NEOLITHIC EXPLOITATION AND TRADE OF OBSIDIAN IN THE CENTRAL MEDITERRANEAN: NEW RESULTS AND IMPLICATIONS FOR CULTURAL INTERACTION

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Abstract: Obsidian artifacts have been found at many prehistoric sites throughout the central Mediterranean, many of them up to hundreds of kilometers from their geological sources on the islands of Lipari, Palmarola, Pantelleria, and Sardinia. New geochronological surveys of these sources have resulted in more precise location and documentation of each obsidian flow or outcrop, and allow the consideration of factors such as access (e.g. topography, distance from coast), size and frequency of nodules, and mechanical and visual properties, in their exploitation. Physical and chemical analyses of large numbers of geological specimens demonstrate the utility of methods such as high precision density measurement, as well as elemental and isotopic fingerprinting, in identifying sources. Analyses of large numbers of artifacts demonstrate the differential use of island subsources, and suggest particular motives and mechanisms for their exploitation. The spatial and chronological patterns of obsidian distribution may be used to address such issues as the colonization of the islands; the introduction of Neolithic economies; and the increasing social complexity of Neolithic and Bronze Age societies in the central Mediterranean.

INTRODUCTION

Obsidian sourcing has been a major aspect of archaeological research for more than a quarter-century (Cann & Renfrew 1964; Williams-Thorpe 1995; Tykot 2002a), yet until recently the central Mediterranean sources were not at fully documented (Fig. 1). Furthermore, while many studies (e.g. Hallam et al. 1976; Williams-Thorpe et al. 1979; 1984; Crisci et al. 1994; Bigazzi & Rudi 1996) 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 current NSF-funded geochronologcal survey of obsidian sources on 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 on the Monte Arci sources in Sardinia (Tykot 1997; 1998). The analysis of over 1200 artifacts from dated geological contexts will allow geographic and chronological patterns of specific source exploitation to be recognized (for results on Sardinian obsidian, see Tykot 1996; 2001; 2002b; 2002c). These data will 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.

OBSIDIAN IN THE CENTRAL MEDITERRANEAN

Obsidian was used in the central Mediterranean primarily during the Neolithic period (ca. 6000-3000 BC) for blade and flake tools. The sources on Lipari, Pantelleria and Palmarola are widely thought to have been a major factor in the initial settlement of these islands. Although Sardinia was settled earlier, the exploitation of its obsidian sources only began in the Neolithic. 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 1999).

Previous research on the multiple obsidian sources in the Monte Arci region of Sardinia has revealed differential patterns of exploitation which may be attributed to chronological and cultural change, as well as geographic variation and the availability of alternative lithic raw materials. These patterns were only revealed through the systematic characterization of each obsidian source locality and the analysis of large numbers of archaeological artifacts. Distinctly different patterns of utilization of Sardinian obsidian existed at archaeological sites in France, where type SA accounts for more than 90% of the Sardinian obsidian, compared to Sardinia, Corsica and northern Italy, where it accounts for less than 50% (Tykot 1996; 2002b; 2002c; Williams-Thorpe et al. 1979; 1984; Crisci et al. 1994; Ammerman & Poilgase 1997; Poupeau et al. 2000; de
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Figure 1. Obsidian sources in the Mediterranean area, and archaeological sites where obsidian has been found in the central Mediterranean. Sites in Sardinia not shown.

Figure 2. Regional frequencies of obsidian source usage in the central Mediterranean. Data from published sources cited in the text. Most fission track analyses attribute obsidian to Monte Arci (Sardinia) without differentiating between subsources. The number of artifacts analyzed is shown at the top of each bar.

Francesco & Crisci 2000) (Fig. 2). This could be explained by different trade and transport mechanisms, the availability of other lithic raw materials, particular obsidian use functions, and/or selection for certain visual and physical properties.

In other areas of the central Mediterranean, obsidian from Lipari, Palmarola, and Pantelleria was used more frequently. While obsidian from Lipari clearly has the widest distribution, Palmarola obsidian is quite common in archaeological assemblages in central Italy, and Pantelleria contributes a
significant percentage at sites in Sicily, Malta, and Tunisia (Bigazzi & Radi 1996; Francavilla & Piperno 1987; Nicoletti 1997). This project is proceeding to characterize these other island sources using the same detailed and comprehensive approach, with the expectation that previously unknown patterns of exploitation and distribution will be revealed. Geoarchaeological fieldwork was conducted in 2000 and 2001 to fully document each source and obtain samples for physical and chemical characterization studies. The preliminary results of this research are reported here.

