Title
Source Provenance of Obsidian Artifacts from Late Classic Contexts at Kipp Ruin (LA 153465) and Joyce Well (LA 11823), Southern New Mexico

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SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM LATE CLASSIC CONTEXTS AT KIPP RUIN (LA 153465) AND JOYCE WELL (LA 11823), SOUTHERN NEW MEXICO

Landsat shaded relief of a portion of the Basin and Range region of northwestern Chihuahua showing the relationship between the Sierra Fresnal and Lago Fredrico secondary deposits of obsidian. INEGI Ciudad Juarez 1:250,000 H13-1 sheet. Width of grids 1,000 m, sheet oriented north-south.

by

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Report Prepared for

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INTRODUCTION

The analysis here of 29 obsidian artifacts from Kipp Ruin near Deming, New Mexico, indicates a very diverse provenance assemblage with sources in western and southern New Mexico, northern Chihuahua, and probable secondary deposits from the Rio Grande Quaternary alluvium. At the Joyce Well site, the 34 artifacts were all produced from Antelope Well (El Berrendo) obsidian that is available in the alluvium in and around the site.

LABORATORY SAMPLING, ANALYSIS AND INSTRUMENTATION

All archaeological samples are analyzed whole. The results presented here are quantitative in that they are derived from "filtered" intensity values ratioed to the appropriate x-ray continuum regions through a least squares fitting formula rather than plotting the proportions of the net intensities in a ternary system (McCarthy and Schamber 1981; Schamber 1977). Or more essentially, these data through the analysis of international rock standards, allow for inter-instrument comparison with a predictable degree of certainty (Hampel 1984; Shackley 2011).

All analyses for this study were conducted on a ThermoScientific Quant’X EDXRF spectrometer, located in the Archaeological XRF Laboratory, El Cerrito, California. It is equipped with a thermoelectrically Peltier cooled solid-state Si(Li) X-ray detector, with a 50 kV, 50 W, ultra-high-flux end window bremsstrahlung, Rh target X-ray tube and a 76 µm (3 mil) beryllium (Be) window (air cooled), that runs on a power supply operating 4-50 kV/0.02-1.0 mA at 0.02 increments. The spectrometer is equipped with a 200 l min⁻¹ Edwards vacuum pump, allowing for the analysis of lower-atomic-weight elements between sodium (Na) and titanium (Ti). Data acquisition is accomplished with a pulse processor and an analogue-to-digital converter. Elemental composition is identified with digital filter background removal, least squares empirical peak deconvolution, gross peak intensities and net peak intensities above background.
The analysis for mid Zb condition elements Ti-Nb, Pb, Th, the x-ray tube is operated at 30 kV, using a 0.05 mm (medium) Pd primary beam filter in an air path at 200 seconds livetime to generate x-ray intensity Ka-line data for elements titanium (Ti), manganese (Mn), iron (as \( \text{Fe}_2\text{O}_3 \)), cobalt (Co), nickel (Ni), copper (Cu), zinc (Zn), gallium (Ga), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), niobium (Nb), lead (Pb), and thorium (Th). Not all these elements are reported since their values in many volcanic rocks are very low. Trace element intensities were converted to concentration estimates by employing a least-squares calibration line ratioed to the Compton scatter established for each element from the analysis of international rock standards certified by the National Institute of Standards and Technology (NIST), the US. Geological Survey (USGS), Canadian Centre for Mineral and Energy Technology, and the Centre de Recherches Pétrographiques et Géochimiques in France (Govindaraju 1994). Line fitting is linear (XML) for all elements but Fe where a derivative fitting is used to improve the fit for iron and thus for all the other elements. When barium (Ba) is analyzed in the High Zb condition, the Rh tube is operated at 50 kV and up to 1.0 mA, ratioed to the bremsstrahlung region (see Davis 2011; Shackley 2011). Further details concerning the petrological choice of these elements in Southwest obsidians is available in Shackley (1988, 1995, 2005; also Mahood and Stimac 1991; and Hughes and Smith 1993). Nineteen specific pressed powder standards are used for the best fit regression calibration for elements Ti-Nb, Pb, Th, and Ba, include G-2 (basalt), AGV-2 (andesite), GSP-2 (granodiorite), SY-2 (syenite), BHVO-2 (hawaiite), STM-1 (syenite), QLO-1 (quartz latite), RGM-1 (obsidian), W-2 (diabase), BIR-1 (basalt), SDC-1 (mica schist), TLM-1 (tonalite), SCO-1 (shale), NOD-A-1 and NOD-P-1 (manganese) all US Geological Survey standards, NIST-278 (obsidian), U.S. National Institute of Standards and Technology, BE-N (basalt) from the Centre de Recherches Pétrographiques et Géochimiques in France, and JR-1 and JR-2 (obsidian) from the Geological Survey of Japan.
(Govindaraju 1994). Many of the samples were quite small (< 10 mm minimum diameter) and a 3.5 mm tube collimator was employed to concentrate the energy in a smaller area (i.e. Sample 9 at Kipp Ruin). Additionally, Ba was acquired for some of the samples to increase confidence in source assignment.

