass from Obsidian Cliffs, a large glaciated Pleistocene obsidian flow in the central High Cascades, are not uncommon in these river gravels. The presence of obsidian from other sources was typically ascribed to the presence of exchange systems — the geologic sources of the glass were thought to largely lie among the many sources that are found east of the Cascades in eastern Oregon.

In recent years, however, several locally available obsidian sources have been identified in western Oregon (Figure 3). Major "new" secondary and primary outcrops of glass now include:

1. *Devil Point*. Found at an ash-flow unit exposed in a high ridge a few km southeast of Mt. Jefferson, glass from this source was available locally and was apparently used primarily within a radius of a few tens of kilometers from the source.

2. *Inman Creek*. Obsidian nodules up to 17 cm in diameter are found in a conglomerate stratum intersected by Inman Creek and several other small streams in the Fern Ridge Reservoir area of the southwestern Willamette Valley. The large size and relative abundance of the nodules (common at this location) initially suggested a local primary source, most likely one located in the eastern part of the Coast Range (a conclusion that, while reasonable, appears to have been premature; Skinner, 1986).

3. *Siuslaw River*. Nodules of glass up to four cm in diameter are found in gravel bars only a few kilometers from the mouth of the Siuslaw River at Florence.

4. *Salt Creek*. Oligocene-Miocene rhyodacitic lavas and associated obsidian flows are mentioned by Woller and Black (1983; mapped as Unit Tomr) in the Salt Creek Falls vicinity. Nodules of glass from this source are found in Highway 58 roadcuts and in the stream gravels of Salt Creek west to its confluence with the Middle Fork of the Willamette.

5. *Bill's Creek*. Reported by Heid (1986), small obsidian nodules from the Bill's Creek Site locale are found on the surface at this site and in volcaniclastic sediments exposed in nearby road cuts.

6. *Winberry Creek*. A source of obsidian-like vitrophyre located northeast of Lowell on Winberry Creek. Glass from this source is of marginal artifact quality and was probably used only rarely for the manufacture of prehistoric stone tools (Millhollen, 1991; Skinner, 1983).

7. *Willamette River Gravels*. Neutron activation studies of obsidian collected from Willamette River gravel bars indicate that small nodules of glass from both Inman chemical groups and Obsidian Cliffs co-occur in river gravels south of Eugene.

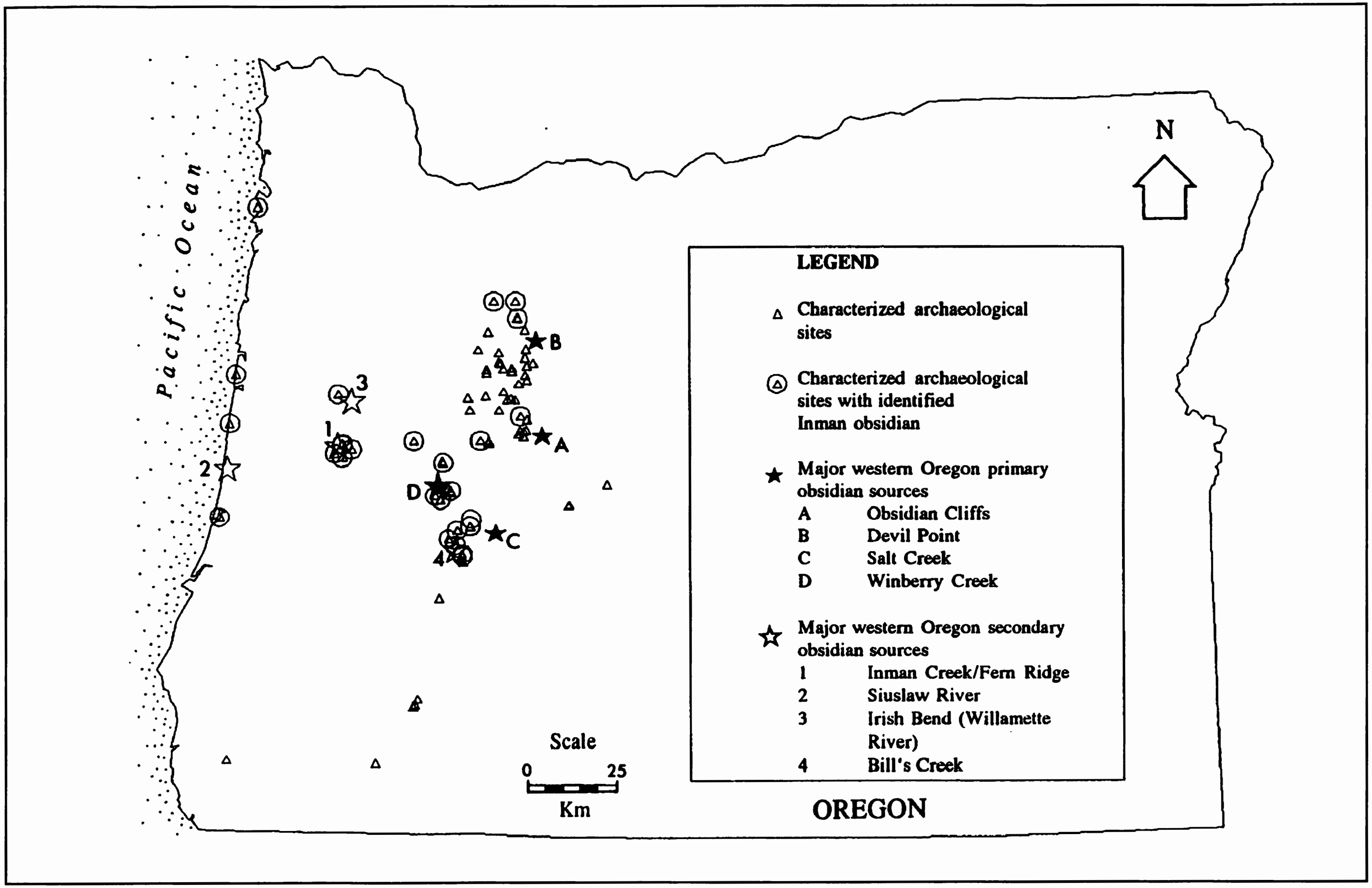


Figure 3. Obsidian sources and characterized archaeological sites in western Oregon (from Skinner, 1991:31).

