Identification and Characterization of the Obsidian Sources on the Island of Palmarola, Italy

Robert H. Tykot[1], Teddi Setzer[2], Michael D. Glascock[3] and Robert J. Speakman[3]

[1] *Laboratory for Archaeological Science, Department of Anthropology, University of South Florida, 4202 East Fowler Ave., SOC 107, Tampa; rtykot@chuma1.cas.usf.edu*
[2] *University of South Florida; tsetzer@helios.acomp.usf.edu*
[3] *Missouri University; glascockm@missouri.edu; speakmanr@missouri.edu*

Introduction

Obsidian was used in the central Mediterranean primarily during the Neolithic and Bronze Age periods (ca. 6000-1000 BC) for blade- and flake-tool technologies. The detailed analysis of obsidian sources and mechanisms of exploitation, along with typological and use-wear studies promise to provide important insights into the socioeconomic structures of Neolithic societies in this region (Tykot 1996). Obsidian sourcing has been a major aspect of archaeological research for more than a quarter-century (Cann & Renfrew 1964). It has been demonstrated by several research groups, mainly using neutron-activation analysis (NAA), X-ray fluorescence (XRF), and more recently ICP mass spectrometry (ICP-MS), that it is possible to chemically "fingerprint" not only the Mediterranean island sources of Antiparos, Giali, Lipari, Melos, Palmarola, Pantelleria, and Sardinia, but multiple source localities on Melos, Pantelleria, and Sardinia (Hallam *et al.* 1976, Francaviglia 1986, Tykot 2002). Yet until recently the central Mediterranean sources themselves were not all fully documented. Furthermore, while many studies have contributed to a general picture of obsidian distribution, the source analysis of artifacts mostly has been limited to small numbers from any one site, limiting the determination of regional and chronological patterns of obsidian use (Tykot & Ammerman 1997).

Our NSF-funded geoarchaeological survey of obsidian sources on the islands of Lipari, Palmarola and Pantelleria has employed a systematic approach to the documentation of the multiple localities where obsidian may be found, and complements previous work done in the Monte Arci area of Sardinia where at least four distinct sources were exploited (Tykot 1997). The analysis of large numbers of artifacts from dated archaeological contexts allows geographic and chronological patterns of specific source exploitation to be recognized, and these data may be used to test models of maritime capabilities, identify interconnections between island and mainland populations, and to reconstruct the economic and sociopolitical role of obsidian and other raw materials in prehistoric Mediterranean societies. We present here preliminary results of our investigation of the geological sources of obsidian on Palmarola, commonly considered to be the least important of the central Mediterranean sources, and for which few published reports are available.

Previous Research

Palmarola is the westernmost of the Pontine Islands, located west of Naples about 35 km from the mainland (Fig. 1). Less than 3 km^2 in area, the island was first formed 5 million years ago, with the intrusion of soda-rhyolitic lavas coming later. Two K-Ar dates and two fission-track dates on obsidian from Monte Tramontana fall between 1.6 and 1.7 million years ago (Barberi *et al.* 1967, Belluomini *et al.* 1970, Bigazzi *et al.* 1971, Bigazzi & Radi 1981), and artifacts from Italian archaeological sites have equivalent fission-track ages (Arias *et al.* 1984), although some recently reported fission-track dates appear to show some spread in values (Bigazzi & Radi 1996). If obsidian were produced in multiple eruptions, then it would be more likely that different source localities could be identified chemically.

While some earlier reviews report that Monte Tramontana was the only source of usable obsidian, abundant secondary obsidian deposits have mainly been reported from the southeastern tip of the island at Punta Vardella (Buchner 1949, Herold 1986). The domal crust of obsidian which transects the island from Il Porto to Scoglio Spermatore reportedly contains only devitrified nodules of massive obsidian with frequent inclusions, while the glassy perlites and pitchstones found along much of the east coast are described as unsuitable for toolmaking (Barberi *et al.* 1967, Herold 1986).

