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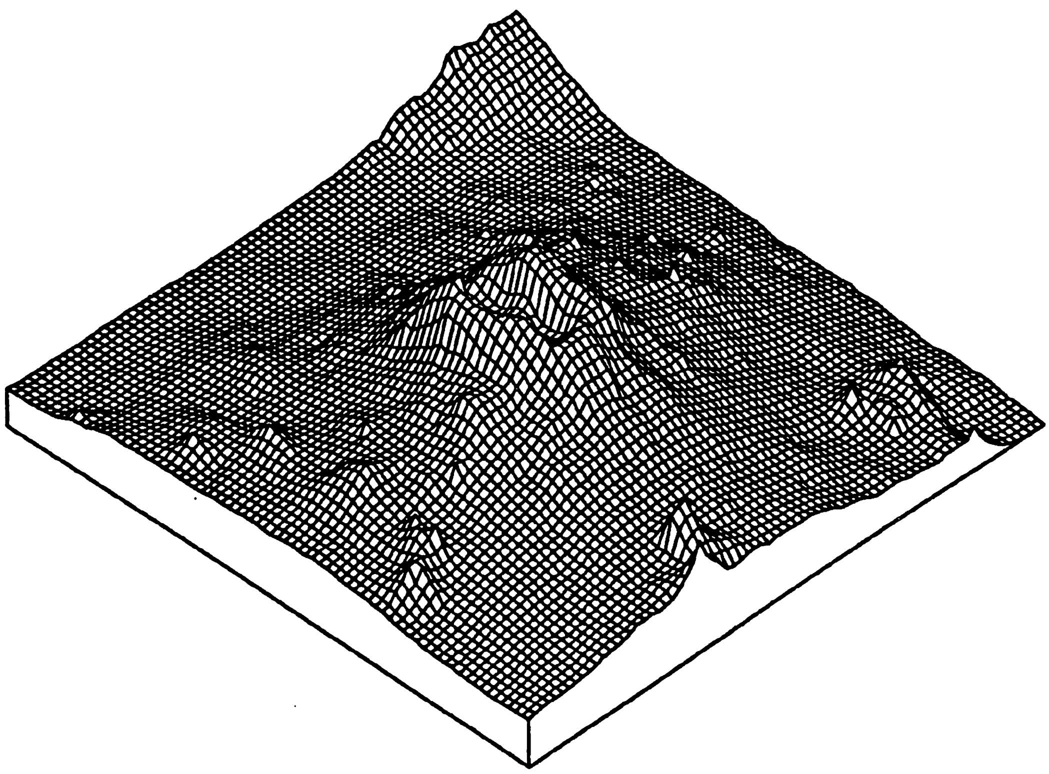
Obsidian Research in the Newberry Volcano Region of Central Oregon, Part I: The Sources



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[SLIDE: Newberry Volcano DEM]

The Newberry Volcano region of central Oregon pictured in the slide of the digital elevation model is, without a doubt, one of the most obsidian rich areas in the United States and perhaps the world. Many different Pliocene to late Holocene flows and domes of glass which fall into the prehistoric obsidian procurement sphere of the Newberry Volcano and Upper Deschutes River region have now been identified. Not surprisingly, obsidian was the preferred lithic raw material for the prehistoric occupants of this region and, in the Upper Deschutes River drainage, typically comprises the major portion of almost all archaeological collections.

When I was asked to put together a presentation on some aspect of current obsidian research in central and north-central Oregon, my first thought was simply **where to begin**. Thanks to several still in-progress obsidian characterization and hydration projects, most notably the work associated with the PGT-PG&E Pipeline Expansion Project, we now have plenty of new material available. Although it is tempting to leap directly into speculations about the prehistoric patterns of obsidian use in this region and what those patterns might mean, I've decided today to begin primarily at the beginning, with the obsidian sources themselves and I've titled my topic for today -- *Obsidian Research in the Newberry Volcano Region of Central Oregon, Part I: The Sources.* I will, however, have to slip in a few of the speculations about prehistoric procurement patterns that I've already cautioned against.