Archaeological sites adjacent to the Willamette River often contain unmodified or split nodules of glass. Nodules of unmodified raw material, most likely from local alluvial deposits and river gravels, have also been reported from many other archaeological contexts throughout the Willamette Valley (Silvermoon, 1991; Skinner, 1991).

Trace element studies of obsidian from these sources revealed that glass from the Inman Creek source locale was separable into two distinct chemical groups termed Inman A and Inman B (Skinner, 1983, 1986, and 1994). Eventually, these two chemical groups were correlated with characterized samples from the Siuslaw River, Willamette River gravels, Salt Creek, and Bill's Creek (Figure 4). Unexpectedly, the geochemical evidence indicated that the primary source of the Inman A glass was an obsidian-rhyolite flow exposed in a Highway 58 roadcut near Salt Creek Falls. Obsidian from both geochemical groups was present at several of the secondary source sampling locations. The primary source location of the Inman B glass, however, remained unidentified.

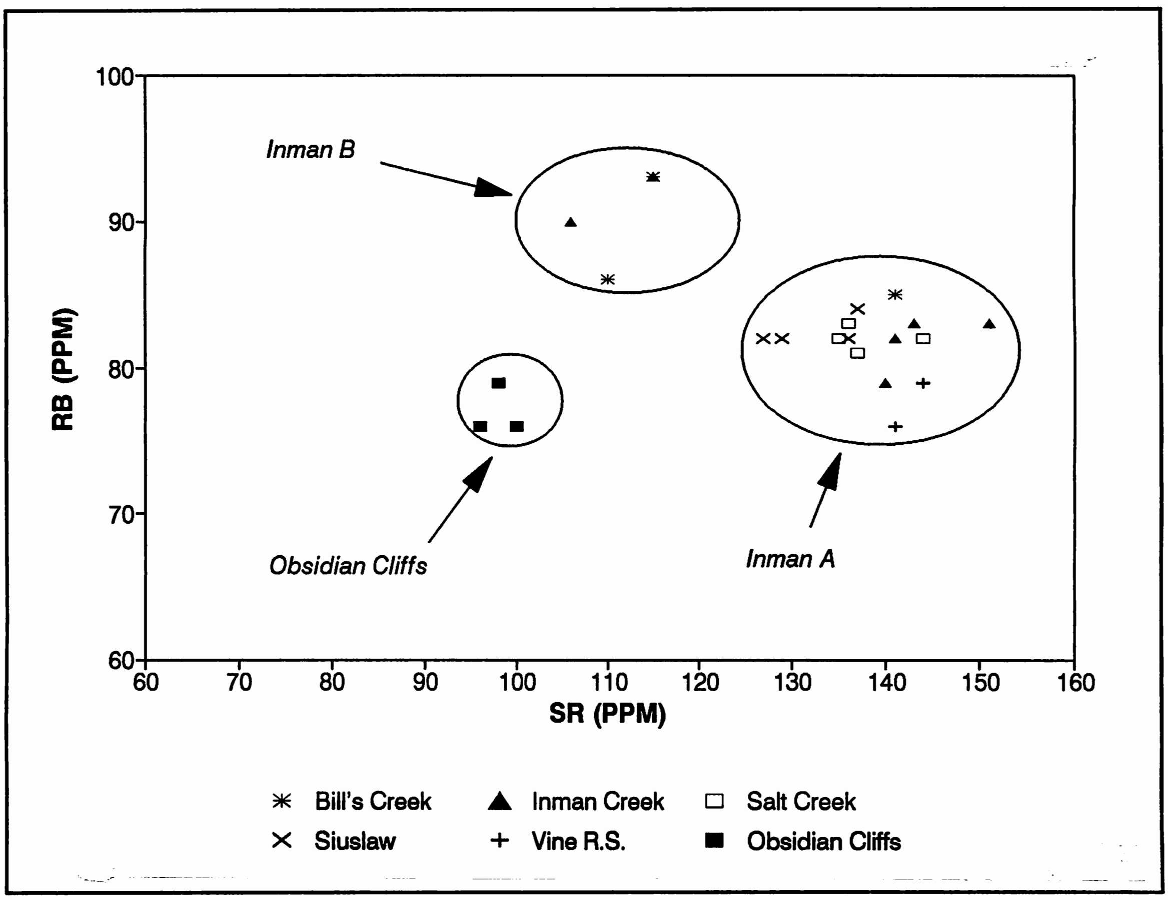


Figure 4. Scatterplot of Rubidium plotted versus Strontium for obsidian samples collected at Inman Creek, Salt Creek, the Siuslaw River, Bill's Creek, and Obsidian Cliffs (from Skinner, no date).

