

# PROCEEDINGS OF THE TWENTY-SEVENTH ANNUAL KECK RESEARCH SYMPOSIUM IN GEOLOGY

April 2014  
Mt. Holyoke College, South Hadley, MA

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KAREN ROTH, Washington and Lee University  
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## MAGNETIC CHARACTERISTICS OF OBSIDIANS IN MULE CREEK, NM

**MICHAEL BABATUNDE HARRISON**, California State University, Chico

**Research Advisor:** Todd J. Greene

### INTRODUCTION

Rhyolitic glass (obsidian) is an important archeological material because it can easily be fractured into a sharp edge tool. Archeologists and geoarcheologists have commonly used geochemical methods to characterize obsidian in order to trace the geographic pathways from its geological source. To adequately determine the source of archaeological obsidian artifacts, it is essential to characterize unambiguous properties of the source to compare with the properties of the artifact. This study focuses on the magnetic characteristics of obsidians located at N. Sawmill Creek, Antelope Creek, and west Antelope Creek site within the Mule Creek locality, New Mexico.

### BACKGROUND

The Mule Creek eruptive vent is located within the Mogollon-Datil volcanic field. The vent is approximately 11 km north of the settlement of Mule Creek and approximately 8 km east of the Arizona border (Ratté 2004). The rhyolite of Mule Creek dates between 17.7 and 19.0 Ma.

Obsidian is a disordered and aphyric volcanic rock associated with rhyolitic deposits and is defined by its holohyaline texture. Iron and magnesium make obsidian black and are key elements in microscopic grains of magnetite and hematite found in obsidian. Submillimeter hematite and magnetite grains are largely responsible for magnetic properties and can reflect the net result of the grain sizes, concentrations, compositions, morphologies, and spatial arrangement of magnetic minerals (Feinberg and Frahm 2013).

### METHODS

In this study, low-field magnetic susceptibility, natural remanent magnetization, and alternating-field demagnetization are measured from 64 samples. Seventeen spatially distributed samples were measured from N. Sawmill Creek, thirty-three spatially distributed samples were measured from Antelope Creek, and fourteen samples were measured from west Antelope Creek site.

Low-field magnetic susceptibility measures the induced magnetization in response to a magnetic field. These measurements are commonly interpreted as reflecting the magnetic mineral concentration of a sample. The applied magnetic field in these measurements are weak and do not permanently affect the magnetization of the sample. Measurements were recorded with an MS2 Bartington susceptibility meter at California State University, Chico and at the University of California, Davis, Paleomagnetism Laboratory. Measurements take approximately 1-2 minutes per sample.

Natural remanent magnetization (NRM) refers to a permanent magnetic moment within the mineral grains given through natural processes. These moments are primarily due to the thermal remanent magnetization (TRM) acquired as the obsidian originally cooled from a lava flow. NRM is subjected to partial erasing by dissolution and alteration. Alterations are due to reheating by secondary lava flows, fire, lightning, etc. Full demagnetization measurements were recorded with a superconducting rock magnetometer (u-channel magnetometer) at the UC Davis Paleomagnetism

Laboratory, and take approximately 40-50 minutes per set of samples (up to 7).

Alternating-field demagnetization is usually effective in removing secondary NRM. Using stepwise demagnetization we can reveal the median destructive field (MDF), which is the strength of the applied field needed to decrease the initial remanent magnetization by a half. In this study, the demagnetization followed the steps of 0, 10, 20, 30, 40, 50, 60, 80, 100, and 120 mT. Measurements were recorded with a superconducting rock magnetometer at the UC Davis Paleomagnetism Laboratory and take approximately 50-60 minutes per set.

## RESULTS

Low-field magnetic susceptibility has some minor variability between the three sites. The mean value of samples from N. Sawmill Creek is  $23.8 \times 10^{-8} \text{ m}^3\text{kg}^{-1}$ . The mean value of samples from Antelope Creek is  $52.7 \times 10^{-8} \text{ m}^3\text{kg}^{-1}$ . The mean value of samples from the west Antelope Creek site is  $14.9 \times 10^{-8} \text{ m}^3\text{kg}^{-1}$ . Antelope Creek can be distinguished by its relatively high mean value in susceptibility. The standard deviation between samples from N. Sawmill Creek is  $21.2 \times 10^{-8} \text{ m}^3\text{kg}^{-1}$ . The standard deviation between samples from Antelope Creek is  $25.6 \times 10^{-8} \text{ m}^3\text{kg}^{-1}$ . The standard deviation between samples from the west Antelope Creek site is  $8.6 \times 10^{-8} \text{ m}^3\text{kg}^{-1}$ . The west Antelope Creek site can be distinguished by its relatively low variation in susceptibility values.