Some of the conclusions that I've drawn for today related to the Pipeline Project obsidian studies were developed jointly with Richard Hughes and were the subject of a paper by Richard and myself that was presented at last month's SAA Meeting in Anaheim.

[SLIDE: All Characterized PEP sites]

Before I go any farther, I'd like to briefly introduce you to the sources of the data that I've used. Much of what we now know about prehistoric obsidian source use in central and north-central Oregon is the direct result of the extensive obsidian studies carried out in conjunction with the PGT-PG&E Pipeline Expansion Project. Over 9,500 obsidian artifacts from 133 Oregon, California, and Idaho sites were analyzed as part of the Project. These obsidian studies comprise, to my knowledge, the most extensive collection of characterized obsidian artifacts associated with any single archaeological project in the world to date. Although big numbers alone don't necessarily reflect anything but the amount of money spent, it is clear from an early look at the results of these obsidian investigations that the large sample and broad areal coverage will reveal some provocative insights into the patterning -- and changes in patterning over time -- in regional source use that would not have been discernable in smaller packages.

[SLIDE: Oregon PEP sites]

During the course of the Pipeline obsidian studies, almost 6,600 obsidian artifacts from 83 Oregon archaeological sites were geochemically characterized. Eighteen Newberry Volcano region sites in Deschutes and Crook counties accounted for 2,710 samples -- the results from these sites provide the basis for much of my presentation today.

[SLIDE: Oregon PEP Obsidian Sources]

The geologic sources that were used in the Upper Deschutes River Basin are predominantly local -- the Newberry Volcano and Big Obsidian Flow chemical groups, McKay Butte, Quartz Mountain, and Obsidian Cliffs. Also present in very small quantities is glass from the Spodue Mountain and Silver Lake/Sycan Marsh sources in the Klamath Basin, from the Inman Creek source located in the Mt. David Douglas area of the Western Cascades, and from sources in or near the boundary of the northwestern Great Basin - Cougar Mountain, Glass Buttes, Whitewater Ridge, Little Bear Creek, Brooks Canyon, and Juniper Spring.

It's interesting to note that only 21 of the over 2,700 samples from Upper Deschutes drainage sites were unable to be correlated with known sources -- with a major exception that I'll cover later. It is clear from this archaeological evidence that we have probably now identified **all major sources** in the Newberry Volcano and Upper Deschutes region.

What I'll do for the remainder of the presentation, then, is to take you on a whirlwind tour of the sources of glass that were used or are present in the Newberry Volcano and Upper Deschutes drainage obsidian procurement sphere. There's a lot of ground to cover, so let's begin with the High Cascades sources.

[SLIDE: The Cliffs of Obsidian Cliffs]

The largest and most extensive of the Oregon High Cascades obsidian sources is **Obsidian Cliffs**, a 2.5 km-long glaciated obsidian-rhyolite flow situated at the western base of the Middle Sister Volcano. As seen in the slide, the flow is terminated by spectacular 90-m-high cliffs. The Pleistocene glaciers that swept over this flow carried the glass into the McKenzie River drainage - glacial and fluvial deposits containing obsidian nodules are widespread in this drainage and in the Willamette Valley alluvial deposits to the west.

[SLIDE: Obsidian Outcrop from Plateau]

The top of the flow forms a stepped plateau that is littered with both high-quality raw material and vast quantities of reduction debris. There is absolutely no doubt that this source received a great deal of prehistoric attention and was a major High Cascades destination once the winter snows had melted. Thanks to research sponsored by the U. S. Forest Service, this flow is also now one of the few in Oregon for which adequate geochemical data are available.

[SLIDE: Obsidian Cliffs trend-surface]

Obsidian from the Obsidian Cliffs flow was widely prehistorically used in both western and central Oregon. These trend-surface maps show the spatial patterning and frequency of Obsidian Cliffs glass *[SLIDE: Obsidian Cliffs contour]* -- in 10% contour intervals -- for about 1,400 artifacts from 205 characterized archaeological sites. The Obsidian Cliffs source procurement sphere is well delineated in the diagrams -- glass from the source was extensively utilized in the Western Cascades, the Willamette Valley, and the Lower Deschutes River drainage of central Oregon.