Although the primary source location of the Inman B glass has not yet been found, several lines of evidence strongly suggest that it is located somewhere in the Mt. David Douglas region:

1. Trace element studies of obsidian artifacts from western Oregon sites indicate a geographic pattern of Inman A and Inman B materials that is approximately coincident to the drainage of the Middle Fork of the Willamette River (see Figure 2 and Figure 5; the data plotted in Figure 5 are current through 1990).

2. Recent XRF studies of obsidian artifacts and raw material collected from sites associated with the Warner Creek Fire indicate that a high percentage (16.4 %) of the characterized glass originated from the Inman B source. 35-LA-512 (N=37), the largest site that was sampled, produced 10.8 percent of the Inman B artifacts and 43.2 percent of the Inman A items (see Table 1).

3. Trace element studies of several primary and secondary source outcrops indicate the presence and co-occurrence of both Inman A and Inman B obsidian in the Middle Fork drainage of the Willamette River. This indicates that the source of the Inman B glass almost certainly lies within this drainage.

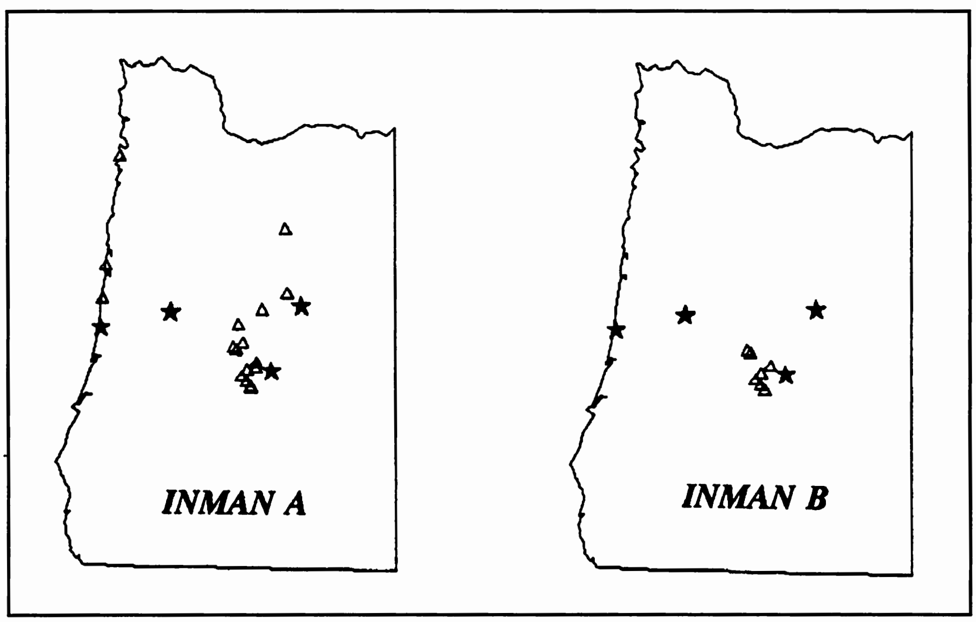


Figure 5. Distribution of Inman A and Inman B obsidian (triangles) from characterized archaeological sites (data plotted are current through 1990; from Skinner, 1991:26). See Figure 1 for a guide to the sources (stars).

4. Inman A and Inman B glass co-occur in most investigated secondary contexts, suggesting that both groups were deposited contemporaneously from the same original source area.

XRF Studies of the Warner Creek Fire Collection: A Brief Reexamination

Before this reconnaissance investigation, trace element studies of 73 obsidian artifacts and unmodified nodules of raw material were carried out with items collected in conjunction with studies of the Warner Creek fire northeast of Oakridge, Oregon, near the current study area (Jackson et al., 1993; Winkler, 1993). Over 34 percent of the characterized artifacts were correlated with the Inman A source group; an additional 16.4 percent were assigned to an Unknown D chemical group. Recent geochemical reanalyses of samples used to originally characterize the Inman Creek source area indicate that this Unknown D source is, in reality, the Inman B source (Jackson and Davis, 1993). Site 35-LA-512 is shown in Figure 6 (other Warner Creek Fire sites are located a few kilometers to the northwest of 35-LA-512).

Table 1. Results of Warner Creek Fire obsidian studies reevaluated in light of recent geochemical investigations of Inman Creek source samples.

Obsidian Source	LA 226	LA 512	LA 1047	LA 1061	LA 1063	LA 1064	LA 1065	LA 1066	Dexter Nodule	Total
Inman A	1	16	3	1	1	1	1	-	1	25 (34.2%)
Inman B (Unknown D)	2	4	4	-	-	1	1	-	-	12 (16.4%)
Newberry Volcano	3	1	2	-	-	1	-	-	-	7 (9.6%)
Obsidian Cliffs	4	6	1	-	-	-	1	1	-	13 (17.8%)
Quartz Mountain	-	1	-	-	2	1	-	1	-	5 (6.8%)
Silver Lake/ Sycan Marsh	-	2	1	-	-	-	-	-	-	3 (4.1%)
Spodue Mountain	-	3	-	-	-	-	-	-	-	3 (4.1%)
Unknown 1	-	1	-	-	-	-	-	-	-	1 (1.4%)
Unknown 2	-	1	-	-	-	-	-	-	-	1 (1.4%)
Unknown 3	-	2	1	-	-	-	-	-	-	3 (4.1%)
Total	10	37	12	1	3	4	3	2	1	73

The relative frequencies of local versus non-local debitage, cores, and projectile points in the Warner Creek Fire collection suggest that local material was most often used in the manufacture of utilitarian tools while glass from eastern Oregon sources most often arrived in the form of completed tools. For example, only one projectile point was made from Inman A material; the other six recovered points originated from either eastern Oregon sources (N=5) or Obsidian Cliffs (N=1). All identified cores were correlated with the Inman A and Inman B sources.