The original NRM of the three sites have some variability. The mean value of samples from N. Sawmill Creek is  $1.53 \times 10^{-3} \text{ Am}^2 \text{ kg}^{-1}$ . The mean value of samples from Antelope Creek is  $3.46 \times 10^{-4} \text{ Am}^2 \text{ kg}^{-1}$ . The mean value of samples from the west Antelope Creek site is  $1.57 \times 10^{-4} \text{ Am}^2 \text{ kg}^{-1}$ . N. Sawmill Creek can be distinguished by its relatively high mean value in NRM. The standard deviation between samples from N. Sawmill Creek is  $1.43 \times 10^{-3} \text{ Am}^2 \text{ kg}^{-1}$ . The standard deviation between samples from Antelope Creek is  $2.90 \times 10^{-4} \text{ Am}^2 \text{ kg}^{-1}$ . The standard deviation between samples from the west Antelope Creek site is  $1.27 \times 10^{-4} \text{ Am}^2 \text{ kg}^{-1}$ . N. Sawmill Creek can be distinguished by its relatively high values and variation in NRM. Figure 1 displays

variability between the three sites with an NRM intensity vs. low-field susceptibility chart, in which the three sites are distinguished by N. Sawmill Creek's relatively high values in NRM and Antelope Creek's relatively high values in susceptibility.

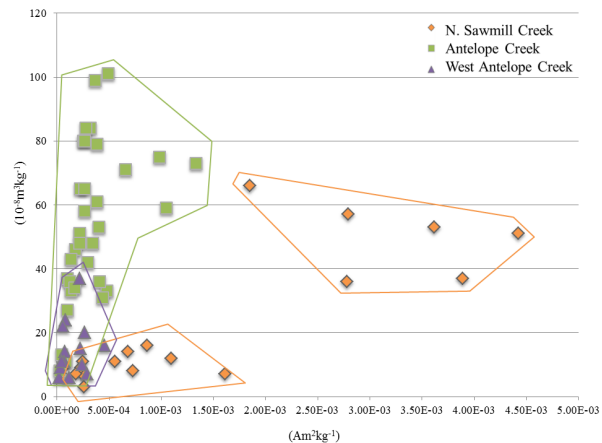


Figure 1. NRM intensity vs. low-field susceptibility. Samples on the scatter plot are boxed to display trends between the three sites.

Alternating field demagnetization data displays the direction of inclination and declination of NRM at each demagnetization step (Fig. 2a). The fraction of the original NRM remaining at each demagnetization step is also displayed (Fig. 2b). Samples typically tend to increasingly lose NRM intensity between each step (Figure 2b). A few samples that have high NRMs and dramatically lose NRM intensity between the first steps (low MDFs) probably display a recent isothermal remanent magnetization due to lightning strikes (Fig. 3). Sample MH061813-1-2-1 has the highest original NRM of its location (Fig. 3). Some samples may increase NRM between demagnetization steps. This is a result of two components of magnetization that are at high angles with each other. If the older component has a coercivity of remanence higher than the younger component, the NRM will appear to increase as the younger component is removed.

The median destructive field displays the approximate demagnetization step level in which more than 50% of the original NRM is removed. The median destructive field between samples has no real variability. The