The data from the WinTrace software were translated directly into Excel for Windows software for manipulation and on into SPSS for Windows for statistical analyses. In order to evaluate these quantitative determinations, machine data were compared to measurements of known standards during each run. RGM-1 a USGS obsidian standard is analyzed during each sample run for obsidian artifacts to check machine calibration (Table 1). Source assignments were made by reference to Shackley (1995, 1998a, 2005; see Table 1 and Figures 1 through 3 here), as well as source standard data at this lab.

RESULTS

Obsidian Sources in the Mogollon-Datil Volcanic Province

Before a discussion of the results, a brief outline of the two major source groups in the Mogollon-Datil Province is helpful.

Mule Creek. One of the most startling discoveries in the 1990s was the chemical variability in Mule Creek obsidian (Shackley 1995, 1998b). In earlier studies, I noted two "outliers" collected at Mule Creek with significantly higher rubidium concentration values (Shackley 1988:767). These outliers have now been identified as a distinct chemical group, often mixed in the regional Gila Conglomerate with three other chemical groups. The geology in the area is complex and has been studied by Ratté, and others for some time (Brooks and Ratté 1985; Ratté 1982; Ratté and Brooks 1983, 1989; Ratté and Hedlund 1981; Rhodes and Smith 1972). Primary in situ perlite localities for three of the chemical groups have been located, but
the secondary distribution of these source groups within the Mule Creek Basin is less well understood.

At least four distinct chemical groups are evident, distinguished by Rb, Y, Nb, and Ba, and a lesser extent Sr, and Zr elemental concentrations, and are named after the localities where marekanites have been found in perlitic lava: Antelope Creek; Mule Mountains; and Mule Creek/North Sawmill Creek all in New Mexico (see Shackley 1995, 1998b). It is quite evident that the obsidian at the Antelope Creek locality and adjacent secondary deposits constitute the volumetrically largest source of all the Mule Creek sources. The Tertiary Age dome complex at Antelope Creek covers hundreds of hectares and virtually all of it exhibits artifact quality marekanites. Parenthetically, surveys to the west in the Big Lue Mountains on the Arizona/New Mexico state line indicate a mix of North Sawmill Creek and Antelope Creek marekanites in secondary alluvium at a ratio of about six North Sawmill Creek to one Antelope Creek similar to the ratio reported in Shackley (1988). The Antelope Creek eruptive event about 17 mya was quite extensive.

Additionally, during the 1994 field season, a fourth sub-group was discovered in the San Francisco River alluvium near Clifton, Arizona and in older alluvium between Highway 191 and Eagle Creek in western Arizona north of Clifton called provisionally San Francisco River nodules. While in situ nodules have not yet been found they are certainly located somewhere west of Blue River and north and west of the San Francisco River since none of this ‘low zirconium’ sub-group was discovered in alluvium upstream from the juncture of the Blue and San Francisco Rivers. The genetic relationship between the Mule Creek localities is apparent in the bivariate plots of trace elements (Figures 2 and 3), and signifies the very complex nature of the Mule Creek silicic geology, with subsequent depositional mixing in the Gila Conglomerate. Glass at other Tertiary sources in the Southwest, such as Sauceda Mountains and Antelope
Wells, also appear to exhibit more than one chemical mode, although not as distinct as Mule Creek or Mount Taylor, discussed below (Shackley 1988, 1990, 1998b). The Mule Creek case is unusual because the chemical groups are not always spatially discrete and occur together in the extensive Gila Conglomerate which is mainly composed of Mule Creek rhyolite and tuffs in the area where the marekanites do occur (see Ratté and Brooks 1989).