Mt. David Douglas Reconnaissance Investigation

A total of 19 different locations were examined during the two days of field work reported here. The results of the field work are summarized in Table 2; locations of the examined localities are shown in Figures 6 and 7.

Discussion

Black and gray obsidian nodules were found at 14 of the 19 locations that were investigated. All collection sites were located at primary obsidian sources near Mt. David Douglas, at colluvial deposits originating from the immediate Mt. David Douglas area, or at gravels in streams draining the immediate Mt. David Douglas area. All obsidian samples were collected at an elevation below 5720 feet on the eastern, southern, and northern slopes of Mt. David Douglas. Several of the sampling locations had been previously recorded as archaeological sites and nodules of "ignimbrite", the term often previously erroneously used to describe the porphyritic and banded obsidian found in the area (see Table 2).

Megascopic Characteristics

Three megascopically distinguishable varieties of glass were noted at most of the sample locations:

1. Black obsidian, often banded, with a uniform vitreous luster.
2. Black obsidian, often banded, with a uniform vitreous luster and abundant microscopic microphenocrysts in the glassy groundmass. The phenocrysts are distinguishable as tiny "flaws" in the surface of the glass and are easily visible on a freshly broken surface. The largest of the phenocrysts are barely visible to the naked eye.
3. Gray obsidian, often banded, with a uniform vitreous to dull matte luster.

Cortex on all samples is often completely intact and smooth, characteristics typical of occurrences of obsidian at or near primary sources. Black obsidian nodules range in roundness from rounded to subangular and in sphericity from subprismoidal to discoidal (AGI, 1982). Gray nodules are more typically subangular to rounded in roundness and prismoidal to subprismoidal in sphericity.

Raw Material Size

The relatively small size of available nodules in the Mt. David Douglas area in comparison to the larger material available at Inman Creek points to a complex and puzzling depositional history. Even glassy nodules collected at the primary source localities visited during this investigation do not reach the diameter of nodules recovered nearly 100 kilometers west of Mt. David Douglas in the southwestern Willamette Valley. At this time, the difference in grain size remains enigmatic, although it does suggest that two very different depositional processes were responsible for the emplacement of obsidian in the two areas.

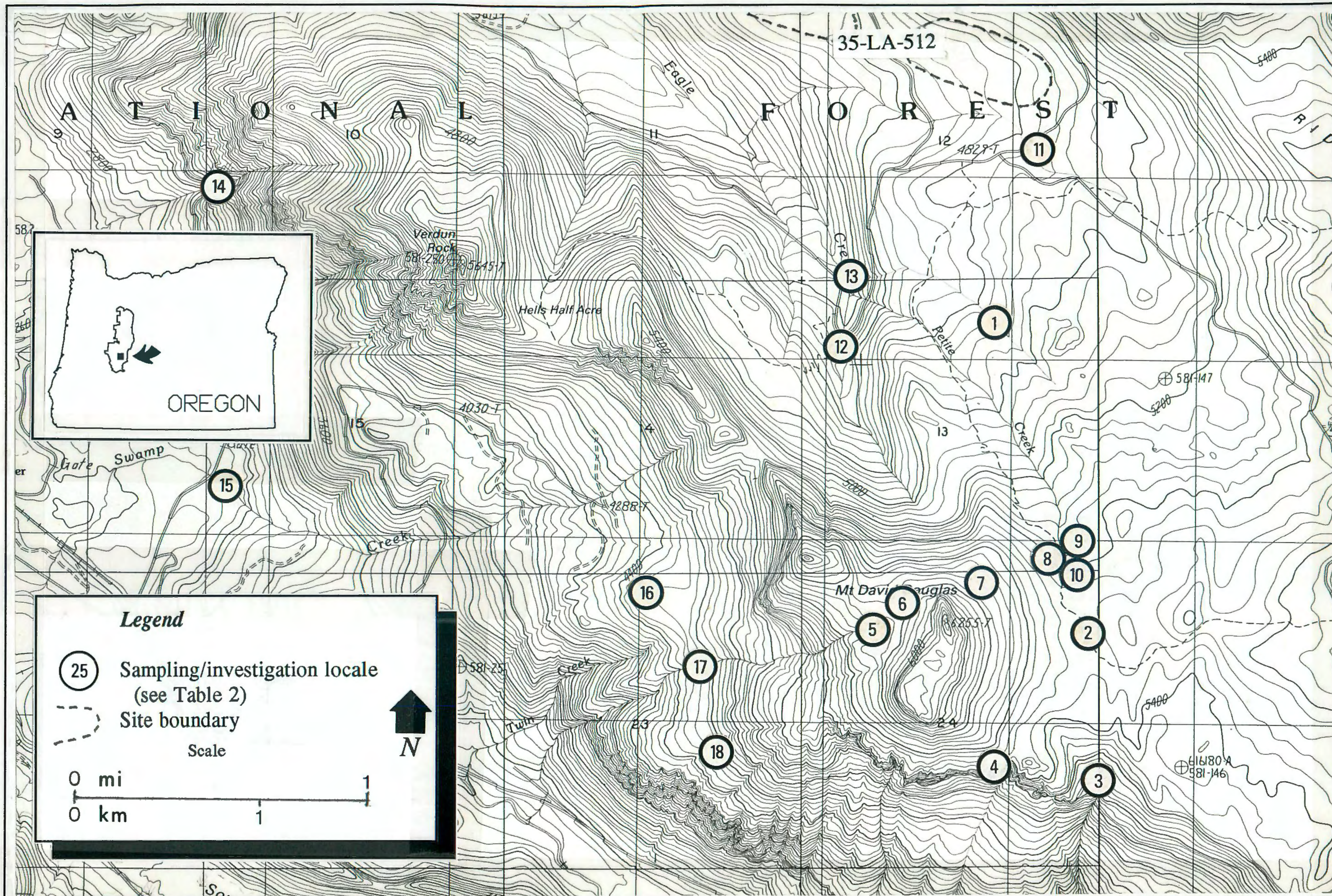


Figure 6. Location of investigated obsidian sources and localities in the Mt. David Douglas region.