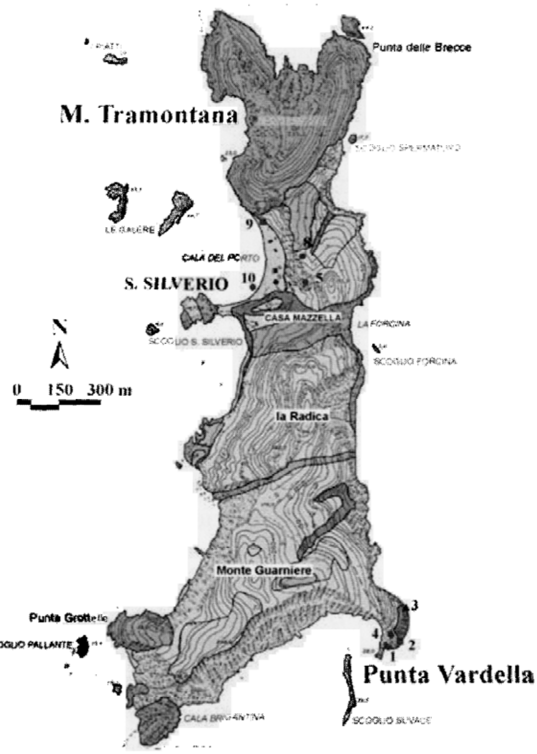

Figure 1 Map of Palmarola showing geological sample collection localities.

Prior to this study, it was not possible to specify which source(s) was utilized since neither of the researchers who collected and analyzed geological samples also analyzed archaeological material. Furthermore, Francaviglia (1986) only took samples from the south side of Monte Tramontana, while Herold's unpublished thesis (1986) includes data for only seven trace elements (which do, nevertheless, suggest some variation between Monte Tramontana and Punta Brecce on the central east coast). Apparently no samples from Punta Vardella previously had been chemically analyzed.

Geological Survey

A detailed survey of the island was conducted in 2000 and 2001, involving systematic walking and collection along the coastlines, snorkeling to collect samples from nearby islets and areas submerged due to post-glacial sea-level rise, and scaling the mountainous peaks of the interior of the island. We collected nearly 300 samples of workable obsidian, primarily from secondary deposits both at Punta Vardella and in the port area near San Silverio to the southwest of Monte Tramontana. A small amount of highly transparent obsidian was found at Punta Vardella, but most of the material found in both localities is grey to black and nearly opaque (and difficult to visually distinguish from opaque Sardinian obsidian). Only devitrified obsidian of unworkable quality was found in situ anywhere else on the island.

Physical/Chemical Analysis

A multi-method approach was used to physically and chemically characterize the geological samples from Palmarola. All samples were visually described for attributes including color, transparency, luster, presence of phenocrysts and spherulites, and banding. Transparency and luster were scored on a scale of 0 - 5; most specimens have low transparency (0 - 2) and modest luster (2 - 3.5), although some from the area north of Punta Vardella were highly transparent and lustrous. High-precision density was determined for all samples using a Mettler AT261 electronic balance and water-displacement density kit. While no significant variation in density was observed among Palmarola samples, there are notable differences between Palmarola, Lipari and Pantelleria. Unfortunately, the visually similar Sardinia C obsidian has the same density. The electron microprobe was previously used to characterize the major/minor element composition of Mediterranean obsidians (Tykot 1997), but it was anticipated that trace-element analysis would be necessary to potentially distinguish among Palmarola source localities.

For the full chemical characterization of the geological samples, therefore, a combination of X-ray fluorescence spectrometry, neutron-activation analysis, and laser-ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) was employed. XRF would be the preferred technique for major-, minor- and trace-element analysis of homogeneous materials such as obsidian if a sufficiently large (1 cm^2) and flat surface were available and the entire artifact could fit inside the sample chamber. While this criterion is not an obstacle for the analysis of geological specimens, it can be a significant limitation for many archaeological collections where the artifacts are small, narrow blades. In the Mediterranean region, several obsidian studies have used XRF so that some pre-existing data are already available (Francaviglia 1986, Herold 1986, De Francesco *et al.* 1998).

Neutron-activation analysis, however, has been the workhorse of archaeological provenance studies for three decades. As many as 35 elements can be measured for a solid or powdered sample, with excellent precision for rare-earth elements, although NAA is not appropriate for determining bulk chemical composition in silicate rock samples. The results of several hundred obsidian analyses are already available for the Mediterranean region (Hallam *et al.* 1976, Herold 1986, Ammerman & Polglase 1997).

ICP-MS is now an established method of trace-element analysis (Tykot & Young 1996, Gratuze 1999). Compared to NAA, ICP-MS has greater sensitivity for many elements, especially those found in silicate rocks, and is therefore probably the best single technique for initially evaluating which trace elements may be useful in an archaeological provenance study. The preparation of silicate samples for solution analysis, however, is both time consuming and destructive. Solid samples may be introduced using a laser ablation (LA) device, but this results in reduced sensitivity and precision. If this precision is nevertheless sufficient for the separation of all archaeological significant source groups, though, then LA-ICP-MS becomes an excellent technique for the analysis of obsidian artifacts since samples need not even be removed from whole artifacts and the tiny holes left by the laser (as small as 10 μm in diameter) make this microanalysis technique virtually non-destructive.