[SLIDE: Upper Deschutes Newberry/Obsidian Cliffs OH Histogram]

As illustrated by this frequency distribution histogram of obsidian hydration measurements, Obsidian Cliffs glass was used relatively infrequently in Upper Deschutes River Basin sites nearer Newberry Volcano. Although the overall percentage of Obsidian Cliffs glass is low -- about 2 percent of the total Upper Deschutes Pipeline artifacts came from the source -- it was the most widely-used non-local source of glass in this region.

[SLIDE: Lower Deschutes Newberry/Obsidian Cliffs OH Histogram]

Farther north, in the Lower Deschutes River Basin nearer the source and in an area without indigenous competing obsidian sources, the frequency of use increases. This slide shows that once the Newberry Volcano obsidians were erupted at about 5 μm, however, they quickly bein to replace Obsidian Cliffs glass at north-central Oregon sites. The plotting of Obsidian Cliffs and Newberry Volcano glass on the same histogram here implies a similar hydration rate for the two sources -- this similarity in hydration rate **is** suggested by some rather sketchy stratigraphic data for a relatively small sample of Obsidian Cliffs artifacts recovered from pre-Mazama contexts.

[SLIDES: Broken Top Panorama]

Moving south down the High Cascades to the Broken Top-South Sister Volcano area, three little-known artifact-quality sources of obsidian are also found - the **Tumalo Creek** source, the **Tam McArthur Rim** source, and the **Carver Flow** source. Initial neutron activation studies show that all three sources are chemically-distinguishable from one another and from other regional sources. At this point, however, prehistoric use of the three sources has not been demonstrated. It is certain, though, from the low frequency of unknown sources that were identified during the Pipeline obsidian studies, that these three sources were all fairly minor ones.

[SLIDE: Rock Mesa]

Farther south along the High Cascades, several more late Holocene sources of obsidian are encountered on the southern flanks of South Sister Volcano. Located here are over a dozen different obsidian flows related to two series of nearly coeval eruptive events that occurred about 2,000 radiocarbon years ago, the **Rock Mesa** and the **Devils Hill** volcanic episodes.

[SLIDE: Devils Hill Dome Chain from Sparks Lake]

The chemical composition of all these different flows is virtually indistinguishable and they all fall within a single chemical group. The quality of glass at all the sources is also rather poor and only a small handful of characterized artifacts, none of them from east of the Cascades, are known to have originated from these sources.

[SLIDE: Newberry Volcano DEM]

One of the major Oregon hot spots for obsidian sources is centered at Newberry Volcano -- now the Newberry National Volcanic Monument -- a large Quaternary composite volcano located only a few miles southeast of us. Newberry Volcano is topped by a large summit caldera that houses, in addition to the two large lakes visible in the Digital Elevation Model of the volcano, at least two chemically distinguishable groups of flows. Several other sources of glass are located on the flanks of the volcano.

[SLIDE: Newberry Geomap]

Without a doubt, the most significant of the Newberry Volcano caldera sources are those that fall into the **Newberry Volcano geochemical group** - the Interlake Flow, the East Lake Flows, the Game Hut Flow, and the Central Pumice Cone Flow.

[SLIDE: Newberry Caldera Sources]

These flows, dated by obsidian hydration methods from about 6,400 to 3,400 years, erupted beginning not long after the cataclysmic eruptions of Mount Mazama and are stratigraphically constrained in age to a maximum of about 6,900 radiocarbon years. The flows within this chemical group are indistinguishable through standard XRF trace element methods. The flows are also proving to be rather inseparable using more powerful analytical techniques that look at a wider spectrum of trace elements -- current neutron activation studies by Tom Connolly and myself have shown only very limited possibilities in chemically separating this group into separate identifiable flows. Fortunately, because of the spatial proximity of all the sources, this is largely a non-problem. The ability to distinguish among the specific flows, however, would give us considerable temporal resolution for artifacts correlated with the specific Newberry Volcano sources.

