

Original Study

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Obsidian Studies in the Prehistoric Central Mediterranean: After 50 Years, What Have We Learned and What Still Needs to Be Done?

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Abstract: Obsidian sourcing studies have been conducted in the central Mediterranean for more than 50 years. Detailed studies have been done on the geological sources on four Italian islands, and many analytical methods have been used to successfully distinguish between them. The ability to conduct analyses using those minimally (LA-ICP-MS) or totally (XRF, pXRF) non-destructive to artifacts has led to >10,000 analyses just in the last decade. Along with the ability to assign artifacts to specific geological subsources, and an increased number of studies of techno-typology, this has allowed interpretations to be made about source access and territorial control, craft specialization and the *chaîne opératoire*, as well as the modes, frequency, and directions of movement and how that varied spatially and temporally. Obsidian especially from Lipari and from Monte Arci in Sardinia traveled hundreds of kilometers on a regular basis starting in the Early Neolithic. By the Late Neolithic, in some areas there was selection of specific obsidian sources and subsources, and differences in production methods and tool typology. Obsidian distribution and usage in the central Mediterranean continued over four-and-one-half millennia, in many areas well into the Bronze Age. There is much more still to do integrating these different studies, especially use-wear studies, along with those of lithic and other materials that also played a role in prehistoric transport and trade systems.

Keywords: obsidian provenance/provenience, trade and exchange, trace element analysis, X-ray fluorescence (XRF), Italy, France, Croatia, Malta, Tunisia

1 Introduction

Since the early analytical studies of the 1960s and 1970s indicated that the four Italian island obsidian sources could be distinguished by their elemental composition, considerable research has been done on the quantity, quality, accessibility, and physical and visual features of obsidian from each source, and some primary production areas have been identified. Chemical analysis of major and trace elements can distinguish not just each island, but specific sub-sources on Lipari (4), Palmarola (3), Pantelleria (5), and Sardinia (7), and in this millennium the use of non-destructive, portable instruments has enabled studies of entire assemblages within museums and storage facilities at a very modest expense.

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Nearly 15,000 obsidian artifacts from archaeological sites in Italy, France, Croatia, Malta, and Tunisia have been analyzed since the early 1960s, which allows statistical comparisons of individual site contexts, between multiple sites, and for different time periods within the Neolithic and Bronze Ages (Table 1). These data may be used in making interpretations at both small and large geographic scales about issues such as source access and territorial control, craft specialization and the *chaîne opératoire*, and the modes, frequency, and directions of material movement. Artifacts of Lipari and Sardinia obsidian are found at many sites hundreds of kilometers away starting in the Early Neolithic period, and this long-distance transport – including maritime travel – may reflect parallel and opposite direction movement of other materials such as ceramics, flint and other lithics, domestic animals and their secondary byproducts, and knowledge.

Table 1. Obsidian artifact analyses by geographic area, divided by these laboratories: 1. Tykot (1992–); 2. Cambridge University & Bradford Laboratory (1964, 1976–1984); 3. CESNEF, Politecnico di Milano (1979–1997); 4. Pennsylvania State University (1984); 5. CNR-ITABC, Rome (1984–1988); 6. Università degli Studi della Calabria (1994–2012); 7. Northwest Research Obsidian Studies Laboratory, Corvallis, Oregon (1997); 8. Istituto di Geoscienze e Georisorse – CNR, Pisa (2003); 9. Università degli Studi di Napoli Federico II (2006); 10. Università degli Studi di Bari (1995–); 11. LANDIS, Università di Catania (2004–); 12. CNRS-Université Bordeaux 3 (2004–); 13. CNRS, Centre de Recherches Ernest Babelon, Orléans (2010–); 14. McMaster Archaeological XRF Laboratory (2014–); 15. Istituto Nazionale di Geofisica e Vulcanologia, Rome & Palermo (2017).

Country	Region	Analyzed	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Croatia		314	314														
France	Southern	263						228							35		
France	Corsica	1270	543	9				85						633			
Italy	Abruzzo	594	319					265		10							
Italy	Basilicata	137	137														
Italy	Calabria	2252	2200		52												
Italy	Campania	302	286					16									
Italy	Emilia-Romagna	183	94	11	17			42		19							
Italy	Lazio	556	117						35	10				394			
Italy	Liguria	61			61												
Italy	Lombardy	29	5	14				10									
Italy	Marche	169	1					168									
Italy	Puglia	348	219					62				67					
Italy	Sardinia	2021	1391	79		104	4	49						106		288	
Italy	Sicily	3172	1706				152				15		1299				
Italy	Tuscany	778	418					360									
Italy	Favignana	25	25														
Italy	Filicudi	50	50														
Italy	Lampedusa	58	58														
Italy	Levanzo	11	11														
Italy	Lipari	220	220														
Italy	Panarea	45	45														
Italy	Pantelleria	208	115				93										
Italy	Salina	205	205														
Italy	Ustica	1193	1021	2													170
Malta	Malta	395	370	25													
Malta	Gozo	60	60														
Spain	Catalonia	6													6		
Spain	Balearics	1	1														
Tunisia		33	14											19			
Tunisia	Zembra	33	33														
Total		14992	9978	140	130	104	249	1285	35	39	15	67	1299	1152	41	288	170