In the present study, 80 geological samples from Palmarola were analyzed at the Archaeometry Laboratory at the Missouri University Research Reactor for 27 elements by NAA, for 23 elements by XRF, and 41 elements by LA-ICP-MS. The NAA data clearly demonstrate that three source localities may be distinguished, i.e., Punta Vardella, the northern end of P. Vardella, and Monte Tramontana. There is reasonable separation using bivariate plots of elements such as Ce and Yb (Fig. 2), and statistically robust differences when using multivariate discriminant function analysis of Ce, Cs, Fe, La, Rb, Sm, Ta, Th, U, Yb and Zr (Fig. 3). Although possible, the separation is not nearly as good using LA-ICP-MS.

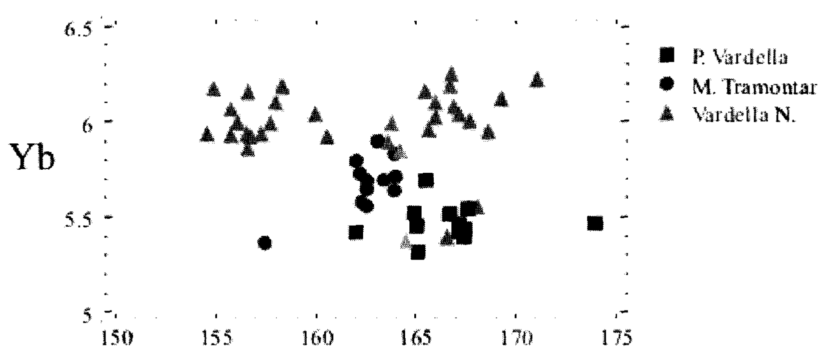

Figure 2 Neutron activation data (in ppm) for Ce and Yb in Palmarola geological samples.

Published analyses of 23 artifacts from Gaione (Ammerman *et al.* 1990) and Arene Candide (Ammerman & Polglase 1997) were then re-examined to see whether attributions could now be made to more than just 'Palmarola.' Differences in elements analyzed and their absolute concentrations as determined by the respective laboratories in Pavia, Milan, and Missouri, however, prevent direct comparison with our detailed geological data, although it does appear that a few of the 23 artifacts have compositions sufficiently distinct to suggest that they came from a different source than the others. Analyses of obsidian artifacts with the same techniques in the same lab will eventually demonstrate which source or sources on Palmarola were exploited in antiquity.

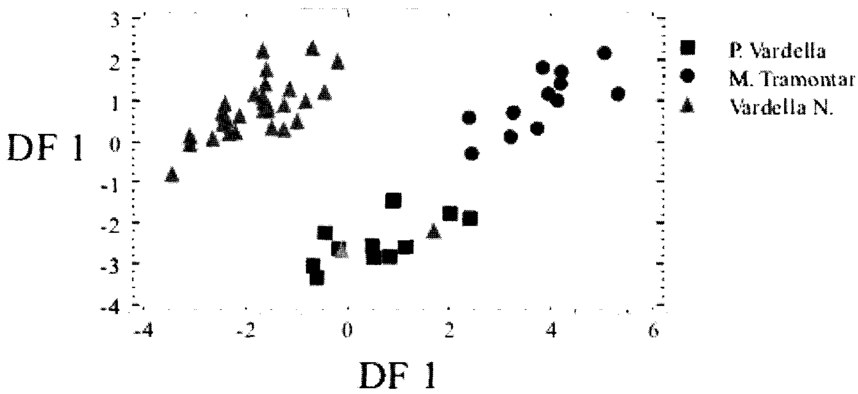

Figure 3 Discriminant function analysis of NAA data for Palmarola geological samples.

Conclusion

Obsidian from Palmarola, rarely documented previously, is actually well represented at sites in central and northern Italy, despite the potentially hazardous journey required to a remote island with few other resources. If artifacts can eventually be attributed to specific source localities, it will provide insights on procurement strategies and exchange mechanisms, as has already been successfully done for Sardinia. When integrated with typological, technological, and use-wear studies, a more complete understanding of human behavior in the Neolithic central Mediterranean will result.

Acknowledgments

This research was supported by a National Science Foundation grant (BCS 0075535) to Robert H. Tykot. The work on Palmarola was conducted with the permission and logistical assistance of Annalisa Zarattini and Antonella Molinaro of the Soprintendenza Archeologica di Lazio. Samples were collected with the help of USF students Barbara Vargo and Julie Bliss, and processed in the lab with the assistance of John Bernal, Lisa Beyer, Jennifer Dukes, Rebecca Glazer, Scott McCready, and Gail Walton.