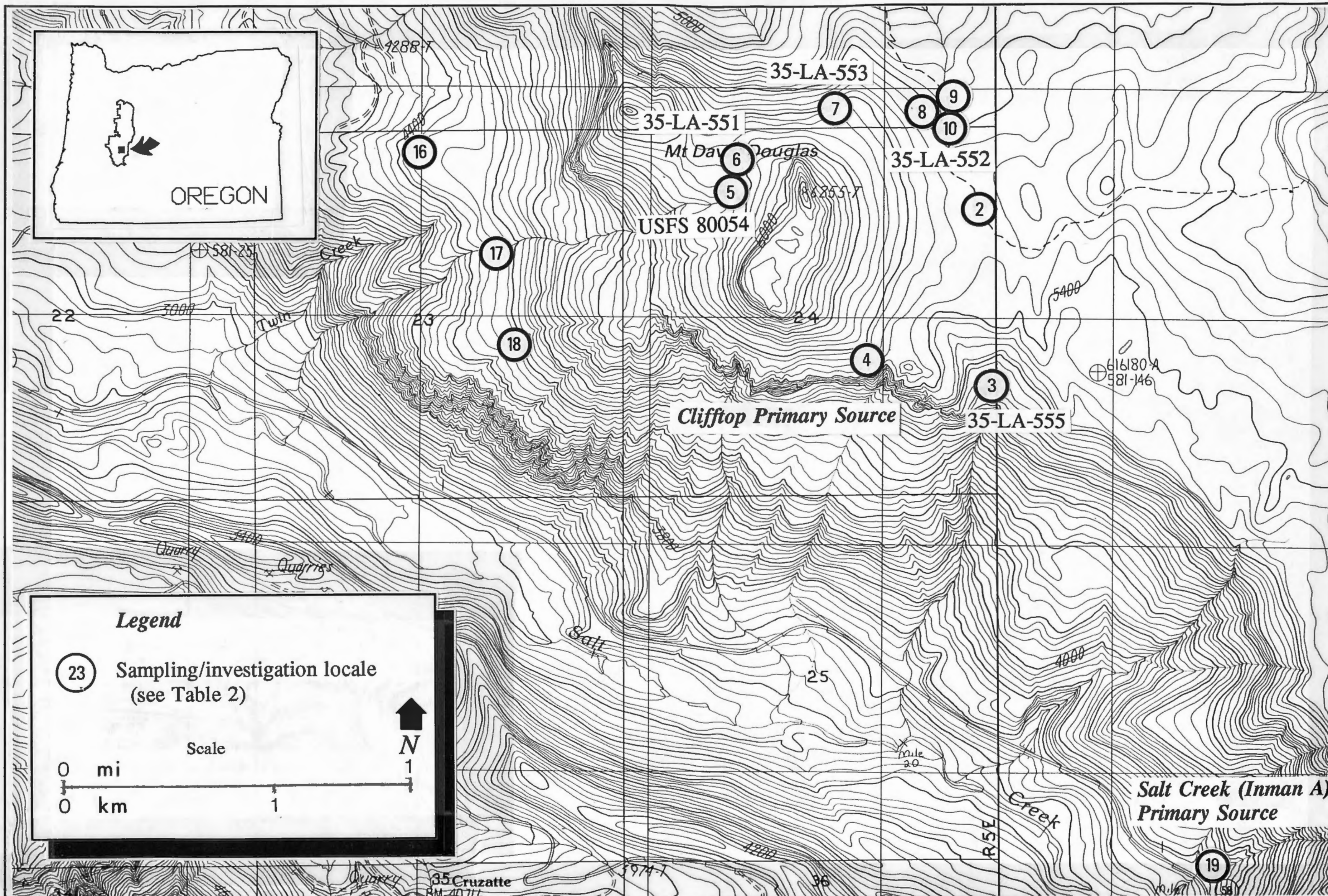


Figure 7. Location of investigated archaeological sites and obsidian source localities in the immediate Mt. David Douglas area.

Table 2. Obsidian sampling and investigation localities.