Many important studies of obsidian in Italy still remain. There are many geographic areas with few sites and/or small numbers of artifacts tested; limitations on chronological and contextual assignment of artifacts from surface surveys and early museum collections; and few sourcing studies have been directly incorporated with those on production technology and artifact typology, and on wear patterns and residues representing their usage. Obsidian hydration dating has been rarely used in Italy (Dyson et al. 1990, Michels et al. 1984, Skinner et al. 1997) and should be properly tested and calibrated, while GIS and other techniques need to be used more to produce geospatial distribution patterns and fall-off curves considering terrain and transport methods from the source area to potential village centers to peripheries, and for specific time periods within the 4500+ years that obsidian was regularly used (ca. 6000–1500 BC) (Costa 2007, Freund 2014a, Pessina and Radi 2006, Vaquer 2006).

In this half-century history of obsidian studies, this paper synthesizes the analytical research conducted by the author and colleagues, and discusses the integration and interpretation of the data with archaeological research questions.

2 Geological Background of Obsidian in the Central Mediterranean

Geological sources of obsidian exist on several volcanic islands in the central Mediterranean, and also in the Aegean, the Carpathian mountains of southeast Europe, and central and eastern Turkey (Figure 1). Obsidian varies in its color, transparency, presence of phenocrysts (spherulites), and in its physical properties. When prehistoric people had access to more than one source, they likely selected obsidian based on some of these properties, as well as the quantity, size, and accessibility of the raw material from these sources and subsources. Territorial control and other socioeconomic factors may also have been involved, including whether lithic specialists were involved.

For the past 50+ years, a number of different elemental methods of analysis have been conducted on geological samples to show that they may be distinguished, and on obsidian artifacts from archaeological sites to identify their geological sources and try and reconstruct trade patterns. It was only in the early 1960s that the first successful analyses of obsidian distinguishing between sources and attributing artifacts to those specific sources was accomplished, using optical emission spectroscopy (OES) (Cann and Renfrew 1964). In the 1970s, neutron activation analysis (NAA) was applied to obsidian studies in the central Mediterranean (Hallam et al. 1976). With this method, the use of trace elements clearly distinguish between the island sources of Lipari, Palmarola, Pantelleria, and Sardinia, with three subsources for Monte Arci. The use of automated instruments of analysis like NAA allowed the analysis of significant numbers of artifacts, and it was in the 1970s that Renfrew and colleagues developed a hypothesis using interaction zones to compare geographic obsidian distribution patterns in the central Mediterranean. This is not based, however, on specific time periods, in part due to most of the artifacts tested not coming from archaeological excavations. This study is also based on a very modest number of artifacts tested for each site. Nevertheless, it was quite clear that obsidian from Lipari and from Sardinia were traveling over great distances, starting in the Neolithic. Since then, a lot more work has been done, and many more analytical methods have been developed that have facilitated the analyses of a larger number of geological and artifact samples, at much less cost and labor overall.

In the 1980s through early 2000s, detailed geological and geochemical research was conducted on the sources of obsidian in the central Mediterranean. Prior to the early 1980s, little had been done from an archaeological perspective on the sources and subsources of Monte Arci in Sardinia, a large island, while it was hypothesized that issues such as quantity, quality, accessibility, and other features were important for our understanding of obsidian use in prehistory. A survey of the Monte Arci region in Sardinia by Maria Mackey identified the major outcrops, and analyses of an unspecified number of samples by XRF and NAA showed they could be distinguished by major and trace elements (Mackey and Warren 1983).