References

Ammerman AJ, A Cesana, C Polglase & M Terrani 1990: Neutron activation analysis of obsidian from two neolithic sites in Italy, *Journal of Archaeological Science* 17, 209-20.

Ammerman AJ & C Polglase 1997: Analyses and descriptions of the obsidian collections from Arene Candide, in: R Maggi (ed), *Arene Candide: A Functional and Environmental Assessment of the Holocene Sequence (Excavations Bernabo Brea-Cardini 1940-50),* 573-92, Il Calamo, Roma.

Arias C, G Bigazzi, FP Bonadonna, M Cipolloni, JC Hadler, CMG Lattes & G Radi 1984: Fission track dating in archeology. A useful application, in: PL Parrini (ed), *Scientific Methodologies Applied to Works of Arts,* 151-59, Montedison Progetto Cultura.

Barberi F, S Borsi, G Ferrara & F Innocenti 1967: Contributo alla conoscenza vulcanologica e magmatologica delle isole dell'arcipelago Pontino, *Memorie della Societa Geologica Italiana* 6, 581-606.

Belluomini G, A Discendenti, L Malpieri & M Nicoletti 1970: Studi sulle ossidiane italiane. II. - Contenuto in ^{40}Ar radiogenico e possibilità di datazione, *Periodico di Mineralogia* 39, 469-79.

Bigazzi G, FP Bonadonna, G Belluomini & L Malpieri 1971: Studi sulle ossidiane italiane. IV. Datazione con il metodo delle tracce di fissione, *Bolletino della Società Geologica Italiana* 90, 469-80.

Bigazzi G & G Radi 1981: Datazione con le tracce di fissione per l'identificazione della provenienza dei manufatti di ossidiana, *Rivista di Scienze Preistoriche* 36, 223-50.

Bigazzi G & G Radi 1996: Prehistoric exploitation of obsidian for tool making in the Italian peninsula: a picture from a rich fission-track data-set, in: C Arias, A Bietti, L Castelletti & C Peretto (eds), *XIII International Congress of Prehistoric and Protohistoric Sciences-Forlí-Italia September 1996,* 149-56. ABACO, Forlí.

Buchner G 1949: Ricerche sui giacimenti e sulle industrie ossidianiche in Italia, *Rivista di Scienze Preistoriche* 4(3-4), 162-86.

Cann JR & C Renfrew 1964: The characterization of obsidian and its application to the Mediterranean region, *Proceedings of the Prehistoric Society* 30, 111-33.

De Francesco, AM, GM Crisci & U Lanzafame 1998: Nuovi sviluppi del metodo analitico non distruttivo in fluorescenza X per risalire alla provenienza di ossidiane archeologiche, in: C D'Amico & CA Livadie (eds), *Le Scienze della Terra e l'Archeometria,* 141-5, CUEN, Napoli.

Francaviglia VM, 1986: Characterization of Mediterranean obsidian sources by classical petrochemical methods, *Preistoria Alpina* 20, 311-32.

Gratuze B, 1999: Obsidian characterisation by laser ablation ICP-MS and its application to prehistoric trade in the Mediterranean and the Near East: Sources and distribution of obsidian within the Aegean and Anatolia, *Journal of Archaeological Science* 26, 869-81.

Hallam BR, SE Warren & C Renfrew 1976: Obsidian in the western Mediterranean: Characterisation by neutron activation analysis and optical emission spectroscopy, *Proceedings of the Prehistoric Society* 42, 85-110.

Herold G, 1986: *Mineralogische, Chemische und Physikalische Untersuchungen an den Obsidianen Sardiniens und Palmarolas. Grundlagen zur Rekonstruktion Prähistorischer Handelswege im Mittelmeerraum,* unpublished PhD dissertation, Universität (TH) Fridericiana, Karlsruhe.

Tykot RH, 1996: Obsidian procurement and distribution in the central and western Mediterranean, *Journal of Mediterranean Archaeology* 9, 39-82.

Tykot RH, 1997: Characterization of the Monte Arci (Sardinia) obsidian sources, *Journal of Archaeological Science* 24, 467-79.

Tykot RH, 2002: Chemical fingerprinting and source-tracing of obsidian: the central Mediterranean trade in black gold, *Accounts of Chemical Research* 35, 618-27.

Tykot RH & AJ Ammerman, Jr 1997: New directions in central Mediterranean obsidian studies, *Antiquity* 274, 1000-6.

Tykot RH & SMM Young 1996: Archaeological applications of inductively coupled plasma-mass spectrometry, in: MV Orna (ed), *Archaeological Chemistry V* (American Chemical Society, Washington, DC), 116-30.