LIPARI

On Lipari, eruptions during the historic period have significantly changed the island's landscape and obscured most of the obsidian outcrop available during the Neolithic (Bucher 1949; Pichler 1980). Settlements on Lipari dating to the Neolithic have been identified, however, as have large workshops in nearby western Calabria (Ammerman 1985). Earlier geochemical studies by Francavilla (1986) and others were unable to distinguish more than one source on Lipari, and fission-track dates on 66 artifacts of Lipari obsidian from archaeological sites in Italy include only one determination older than 12,500 BP (Bigazzi & Radi 1996), suggesting that most if not all of the obsidian used in antiquity was the result of a single geological episode.

In our survey, more than 1200 geological samples were collected from over 40 localities, each precisely marked using a hand-held global positioning system unit (Fig. 3). Workable obsidian was found along the eastern and northern coasts (perhaps a mixture of prehistoric and recent flows), as well as inland at Gabolliotto and above Canneto, Papassa, and Acquacalda. The in situ obsidian located on Monte della Guardia appears to be mostly of unworkable quality. Detailed examination of both these geological samples and prehistoric artifact assemblages has revealed at least two visual types of Lipari obsidian, one black and highly transparent, the other gray-banded, often with many spherulites present. Dating of each deposit will confirm its age, and chemical analyses will reveal whether more than a single "island" fingerprint exists.

PALMAROLA

Palmarola is a tiny island with no evidence of prehistoric settlement, and until recently its geological history has not been widely studied (Barben et al. 1967; Teleys srl 2000). In the Neolithic, obsidian was likely obtained by seasonal fishermen coming from the mainland or the nearby island of Ponza. Obsidian on Palmarola is primarily to be found along its southeastern and northeastern shores, near Punta Varduella and Monte Tramontana, respectively. A geochemical investigation by Herold (1986) failed to reveal any differences among the deposits on the island, although fission track dates on artifacts (Bigazzi & Radi 1996) suggest a range in their age of formation.

In the current study, over 300 geological samples were collected from 10 localities (Fig. 4). At least two visually distinguishable types of workable obsidian have been identified, including some specimens from the northern part of Punta Varduella that are quite transparent and visually similar to the most commonly used type of obsidian from Lipari, although the size and quantity of workable nodules is much more limited on Palmarola. The obsidian recovered from the southern part of Punta Varduella and from Monte Tramontana, however, 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. Preliminary results from elemental analysis of the geological specimens from Palmarola indicate that these three source localities are chemically distinguishable so it will be possible to determine whether obsidian for artifacts was selected from one or more of them.

PANTELLERIA

Pantelleria is located ca. 120 km from Sicily and ca. 90 km from Tunisia, making it the most remote obsidian source in the Mediterranean. Nevertheless, obsidian from Pantelleria is regularly found at Neolithic sites in Sicily and Malta, and may even have been settled itself in the Neolithic. Five chemical groups of Pantellerian obsidian had been described by Francavilla (1988), but were not all based on the analysis of geological samples. While it is generally thought that most artifacts of Pantellerian obsidian probably come from the Balata dei Turchi sources at the southern end of the island, chemical analysis of Bronze Age artifacts from sites on Pantelleria (Francavilla 1988), in Sicily (Francavilla & Piperno 1987), and on Ustica (Tykot 1995) shows that obsidian from near Lago di Venere and Gelikhamar was also used. Furthermore, fission-track dates on archaeological artifacts from other sites have a range of nearly 100,000 years, suggesting the use of multiple source flows (Bigazzi & Radi 1996).

In 2000-2001, over 900 samples were collected from some 35 localities on Pantelleria (Fig. 5). Three vertically distinct obsidian flow layers were confirmed at both Balata dei Turchi and at Salta La Vecchia, apparently representing different eruptive cycles. Much smaller quantities of obsidian were found in situ within pumice deposits near Lago di Venere, but only surface finds of workable quality were observed near Gelikhamar, perhaps the product of airborne distribution or of erosion from a mostly buried deposit. Two extensive workshop areas were also located near Balata dei Turchi. Pantellerian obsidian may be easily distinguished from the other Mediterranean sources by its dark green color in transmitted light, and at least two visual types have been identified, preliminary results from elemental analysis confirm the existence of at least five chemical groups to which artifacts can be specifically attributed.