[SLIDE: Newberry Trend Surface Map]

Obsidian from the Newberry Volcano chemical type is practically absent from sites west of the Cascades. Except for a limited number of artifacts found to the west, particularly in the Middle Fork Willamette River Drainage, the glass appears to have been conveyed mostly in a north-south direction in central Oregon. Data from over 2,500 characterized artifacts were used to create the trend surface diagram shown here.

[SLIDE: Newberry Contour Map]

The Newberry Volcano procurement sphere extends in the north from the Lower Deschutes River Basin to the Klamath-Upper Deschutes Basin divide in the south where it is rapidly displaced by obsidian from Klamath Basin sources. To the east, use drops quickly as the many sources of high-quality glass in the Great Basin and Ochoco and Malheur National Forests are reached.

[SLIDE: Newberry OH Frequency Distribution]

The obsidian hydration frequency distribution of over 2,000 measured rims from Upper and Lower Deschutes Basin artifacts tells the story of Newberry Volcano glass use over time in this region. It is apparent that after their eruption, the Newberry glasses arrive on the post-Mazama scene with a bang beginning at just a shade over five microns. A production/ consumption peak appears between 2 and 3 μm, hydration measurements approximately equivalent to the period between about 1,000 and 3,000 years ago.

[SLIDE: Big Obsidian Flow]

The second source and most recent obsidian flow within Newberry Caldera is the **Big Obsidian Flow**, a spectacular 1300-year-old flow located below Paulina Peak. The Big Obsidian Flow is chemically distinct from the other post-Mazama obsidians within the caldera and the recent age of the flow appeared to constrain any of the few artifacts that had been correlated with this source to a temporal window of the last 1,300 years.

[SLIDE: Big Obsidian Flow OH Frequency Distribution]

As the results of obsidian hydration studies of Deschutes County Pipeline site artifacts rolled in, however, It soon became apparent that something was seriously amiss with this idea. Obsidian hydration measurements of artifacts correlated with the Big Obsidian Flow were found to range from about 1 to nearly 7 microns. Based on hydration measurements at this slow hydrating source, 1,300 years was thought to be equivalent to about 1 micron.

At about this time, Tom Connolly and myself were busy nuking Newberry Volcano area samples in a separate neutron activation analysis project and had included caldera obsidian from a 10,000 year-old flow largely buried by volcanic ash in our sample collection. Tom had collected samples of this flow, the Buried Obsidian Flow or South Flow, during his excavations in the caldera. Lo and behold, the Big Obsidian Flow and the Buried Flow came up as chemically very similar. As a result, both of these obsidians must now be included in the Big Obsidian Flow chemical group with the unfortunate result that the 1,300 year temporal ceiling has now been raised considerably. Whether these two members of the Big Obsidian Flow chemical type can be eventually geochemically teased apart is the subject of ongoing research by Tom, myself, and Richard Hughes.

[SLIDE: Photo of Newberry - DEM]

Located high on the southeastern flanks of Newberry Volcano is the **very** obscure **Little Obsidian Flow**. Very little is known about the flow except that it is post-Mazama in age and appears to contain little to no tool-quality obsidian. Of more interest is an unnamed older source of glass that outcrops next to the Little Obsidian Flow. Preliminary neutron activation studies suggest that the chemical composition of glass from this source is very similar to that from the Newberry Volcano chemical group and that it may need to be included as the non-caldera component of that chemical group in the future.

Another source type, the **Quartz Mountain** source, is located low on the southeastern flanks of the volcano. This extensive Pleistocene rhyolite-obsidian dome complex with its many outcrops of high-quality glass has so far received only very limited geologic and geochemical attention. The geologic complexity and probable long period of eruptive activity at this source complex suggests that the geochemical range variability may be larger than is currently known. Only further geochemical source studies will bear out this speculation.

Artifacts of Quartz Mountain glass have been identified at sites in the Upper Deschutes River Basin, the Newberry Caldera, and most abundantly, in north-central Oregon. One of the outcrops at Quartz Mountain is the only one in the Newberry Volcano area that I'm aware of in which mahogany-colored glass - of the visual type more commonly associated with Glass Buttes - can be found.