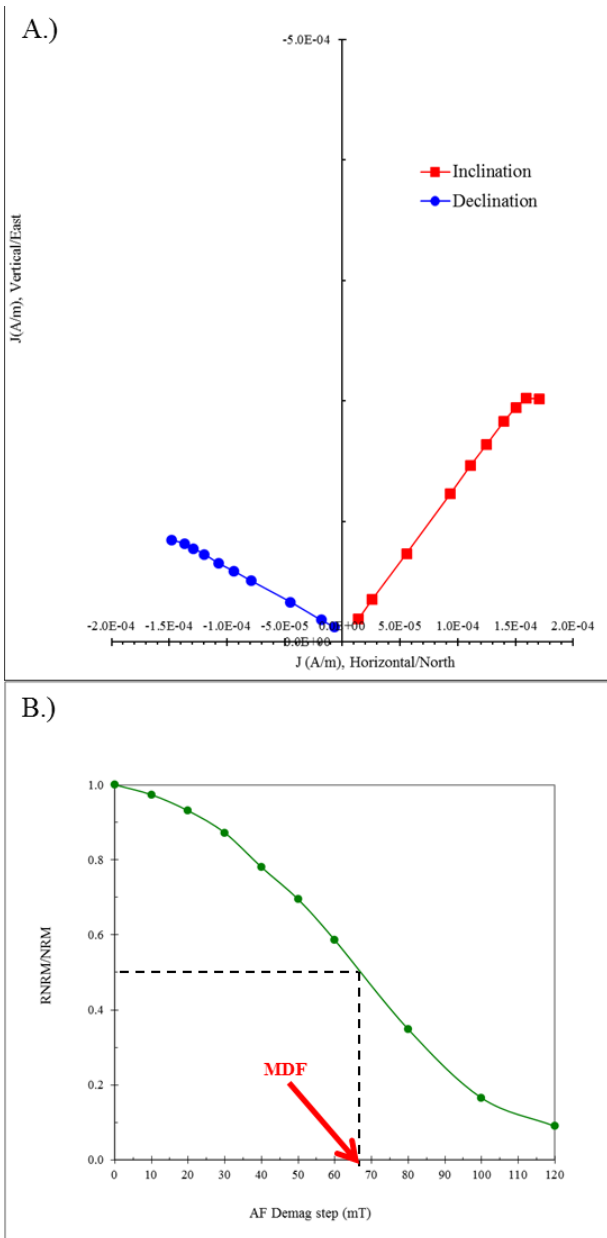


Figure 2. Alternate-field demagnetization data of sample MH062013-2-11 (west Antelope Creek). A.) Vector diagram of inclination and declination between each demagnetization step. B.) The fraction of the original NRM and the NRM during each demagnetization step.

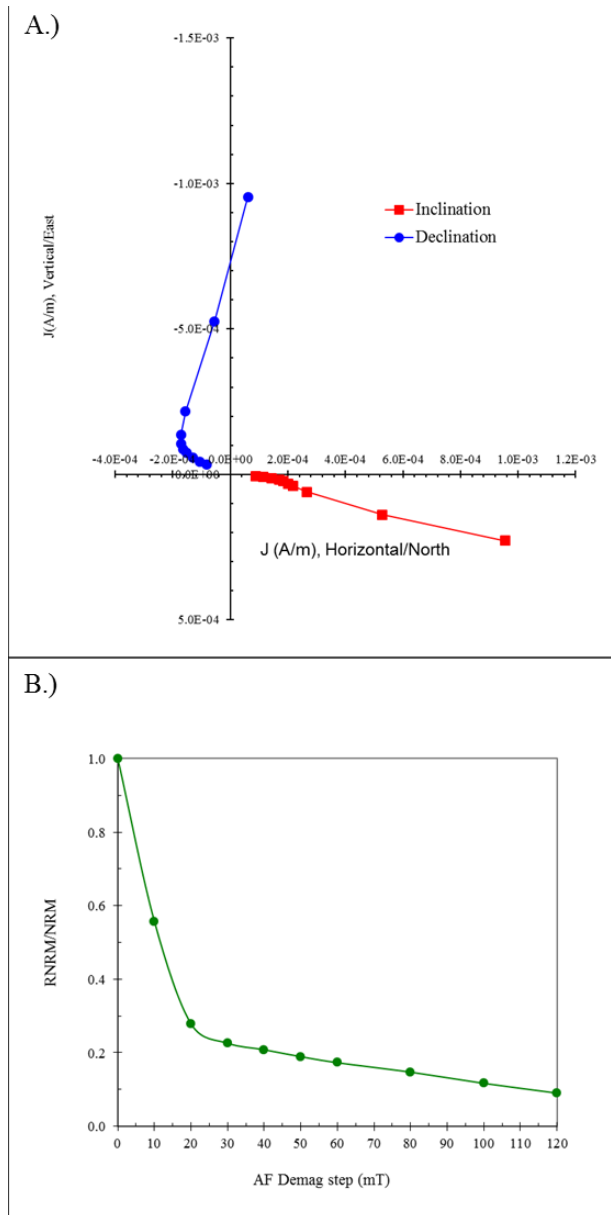


Figure 3. Alternate-field demagnetization data of sample MH061813-1-2-1 (Antelope Creek).