MONTE ARCI, SARDINIA

On Sardinia, all of the obsidian exploited in antiquity comes from the Monte Arci region in the west central part of the island. The existence of two or three chemical groups was
revealed from early analyses of central Mediterranean artifacts (Cann & Renfrew 1964; Hallam et al. 1976), although it was not until later that the geological sources themselves were identified and fully characterized (Mackey & Warren 1983; Framo vignia 1986; Hesford 1986; Etkot 1997; 1998) (Fig. 6). Best known is type SA from the Conca Canna area, very glassy and highly translucent; the SCI and SC2 chemical groups, represented by large blocks found between Punta Pizzighini and Perdas Urias on the northeast side of Monte Arci, are less glassy and mostly opaque. Type SB2, which ranges from highly transparent to nearly opaque and with phenocrysts, also occurs in large natural blocks but apparently less frequently, on the western slopes of Monte Arci near Cuccu Is Abis, Seddai, and Conca S'Ollastu. Type
Figure 4. Map of Palmarola showing localities where geological samples of obsidian were collected in this study.
SB1, not nearly as well represented among artifacts, actually represents three chemically distinct source localities at high elevations east of Santa Maria Zuurbara (Tykot 2001). Survey of the Monte Arci region by Puxeddu (1958) revealed over 200 archaeological sites and several workshops, including the major production center of Mitza Sa Tassa near Perdas Urias where additional fieldwork to document this site has recently begun.

**VISUAL ANALYSIS**

Most provenance studies of obsidian have depended on chemical analyses which take advantage of the homogeneous elemental composition of most sources and the significant differences between each of them, although visual and physical characteristics are also useful in many cases (Tykot 2002a). Since the latter are inexpensive and non-destructive techniques, the ability to use them on very large numbers of artifacts, even if not 100% accurate, may counter-balance the statistical limitations of small numbers of chemically-sources artifacts (even if 100% accurate), and therefore should be investigated first (Tykot & Ammerman 1997). In our studies, physical attributes including workability, color, transparency, luster, and the presence and orientation of microlite crystals, larger phenocrysts, and banding are recorded for all samples. Lipari obsidian is black-grey and either very transparent or streaked with microlites and phenocrysts. Palmarola obsidian is black but opaque, although some transparent obsidian was found near Punta Varda. Pantellerian obsidian is nearly opaque but its green color can be seen in thin edges. The color and translucency of the Pantellerian sources appears to have some systematic variation. Were it not for the several Sardinian obsidian sources, which appear similar to Lipari (SA, SB2) and to Palmarola (SB1, SB2, SC), it would be possible to reliably attribute artifacts found at Neolithic central Mediterranean sites at least to its source island based on visual means. By starting with visual assessments on artifacts from many Neolithic sites, some may be attributed without further analysis, allowing physical and chemical methods to be used as necessary on those still questionable. It must be remembered, however, that significant Neolithic usage patterns and differences have only been revealed through specific intra-island source attribution and visual analysis alone will rarely be sufficient for this purpose.

**DENSITY**

High resolution measurement of density (specific gravity) has also revealed systematic variation among Sardinian obsidian sources, and is an important factor in the calibration of hydration dates (Stevenson & Ellis 1998). Density was
Analysis relied on neutron activation analysis (e.g., Hallam et al. 1976; Williams-Thorpe et al. 1979; 1984; Crummett & Warren 1985; Bigazzi et al. 1986; Ammerman et al. 1990; Randle et al. 1993; Ammerman & Polglase 1997) or X-ray fluorescence (Francaviglia 1986; Francaviglia & Piperno 1987; Crisci et al. 1994; Giardino et al. 1998; De Francesco et al. 1998; De Francesco & Crisci 2000; Pouppeau et al. 2000). While all were successful in attributing artifacts to an island source, some were unable to specify a particular island sub-source either because their laboratory database did not include samples from the different subsources or they were unable to calibrate their results against already published data for these subsources. Of course none attributed artifacts to the specific Palmarola subsources only recognized in the present study, but it is particularly notable for the Sardinian artifacts in some of these studies as well.