*The Mogollon-Datil Province and the Mule Creek area.* The Mule Creek Source Region is one of the most geologically explored archaeological sources of obsidian in the American Southwest (Brooks and Ratté 1985; Ratté 1982; Ratté and Brooks 1983, 1989; Ratté and Hedlund 1981; Rhodes and Smith 1972; Shackley 2005:Figure 3.5). Ratté has organized most of the research in the area focusing on mapping and establishing the origin of the volcanics during the Tertiary as originally described by Rhodes and Smith (1972). This region, which is on the boundary between the Basin and Range complex to the west and southwest, and the southeastern edge of the Colorado Plateau, exhibits a silicic geology that is somewhat distinctive; from the decidedly peraluminous glass of Cow Canyon with relatively high strontium values and the distinct chemical variability of the Mule Creek glasses (Elston et al. 1976; Ratté et al. 1984; Rhodes and Smith 1972; Shackley 2005). The province has been named Mogollon-Datil for its location and major floristic association (Elston et al. 1976). The region is, in part, characterized by pre-caldera andesites and later high-silica alkali rhyolites in association with caldera formation, subsequent collapse and post-caldera volcanism. Most recently, fieldwork and chemical analyses by Ratté and Brooks (1989) lead them to conclude that the Mule Creek Caldera is actually just a graben, although the typical succession from intermediate to silicic volcanism apparently holds.

The obsidian has been directly dated at the Antelope Creek locality (locality 1 in Shackley 2005:Figure 3.5) to 17.7±0.6 mya by K-Ar, and at the Mule Mountain locality at the
same age (17.7±1 mya by K-Ar; Ratté and Brooks 1983, 1989). A single obsidian marekanite taken from the perlitic lava at the Antelope Creek locality was used in the analysis. Unusual in geological descriptions, the obsidian proper was discussed as an integral part of the regional geology.

Rhyolite of Mule Creek (Miocene). Aphyric, high-silica, alkali-rhyolite domal flows from the Harden Cienega eruptive center along southwestern border of quadrangle [Wilson Mountain 1:24,000 Quad, New Mexico; Figure 4 here]. Unit ob, commonly at the base of the flows, consists of brown, pumiceous glass that grades upward into gray to black perlitic obsidian and obsidian breccia. Extensive ledges of partly hydrated, perlitic obsidian contain nonhydrated obsidian nodules (marekenites) which, when released by weathering, become the Apache tears that are widespread on the surface and within the Gila Conglomerate in this region. Age shown in Correlation is from locality about 1 km south of tank in Antelope Creek in Big Lue Mountains quadrangle adjacent to west edge of Wilson Mountain quadrangle. Thickness of flows is as much as 60 m and unit ob as much as 25 m (Ratté and Brooks 1989:map text, bold as in original).

This description adequately characterizes what is found at the other two primary localities (Mule Mountains, and Mule Creek/North Sawmill Creek). Aphyric, artifact quality marekanites are remnant within perlitic glass and tuff lava units. Nodules at all localities are up to 15 cm in diameter although most are under 10 cm. The devitrified perlitic lava, quite friable, erodes easily into the local alluvium. As discussed elsewhere, this is relatively unique in Tertiary sources in the Southwest where most of the obsidian breccia and perlitic lava is often completely eroded away leaving only the rhyolite interior of the dome and a consequent inability
to assign the surrounding marekanites to a specific dome structure (Shackley 2005; see also Hughes and Smith 1993).

The aphyric glass ranges from opaque black to translucent smoky gray with some gray banding. In over 1000 specimens collected from the Mule Creek/North Sawmill Creek group, three are mahogany-brown and black banded similar to Slate Mountain (Wallace Tank) material. Some of the cortex exhibits a silver sheen, but most is a thin black-brown. The material is a fair medium for tool production, but is very brittle much like Los Vidrios. The pressure reduction potential is, however, very good as seen in the sites in this study. The Mule Mountain glass, however, is as good as any in the Southwest, but surprisingly relatively rare in sites tested in the basin.

**Gwynn and Ewe Canyons**

The Gwynn and Ewe Canyon source is located in Gila National Forest, south central Catron County, New Mexico, at over 2500 m in elevation (Shackley 2005). In the an early study (Shackley 1988), this source was not personally mapped or surveyed. My survey in 1993 indicated that marekanites were directly associated with glassy, perlitic rhyolite in Ewe Canyon to the south, although this stream system erodes into Gwynn Canyon. These coalesced domes shown as Feathery Hill on the quadrangle map, exhibit nodule densities in the regolith up to 200 per m². This source is located in Telephone Canyon 7.5' Quad 1963, Catron County, New Mexico. Unmodified marekanites on the domes have maximum diameters near 50 mm, although the vast majority (≥95%) are 30 mm and smaller. Bipolar cores and flakes were found on and near Feathery Hill, but in low densities (<1 per 100 m²).