Stop	Location	Section	T.	R.	Elev. (ft ASL)	Sample #	Description
1	USFS Rd. 503	SW¼NE¼ 13	22S	5E	4800-4860	DDOUG-A	Subangular to rounded nodules of obsidian up to 4 cm in diameter were found in the bed of an intermittent stream located 50-100 m south of the end of Road 503. Small nodules of glass are common in the streambed - a layer of organic debris covers most colluvial deposits in this vicinity and the only exposures are in the streambed. Gray glassy nodules and rhyolitic pebbles were also found. Obsidian was not found in the road bed or road cuts of Road 503. One obsidian flake found in streambed.
2	LA-552	NE¼ NE¼ 24	22S	5E	5450	None collected	Small subangular to rounded obsidian nodules up to about 4 cm in diameter were noted in areas disturbed by logging and road building activities in the vicinity of Site 35-LA-552.
3	LA-555	NE¼SE¼ 24	22S	5E	5000-5200	DDOUG-B	Small nodules of subrounded to rounded black and gray glass up to 4 cm in diameter were collected from the gravels of a small perennial streambed in vicinity of site 35-LA-555. Numerous obsidian flakes in small dry stream channels. Reported as a possible "ignimbrite" quarry source in a 1981 site report.
4	Clifftop Obsidian	NW¼SE¼ 24	22S	5E	5400	DDOUG-C	Subangular to rounded, spherical to discoidal gray and black obsidian nodules were recovered *in situ* from a primary source deposit exposed at the top of basalt cliffs located immediately south of Mt. David Douglas. Nodules up to 6 cm in diameter were collected in the ashy matrix exposed at this location. Other apparent exposures of the obsidian-bearing deposits could be seen at the cliff margin to the west and east of this collection site. Access to this locality, a primary nesting area for Peregrine Falcons, is restricted for much of the year.
5	USFS 80054	NW¼NW¼ 24	22S	5E	5720	DDOUG-D	Small nodules of subrounded to rounded obsidian up to 3.5 cm in diameter were collected from a spring-fed stream channel in a meadow in the vicinity of USFS Site 80054. Occasional small nodules (<1cm diameter) were found on the surface of the hills overlooking the meadow and stream. Natural "ignimbrite" cobbles were reported from this location in a 1981 site report.

Stop	Location	Section	T.	R.	Elev. (ft ASL)	Sample #	Description
6	LA-551	NE¼NW¼ 24	22S	5E	5760	None Collected	No obsidian nodules were observed in the vicinity of Site 35-LA-551. Small scatters of obsidian flakes were noted. Localized sources of "ignimbrite" in the area were reported in a 1981 site report.
7	LA-553	NW¼NE¼ 24	22S	5E	5520	None Collected	No obsidian was observed in the vicinity of Site 35-LA-553.
8	Petite Creek 1	SE¼SE¼ 13	22S	5E	5450	DDOUG-E	Subangular to rounded nodules of glass up to 5 cm in diameter were collected from the surface in a clearcut located immediately north of Petite Creek and immediately west of Road 20500. Numerous obsidian flakes and unformed tools were also found in this vicinity.
9	Petite Creek 2	SE¼SE¼ 13	22S	5E	5400	DDOUG-F	Subangular to rounded small nodules of glass up to 5 cm in diameter were collected from the gravels of Petite Creek. Rhyolitic pebbles were common in the creek gravels.
10	Petite Creek 3	SE¼SE¼ 13	22S	5E	5400	DDOUG-G	Subangular to rounded small angular to subangular nodules up to 3 cm in diameter were collected from the surface of a draw intersecting Petite Creek immediately east of Road 20500.
11	LA-512 area stream	N½SE¼ 12	22S	5E	4640	None collected	No obsidian was found in the intermittent stream bed immediately south of 35-LA-512.
12	Eagle Creek 1	NW¼NW¼ 13	22S	5E	4440	DDOUG-H	1 small rounded nodule (<1cm) was collected from from the gravels of Eagle Creek above the confluence with Petite Creek.
13	Eagle Creek 2	NW¼NW¼ 13	22S	5E	4360	DDOUG-I	A few small rounded nodules (<2cm) were collected from Eagle Creek gravels at the confluence with Petite Creek. These could have been transported down Petite Creek from upstream sources.
14	Verdun Rock Stream	NW¼NW¼ 10	22S	5E	3040	None collected	No obsidian was found in the gravels of an unnamed perennial stream originating from the Verdun Rock vicinity. Stream gravels between a prominent falls and the road were searched.

Stop	Location	Section	T.	R.	Elev. (ft ASL)	Sample #	Description
15	Swamp Creek	NW¼SW¼ 15	22S	5E	2700	None collected	No obsidian was found in the Swamp Creek drainage near Road 5883. Stream gravels were poorly-exposed at this location.
16	Old Growth Lunch Break	NE¼NW¼ 23	22S	5E	4440	None collected	Subrounded to rounded obsidian nodules were found in areas disturbed by road building (Road 363), although none were found in undisturbed areas or road cuts. Because of uncertain provenience (may have been transported with roadbuilding materials), no samples were collected.
17	Twin Creek Area	SW¼NE¼ 23	22S	5E	4520	DDOUG-J	Subangular to rounded nodules of glass up to 4 cm in diameter were collected from several locations in a permanent to intermittent stream drainage located one drainage east of Twin Creek. Obsidian was recovered from stream gravels, from the surface, and *in situ* from ash erosional pedestals in road cuts in this vicinity. This stream drains the meadow area above sampled at stop 5.
18	Road's End	NW¼SE¼ 23	22S	5E	4520	None collected	No obsidian was found in roadcuts or in an intermittent streambed near the end of road 363 and immediately east of a small prominent rockshelter.
19	Salt Creek Obsidian	S½ 29	22S	6E	3720	DOUG-K	Nodules of black and gray obsidian up to 10 cm in diameter were collected in a roadcut of Highway 58 just west of Salt Creek Falls. This location appears to be the primary source exposure for the Inman A chemical group. Zones of black and gray glass are interspersed with tan to gray ashy pyroclastic deposits and devitrified glass that are probably associated with the eruption of an rhyolite-obsidian flow/dome at this location. Nodules of vitreous black glass, gray glass, and devitrified glass are abundant in this location and in nearby roadcuts. The rhyolitic deposits at this location appear to be directly overlaid by the basalts of Mt. David Douglas. Site 35-LA-612 is located on a bench above Salt Creek not far downstream from the sampling location. The site is found immediately downslope from another roadcut exposure of obsidian and is reported as a source of natural obsidian nodules. The Salt Creek Trail, a likely Indian trail, passes by this site.