mean value of samples from N. Sawmill Creek is 89 mT. The mean value of samples from Antelope Creek is 97 mT. The mean value of samples from the west Antelope Creek site is 68 mT. The west Antelope Creek site can be distinguished by its relatively low mean value in MDF. The standard deviation between samples from N. Sawmill Creek is 10 mT. The standard deviation between samples from Antelope Creek is 26 mT. The standard deviation between samples from the west Antelope Creek site is 20 mT. N. Sawmill Creek can be distinguished by

its relatively low variation in MDF values. Some variability between sites can be illustrated with a NRM vs. MDF chart (Fig. 4). west Antelope Creek is distinguished by its low MDF values while N. Sawmill Creek is distinguished with high NRM values.

## DISCUSSION

In a related study, 33 additional samples from Antelope Creek and the west Antelope Creek site



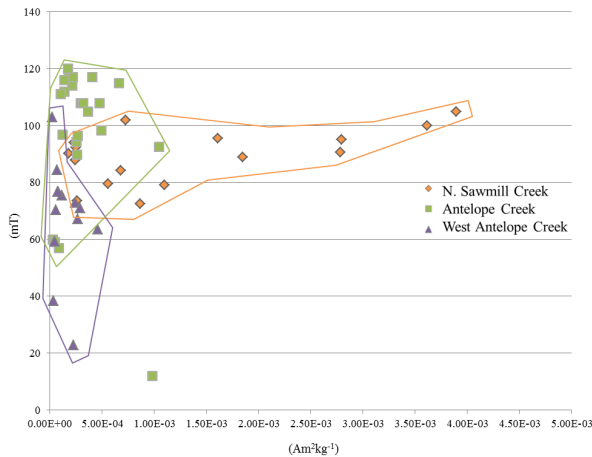


Figure 4. NRM vs. MDF. Samples on the scatter plot are bordered to display trends between the three sites.

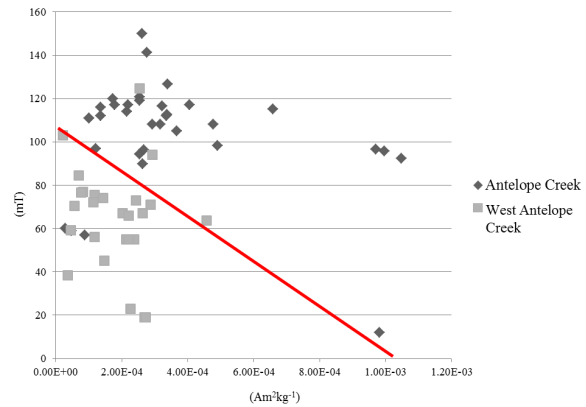


Figure 5. NRM vs. MDF. Samples on the scatter plot are separated with a line to distinguish Antelope Creek and west Antelope Creek.

were measured (Sternberg et al., 2013). When those additional data are compared with the current data, distinct similarities are exhibited. Samples from the west Antelope Creek site exhibit a generally low range in MDF. This low range helps distinguish west Antelope Creek from Antelope Creek when comparing on an NRM vs. MDF chart (Figure 5).

## CONCLUSIONS

Magnetic analysis has been capable of distinguishing obsidian from N. Sawmill Creek, Antelope Creek, and the west Antelope Creek site. Although sample magnetic properties are generally similar, sites can be distinguished with the magnetic properties used in this study. The magnetic characteristic features found in this study appear to be promising for sourcing. Further study using more samples along with different methods is required for adequately characterizing obsidian in Mule Creek.

This portion of the project will not only contribute to the database but can be used for further research. Further work may include using isothermal remanent magnetization testing, multivariate statistical analysis of various magnetic parameters, along with comparing magnetic data to Mount Taylor and Valles Caldera sites in compiling magnetic characteristics throughout New Mexico.

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