As noted above, marekanites are eroding into the Gwynn Canyon system and possibly the upper San Francisco River, although no nodules were noted in the San Francisco River alluvium as far north as Alma, New Mexico.
The Gwynn Canyon and two of the Mule Creek groups (Antelope Creek and Mule Mountains) are very similar in trace element composition (see Shackley 1995, 1998b). Zirconium plotted against Nb, Y, and/or Ba is the best method to discriminate these sources using XRF (Figures 2 and 3). This can be an important issue in western New Mexico late prehistory because these sources are located in very different environments that may have had cultural significance in prehistory. It is possible that in the Mogollon Classic period Gwynn Canyon obsidian could have been controlled by the Cibola branch of the Mogollon while the Mule Creek sources could have been controlled by the Mimbres branch. This may or may not influence the spatial distribution of these obsidian sources in the region and confident source assignment can become crucial. Gwynn/Ewe Canyon obsidian at elevations above 2500 m in elevation are generally well above the elevation favoring maize cultivation and there are virtually no large pueblos at this elevation. Hunting large ungulates, however, is likely in the area. Both deer and elk were seen in the area in the 1990s.

**Obsidian Sources in Northern Chihuahua**

Chihuahua has focused a substantial more attention on obsidian in archaeology than Sonora, including an intensive examination of sources in the central and southern portion of the state (Fralick et al. 1998), and the work at Cerro Juanequeña in the last few years (Hard and Roney 1999; Shackley in Hard and Roney 1999). DiPeso’s original work at Casas Grandes mentioned obsidian, but DiPeso inferred that the obsidian was likely from Mesoamerican sources, which was wrong (Fralick et al. 1998). All the obsidian thus far analyzed from all sites in Chihuahua including that from Casas Grandes is from local sources, indeed there appears to be so many Tertiary marekanite sources in northern Chihuahua, that obsidian in local alluvium is ubiquitous (Fralick et al. 1998; Shackley in Hard and Roney 1999).

**Los Jagüéyes.**
Located on a distributary of the Rio Santa Maria, probably an earlier channel of the river, is a secondary source of marekanites that exhibits at least two source groups based on elemental composition. One of the source groups appears to be the Sierra Fresnal primary source which is actually located about 60 km north of Los Jagüeyes and not along the same drainage system, and actually downstream from Los Jagüeyes (see data in Shackley 2005: Appendix). Again, this is a typical pattern in northwest Mexico frustrating the accurate delineation of obsidian sources. Marekanites up to 50 mm in diameter are located on the lower pebble terrace that contains sub-rounded and rounded marekanites, chalcedony blossoms, and polychrome agate. The area exhibits stone tools including bipolar core fragments of obsidian and 10+ projectile points, many of which look similar to Cienega points and those recovered in Late Archaic/Early Agricultural sites in Chihuahua, Arizona and New Mexico in an area about 100 m in diameter (Hard and Roney 1999). No ceramics were noted. Metate fragments and a portable mortar were also present all produced from vesicular andesite. The density of geological marekanites was up to 1 per 50m$^2$. It is impossible to determine which unreduced nodules were geological and which were cultural. It is possible that the Sierra Fresnal nodules were cultural. An examination of the surrounding hills, that included rhyolite domes, did not reveal any in-situ marekanites. This “source” is located on the INEGI Malpais H13A72 1:50,000 sheet.

**Sierra Fresnal**

This is one of the few “sources” in northwest Mexico where marekanites are associated with coalesced rhyolite domes. All the dome structures are highly eroded and none exhibited in-situ obsidian zones with marekanites. Indeed, it appears that much of the Sierra Fresnal is composed of rhyolite in a series of northwest-southeast trending coalesced domes. The domes are highly eroded and have produced a regolith of silicic ash, rhyolite lava and obsidian that is
eroding east toward Lago Fresnal and Lago Guzman (see Shackley 2005: Figure 3.15, p. 85). Indeed, samples collected from the Arroyo Casas Grandes alluvium 70 km north of Sierra Fresnal exhibit the same elemental concentrations. The Sierra Fresnal collection area is on the INEGI Guzman 1:50,000 H13A42 sheet. The density of nodules near the domes on the east side of the Sierra is up to 50 per 100m² and down to 1 per 50m² one km east toward Lago Fresnal. Bipolar cores and flakes occur very rarely.

Sierra Fresnal nodules have been located in alluvium west of the Sierra Fresnal as well at Arroyo Seco south of Nuevo Casas Grandes and at Lago Fredrico (see Shackley 2005:Figure 3.15). At Lago Fredrico nodules collected by Alan Phelps just west of Sierra Fresnal exhibit different elemental concentrations, probably derived from a different magma source.