Primary Obsidian Source Locations

Two primary source localities were sampled at Mt. David Douglas, one exposed near Salt Creek (Stop 19, Table 2) and the other outcropping atop the basalt cliffs south of the mountain (Stop 4, Table 2). The two primary sources are stratigraphically separated by over 1600 feet (500 m) of basalt flows. Both are mapped as Miocene-Oligocene in age by Woller and Black (1983).

The rhyodacitic lavas in the Mt. David Douglas vicinity are very briefly described by Woller and Black (1983:61):

> Rhyodacitic to rhyolitic (?) lava flows occur on the steep south slopes of Mount David Douglas. The sequence may be as much as 305 m (1,000 ft) thick, but accurate determinations of the total thickness are difficult because of (1) intracanyon Quaternary lavas on the south side of Mount David Douglas that hide parts of the sequence, (2) lithologic similarity between interbedded lavas and those mapped elsewhere as Oligocene-Miocene lavas, undifferentiated, and (3) masking by landslides and colluvium. The Oligocene-Miocene rhyodacitic lavas do not crop out across from Salt Creek from their principal occurrence near Mount David Douglas, indicating that Salt Creek may be following the margin of their outcrop area.
>
> The rhyodacites and rhyolites (?) of this unit are typically buff to pink and aphyric. Flow banding is common, and occasional obsidian flows are present.

The major and trace element composition of three samples of obsidian from the Salt Creek source locality were determined and reported by Woller and Black (1983:110-111; samples P-777, P-821, and P-825). Based on major element composition, the obsidian from this source is classified as rhyodacitic (e.g., $SiO_2 \geq 70\%$ and $K_20 \leq 4\%$).

Primary Source 1: Clifftop Source. Nodules of black and gray obsidian are found in light gray to tan-colored ashy deposits exposed at the top edge of spectacular basalt cliffs located on the southern flanks of Mt. David Douglas (Figure 6). Nodules of glass are common in the ashy matrix; the texture of the obsidian ranges from vitreous to nearly totally devitrified. The maximum size of vitreous glassy nodules found at this location is about six centimeters. The deposits of ash and obsidian are exposed at numerous locations along the top of the basalt cliffs and are easily distinguished as light-colored zones at the edge of the cliffs.

The stratigraphic separation of this source from the Inman A source combined with the geographic distribution of previously characterized obsidian artifacts suggests that the Clifftop Source may be the as yet unlocated Inman B source. This hypothesis may be easily tested by determining the chemical composition of the glass collected at this location. The trace element composition of the Inman B source has been well documented through trace element studies of obsidian artifacts and the verification or refutation of the Clifftop Source as the parent source of the Inman B obsidian should prove to be a straightforward analytical problem.

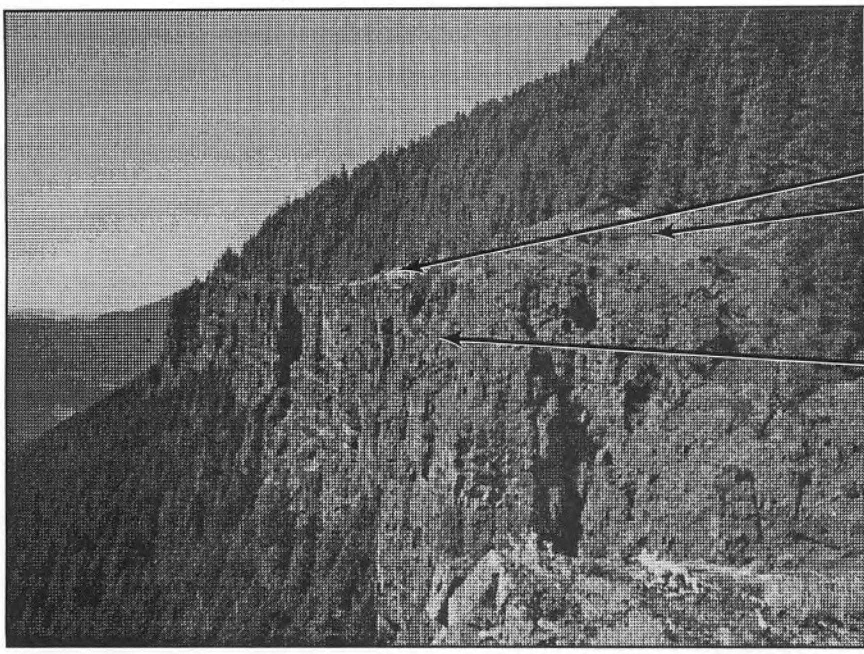
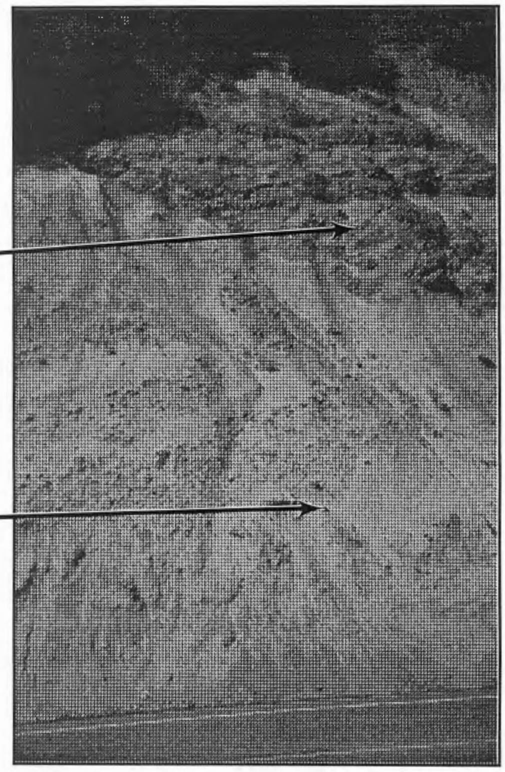


Figure 8. Clifftop Source exposed at the edge of the cliff-forming basalt flows of Mt. David Douglas (Stop 4 in Table 2).

