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SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM LATE CLASSIC CONTEXTS IN THE MIMBRES VALLEY, SOUTHERN NEW MEXICO

by

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Report Prepared for

Rob Jones
The Center For Desert Archaeology
Tucson, Arizona

3 December 2011
INTRODUCTION

The analysis here of 32 obsidian artifacts from three sites in the Mimbres Valley, New Mexico, is dominated by artifacts produced from the Antelope Creek locality at Mule Creek in western New Mexico, one artifact produced from the Mule Mountains locality at Mule Creek, one from Cow Canyon in eastern Arizona, and one that could not be assigned to source, but has been seen in other sites in southern New Mexico (Shackley 2010). Given the dominance of one source in these sites (Antelope Creek), no discussion is offered, however it appears that there is likely a social relationship between the Late Classic occupants at these sites in the Mimbres Valley, and those that occupied the Mule Creek area, or at least consistent access to the sources at Mule Creek. Refer to Shackley (2005 and 2010) for a more detailed discussion of the Mogollon-Datil Volcanic Province sources and the importance of the Mule Creek sources in the Late Classic Southwest, and Taliaferro et al. (2010) for a discussion of Mimbres obsidian provenance from Classic Mimbres sites in the region.

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, Albuquerque, New Mexico. 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 Fe$_2$O$_3^T$), 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).

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 and 2, as well as source standard data at this lab.

OBSIDIAN SOURCES IN THE MOGOLLON-DATIL VOLCANIC PROVINCE – 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; Figure 2, and 4 ). 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 1 and 2), 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; 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 Figure 3.5 here) 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; see Figure 4). Aphyric, artifact quality marekenites 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 some 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 in the region.

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2010  *Source Provenance of Obsidian Artifacts from Late Classic Contexts in Western and Southern New Mexico.* Report prepared for Robert Jones, Center for Desert Archaeology, Tucson, Arizona.


Table 1. Elemental concentrations and source assignments for the archaeological specimens. All measurements in parts per million (ppm).

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Figure 1. Zr versus Rb bivariate plot of the elemental concentrations for all the archaeological specimens.
Figure 2. Nb versus Y bivariate plot of the elemental concentrations for the artifacts produced from the Antelope Creek and Mule Mountains chemical groups at Mule Creek (see Shackley 2010).