Obsidian from **McKay Butte**, a rhyolite dome erupted about 600,000 years ago on the lower western flanks of Newberry Volcano, makes up another major Newberry Volcano chemical type. Obsidian from this source is often a distinctive bluish-gray color and commonly contains small spherulites in the glassy matrix, two megascopic characteristics which visually distinguish it from other sources in the area. McKay Butte obsidian is similar in composition to glass from Quartz Mountain -- Ti must be used to reliably separate the two chemical types. It is likely that artifacts characterized prior to about 1989 may have been incorrectly assigned to one of these two sources and may presently need to be reassigned to a combined Quartz Mountain/McKay Butte group unless further geochemical analyses are performed.

[SLIDE: McKay Butte OH Frequency at 35-DS-263 and 35-DS-557]

The Pipeline data provide some intriguing evidence to suggest a diachronic shift from early, pre-Mazama exploitation of McKay Butte obsidian to the dominance of Newberry Volcano glass in post-Mazama times. This slide shows the relationship between pre- and post-Mazama use of McKay Butte obsidian for samples from two Paulina Prairie Sites, 35-DS-263 and 35-DS-557. What the slide doesn't show is that immediately on the tail of the distribution, Newberry Volcano obsidians begin to appear in large numbers. Given that there are no apparent flintknapping advantages to the newly-erupted Newberry obsidians over those from McKay Butte, the reason for such a shift might appear elusive. However, it seems very possible that the McKay Butte source was covered by Mazama ash and that it was simply not available for direct procurement after about 6,900 B.P. Glass from this source is currently poorly-exposed and available for collection almost entirely in recent road cuts or in areas affected by logging operations.

[SLIDE: Scatterplot of Unknown X, McKay Butte, and Newberry Volcano]

I'd like to end this description of Newberry region sources with a bit of a mystery, an obsidian source we've chosen to call **Unknown X**. In 1990, artifacts from a possible unknown geologic source began to show up in Pipeline XRF studies of Pipeline of Deschutes County sites. At first, we thought that we might be simply looking at previously unrecorded geochemical variability in one of the local sources, perhaps the Newberry Volcano or McKay Butte types. Later studies of large samples of obsidian artifacts from the two Paulina Prairie sites previously mentioned confirmed that the Unknown X source was a real one. The trace element signature of this source appears to be quite distinct when compared with other local sources. The frequency of glass from the Unknown X sources declines very rapidly in sites to the north and south of Paulina Prairie and we suspect that the source is located in the same general vicinity as McKay Butte.

Why haven't we found the Unknown X source yet? A look at the relative frequencies of pre- and post-Mazama artifacts from the Paulina Prairie sites suggests the reason -- Unknown X artifacts occur almost entirely in pre-Mazama components. This bit of indirect evidence suggests that, like McKay Butte, this source may have been covered by Mazama tephra and that direct procurement of the glass may have ceased after the ashfall.

[SLIDE: Newberry Volcano DEM - USGS]

So, where to from here in the study of obsidian sources in the Newberry Volcano region **and** north-central Oregon obsidian regions? Despite the strong beginnings in obsidian source research that I've described here today, we're not even close to done yet.

First and foremost in the "things to do in obsidian research" list is a thorough inventory and survey of geologic sources of obsidian in central and north-central Oregon. Based on the presence of significant quantities of artifacts from Lower Deschutes Basin Pipeline sites that were not able to be correlated with known sources, we know **for a fact** that several major sources of obsidian remain to located.

Next on the list should be placed the geoarchaeological and geochemical investigations of the individual obsidian sources, particularly those that were widely prehistorically used. In particular, we need to know the chemical range of variation present at the sources, their visual characteristics, and the real boundaries of these sources.

As for the next episode in this research, Part 2 in the Newberry Volcano and central Oregon obsidian research story - *Obsidian Research in North-Central Oregon* - I invite you to stay tuned. When the obsidian data from the Pipeline Project are integrated with already existing obsidian characterization and hydration information, Oregon archaeologists will have a body of information perhaps unprecedented in the world for exploring different regional, methodological, and processual research questions and issues. The best is yet to come.

QUESTIONS?