Primary Source 2: Salt Creek Source. Deposits of light-colored ash with a large percentage of gray to black glassy to microcrystalline vitreous obsidian and devitrified glassy nodules can be found exposed in several outcrops along Highway 58 (Skinner and Radosevich, 1991:47). The deposits are very similar in appearance to those found at the previously described Clifftop Source. The deposits are located west of the Salt Creek Falls highway tunnel along roadcuts on the north side of Highway 58. The glassy zone of a rhyolite dome/flow appears to have been intersected by one of the roadcuts (sample collection site DDOUG-19) and nodules of obsidian up to about 10 cm in diameter may be found at this locality. The co-occurrence of glassy and pumiceous zones is a common feature at many rhyolite-obsidian domes and has been described in detail by Fink and Manley (1987). The outcrops of ash and glass exposed in these roadcuts are interpreted here to represent near-vent deposits associated with the Oligocene to Miocene eruption of rhyodacitic to rhyolitic rocks in the Mt. David Douglas vicinity.

Obsidian nodules of archaeologically usable size from this source are also available upstream from McCredie Hot Springs in the gravels of Salt Creek, although a geochemically-identical and more durable gray variety may be available farther downstream.

Figure 9. Near-vent pyroclastic deposits containing obsidian that are exposed in a roadcut on Highway 58 (stop 19 in Table 1).



Conclusions and Recommendations

In general, the patterns of obsidian source use revealed by previous trace element studies of artifact and raw material samples from the Middle Fork Willamette River drainage suggest the existence of at least two independent procurement systems:

1. *Local procurement of obsidian from the Inman A and Inman B geochemical sources and the Obsidian Cliffs source.* Obsidian from all three sources is widely regionally available in primary and secondary source deposits. The prehistoric collection of glass from these sources would reasonably fit within a model of lithic procurement embedded in normal seasonal subsistence activities (Binford, 1979).

2. *Long-distance procurement of glass from multiple sources in eastern Oregon, primarily those in the Newberry Volcano and Klamath Basin regions.* The presence of obsidian from these sources and the high diversity of sources in the Middle Fork Willamette River drainage relative to other major Cascade drainages has been previously documented in an investigation of trans-Cascade obsidian procurement (Skinner and Winkler, 1991) and is further corroborated with data available from the Warner Creek Fire XRF study. The existence of prehistoric exchange systems and/or the use of the Middle Fork Willamette River drainage as a major trans-Cascade travel corridor provide procurement models that would best account for the distribution of the obsidian from eastern Oregon sources.

Field evidence points to the existence of two primary obsidian source localities in the Mt. David Douglas area, one exposed in the road cuts on Highway 58 near Salt Creek, and a second one atop a series of basalt flows near the summit of Mt. David Douglas. Geochemical studies have identified the Salt Creek exposure as the likely parent source for the Inman A chemical group; the primary source of the Inman B glass is not yet known, although the presence of a second primary source high on the southern flanks of Mt. Davis Douglas provides a likely candidate for this as yet unlocated source.

At this point in the development of obsidian procurement studies in the Middle Fork Willamette River drainage, there is a clear need to identify the primary sources of geochemical populations of glass that are locally available and to determine their occurrence and availability in secondary outcrops, e.g., to identify natural source boundaries. Trace element (XRF) studies of obsidian artifacts **and** samples of raw material provide the best method for achieving these ends.

I recommend that a minimum of from two to five samples from several scattered secondary obsidian source localities be selected and submitted for trace element analyses and source assignments. I also recommend that from five to fifteen samples from both primary source outcrops also be analyzed. The larger sample sizes from source outcrops are necessary to establish the geochemical range of variation that is present for trace elements that are routinely used to characterize the glass. While the chemical composition of obsidian sources is often found to be homogeneous, the petrogenesis of obsidian glass can be due to complex and varied processes and the range of chemical variability must be empirically determined for each source and not simply assumed to be homogeneous (Hughes and Smith, 1993). A large sample from the Inman A source will also verify that the Inman B group is not simply an artifact of unrecorded chemical variability at a single geologic source. Because of the relatively low frequency of appearance of the Inman B chemical group in secondary contexts, it should be noted that larger sample sizes from secondary sources will yield higher probabilities of including Inman B samples. Because of this, if the overall number of samples to be analyzed is seriously constrained, I would recommend the use of larger sample sizes from fewer collection localities.

I also recommend, in the larger context of obsidian characterization studies in the Willamette National Forest, that particular emphasis be placed on obtaining relatively large and geographically diverse samples of archaeological obsidian. Obsidian procurement patterns in the Middle Fork Willamette River drainage are demonstrably unique to the Western Cascades and Willamette National Forest and further studies of obsidian in this drainage can be expected to provide disproportionately valuable archaeological results (Skinner and Winkler, 1991).

Acknowledgements. I would like to thank Jeff McAlister, Dick Davis, and especially Carol Winkler, of the Oakridge Ranger District, Willamette National Forest, for their map reading skills and enthusiastic support of this project.

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