**Site by Site Discussion**

**Joyce Well (LA 11823)**

Joyce Well, an Animas Phase site along Deer Creek on the west side of the Animas Mountains in the bootheel region of southwestern New Mexico, was excavated as a field school by William Walker of New Mexico State University in 2004. The site proper is located in sediments that contain marekanites from the Antelope Wells (El Berrendo) obsidian source as described by Shackley (1995, 2005:57). All the artifacts analyzed here were produced from Antelope Wells obsidian, indicating that all the procurement was local (Table 1, Figure 1).

**Kipp Ruin (LA 153465)**

Kipp Ruin is a multi-component site on the lower Mimbres River east of Deming, New Mexico. Unlike Joyce Well, Kipp Ruin exhibits a very diverse obsidian provenance assemblage including western and southern New Mexico sources, northern Chihuahua sources, and probable secondary deposit obsidian procured from the Rio Grande Quaternary alluvium (Church 2000; Shackley 2005, 2010a; Table 2 here). Interestingly, the mix of sources at Kipp Well is similar to
the Black Mountain site with contexts similarly contemporaneous, located at Black Mountain, New Mexico about 30 km west of Kipp Ruin (Shackley 2010b).

The Chihuahuan sources of Sierra Fresnal, and Los Jaguëyes do appear in sites near the International border as discussed above. Again, the Los Jaguëyes source is a secondary deposit source, the primary domes have not been located, but are likely relatively nearby. Both sources could have eroded north, particularly Sierra Fresnal which has been recovered in secondary deposits in the Rio Casas Grande alluvium 20-30 km south of the border.

Finally, the Jemez Mountains sources of Cerro Toledo Rhyolite and El Rechuelos can be found as secondary deposits at least as far south as Las Cruces in Rio Grande alluvium as reported by Church (2000). This is likely the case with the artifacts here.

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2010b Source Provenance of Obsidian Artifacts from Late Classic Contexts in Western and Southern New Mexico. Report prepared for the Center for Desert Archaeology, Tucson, Arizona.
Table 1. Elemental concentrations and source assignments for the archaeological specimens, and analyses of USGS RGM-1. All measurements in parts per million (ppm).

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1 124 | 495 | 8966 | 20 | 17 | 26 | 120 | 33 | 25  | 28  | 9  | Mule Mtns (Mule Cr)     |

2 188 | 130 | 3710 | 39 | 17 | 23 | 219 | 17 | 69  | 38  | 9  | Los Jagueyes, CHIH      |

3 927 | 425 | 7680 | 15 | 14 | 24 | 70  | 45 | 40  | 27  | 9  | El Rechuelos             |

4 908 | 406 | 1027 | 26 | 22 | 43 | 112 | 25 | 32  | 41  | 9  | Antelope Cr (Mule Cr)   |

5 146 | 937 | 2653 | 29 | 13 | 16 | 144 | 12 | 63  | 32  | 9  | Los Jagueyes, CHIH      |

6 116 | 326 | 1046 | 29 | 43 | 60 | 156 | 34 | 25  | 51  | 9  | Sierra Fresnal, CHIH    |

7 195 | 131 | 3778 | 38 | 12 | 24 | 227 | 17 | 69  | 46  | 9  | unknown (CHIH?)         |

8 164 | 322 | 1108 | 29 | 42 | 59 | 141 | 34 | 28  | 46  | 9  | Sierra Fresnal, CHIH    |

9 136 | 317 | 1090 | 29 | 42 | 63 | 157 | 39 | 25  | 43  | 9  | Sierra Fresnal, CHIH    |

10 109 | 408 | 1069 | 25 | 21 | 40 | 104 | 23 | 32  | 41  | 9  | Antelope Cr (Mule Cr)   |
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Table 2. Frequency distribution of obsidian sources at Kipp Ruin.

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Figure 1. Zr versus Rb bivariate plot of the elemental concentrations for the archaeological specimens from Joyce Well and source standards from Antelope Wells (El Berrendo).
Figure 2. Nb versus Y bivariate plot of the elemental concentrations for the artifacts from Kipp Ruin. The “unknown (CHIH) sample, while possibly from the sources that comprise the secondary deposits at Los Jaguëyes, is outside the elemental concentrations for those samples other than Y and Nb (see Table 1; Shackley 2005:Appendix).
Figure 3. Nb versus Y bivariate plot of the elemental concentrations for the artifacts from Kipp Ruin with the high Nb and Y sources deleted for clarity.