Results from the present study are now available for 320 geological samples from Lipari, Palmarola, Pantelleria, and Sardinia, comprehensively analyzed using several analytical techniques (at least 20 more are being analyzed). At the Missouri University Research Reactor Laboratories, instrumental neutron activation analysis was used to measure 27 major and trace elements, while X-ray fluorescence was used for 73 laser ablation ICP mass spectrometry for more than 30 major and trace elements. This multi-method approach was designed to fully characterize the geological sources using the “technique of the future” while allowing cross-referencing with previously published data on artifacts (mostly XRF and NAA) which may be reexamined and found sufficient to attribute them to specific island subsources. Abbreviated protocols for future analyses of obsidian artifacts are also being developed to maximize information about specific source exploitation while minimizing analytical costs and damage to artifacts. Laser ablation ICP-MS appears to best satisfy these requirements as it produces quantitative elemental (and even isotopic) data for the smallest of artifacts while leaving only the finest surface scar (Tykot & Young 1996; Gratua 1999) (Fig. 8).

As already indicated, trace element analysis of the Sardinian samples show seven distinct groups, but the four most significant (SA, SB1, SB2, SC) are also differentiable using major element analysis (Figs. 9-10). So when it is already
SOURCE TRACING OF ARTIFACTS

Obsidian is very commonly found at Neolithic sites in the central Mediterranean, although in generally decreasing frequency at greater distance from the source. Long standing research efforts by a few scholarly groups have revealed a general pattern of obsidian distribution in the region although, as mentioned above, the number of sites for any one cultural period and with more than a few analyzed artifacts is still quite limited (Williams-Thorpe 1995; Tykot 1996; Bigazzi & Radi 1996) (Fig. 11). Nevertheless, it is becoming clear that obsidian from Palmarola, rarely documented previously in northern Italy is actually well represented at a few sites (Ammerman et al. 1990; Ammerman & Polglase 1997), while Pantelleran obsidian is continuously present in the Neolithic levels of Grotta dell’Uzzo in Sicily (Francaviglia & Piperno 1987) and common elsewhere (Nicoletti 1997), when Lipari was previously thought to be a nearly exclusive source for Sicily. Lipari appears to have been the main source, however, of obsidian distributed in the Adriatic, both along the Italian coast and across to the islands of Palagruza, Susac, Korcula, and elsewhere along the Dalmatian coast (Tykot et al. 2001).

The similar relative frequencies of the Sardinian obsidian sources in Early Neolithic assemblages in northern Sardinia, Corsica, and Tuscany are supportive of a simple down-the-line trade mechanism, while the dominance of type SA obsidian in southern France must reflect specific selection for cultural preferences and/or functional reasons (Tykot 1996; 1999; 2002b; Tykot et al. 2002). Chronological change has also been documented at individual sites such as Aren Candise in Liguria, where it has been proposed that a shift occurred in the Late Neolithic towards the presence of
Figure 10. Trace element plot showing 7 sources on Sardinia. Similar plots show 3 sources on Palmarola and 5 on Pantelleria.

Figure 11. General distribution pattern of obsidian from central Mediterranean sources for the Neolithic period. All obsidian tested from Corsica and Sardinia (individual sites not shown) has been attributed to Monte Arci. At most sites, only a few artifacts have been tested, and the broad time span represented obscures chronological variation as well.
CONCLUSION

While the characterization of the geological sources on Lipari, Palmarola and Pantelleria are still in progress, a much better understanding of the accessibility, quantity and quality of obsidian available from these islands for prehistoric exploitation already has been obtained, and the central Mediterranean island sources may be reliably distinguished based on their visual characteristics and density, both inexpensive and non-destructive techniques. Chemical analysis allows precise source attributions, and analyses of obsidian collections from significant archaeological sites are in progress which will double the number of artifacts tested for the entire region. This research will ultimately allow quantitative rather than qualitative assessment of obsidian exploitation and distribution during the Neolithic, and will be integrated with studies of typology, reduction technology and use function to reconstruct the entire sequence of raw material acquisition to tool production. Only in so doing can we interpret dynamic spatial and temporal behavior patterns in their functional and cultural contexts.

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