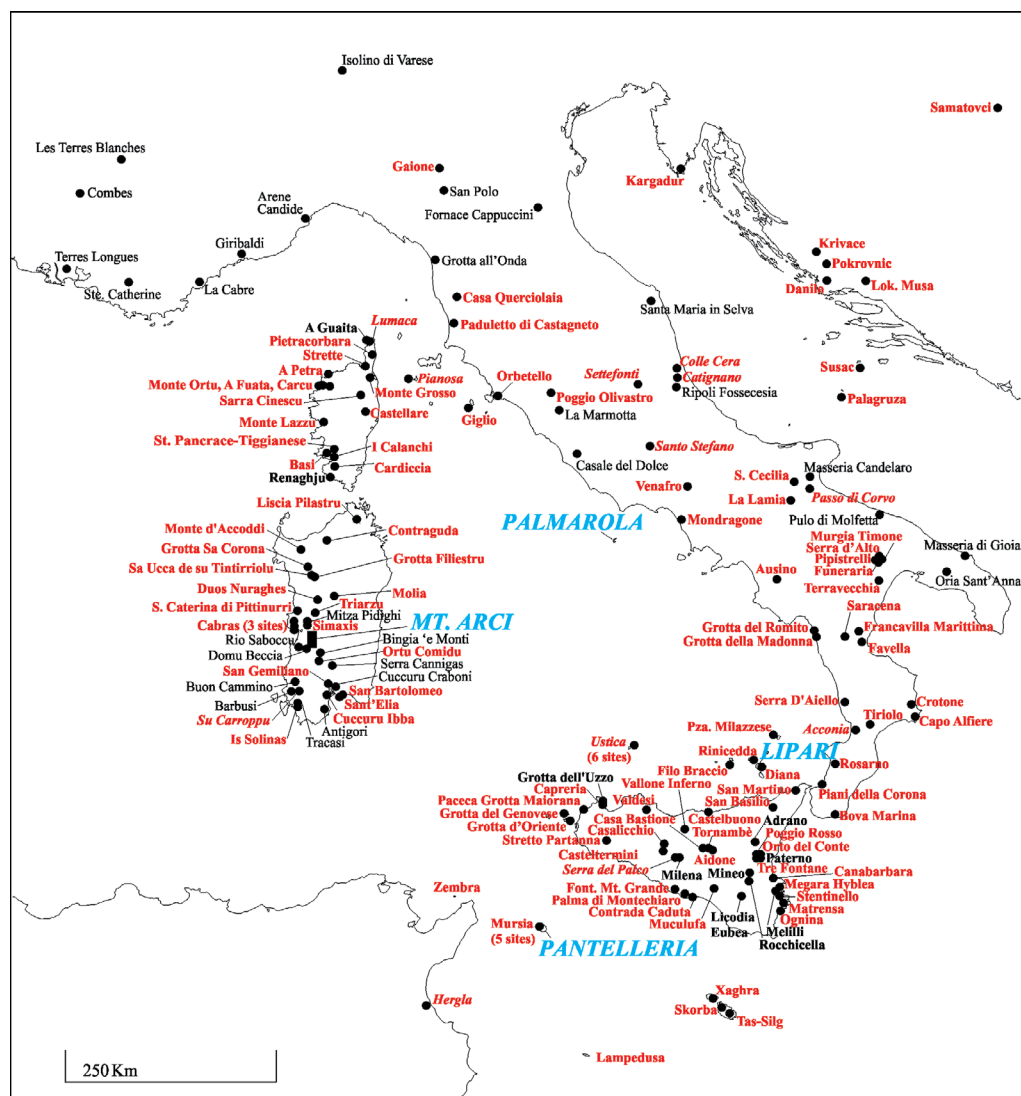


Figure 1. Map showing central Mediterranean obsidian sources and sites with 10 or more artifacts analyzed. Site names in red: sites tested by Tykot and colleagues; in black, by others; in italics, by both.

An extensive survey of the geological sources of obsidian around Monte Arci was then conducted in the later 1980s (Tykot 1992, 1997), and included the collection and analysis of a large number of samples from both primary and secondary deposits where obsidian may still be found in large sizes and quantities, and more accessible at lower altitudes (see also the study by Lugliè et al. 2006, which expands on some obsidian found in secondary deposits). Analyses were conducted primarily using an electron microprobe, with 15–18 tiny samples mounted on a single 1-inch disk, further reducing the time and cost of the analysis and being minimally destructive to the artifacts. The results were able to distinguish more than 4 subsources using major and minor elements, including type SA in the southwest; SB1 and SB2 in the central-west; and SC in the northeast of Monte Arci.

Unlike Sardinia, Lipari is a small island in the Aeolians, just north of Sicily. There is clear evidence of Neolithic settlement on the island, although the obsidian was only geologically formed late in the Mesolithic, perhaps 1000–2000 years earlier (Forni et al. 2013). A detailed survey of the outcrops and secondary sources on Lipari has been conducted (Tykot et al. 2006). Three different prehistoric outcrops have been studied and may be clearly distinguished chemically. The Monte della Guardia obsidian, however, is too small for making stone tools, and the Canneto Dentro sources appears to have been fairly small in size and quantity. The Gabellotto Gorge source is much larger in size and quantity accessible, at both top and bottom of the

gorge, and even these two areas may be chemically distinguished. For Lipari obsidian, the differences in quantity and quality clearly had an impact on which subsources were used by prehistoric people living on and/or visiting Lipari (Tykot et al. 2013).

A detailed survey of obsidian sources on the small island of Palmarola was also done, with three different localities of workable obsidian identified (Tykot, Setzer et al. 2005). Those three subsources could clearly be distinguished using NAA analysis of trace elements. Many more artifacts from mainland Italy sites need to be tested, however, to determine which were being utilized in antiquity.

Pantelleria is located between Sicily and Tunisia, a substantial open-water distance of more than 80 km from the nearest shoreline. Our survey in 2000–2002 reinforced earlier work by Francaviglia (1988), indicating that multiple outcrops exist there, including major quantities at the southern end in the Balata dei Turchi, and additional ones in the north near Lago di Venere, and perhaps some secondary deposits near Gelkhamar in the northwest (see also Tufano et al. 2006, Tufano 2007). Earlier work by Francaviglia (1988) was able to chemically distinguish five different groups for Pantelleria, however, the exact location of some of these was not identified at that time. Further research conducted by Tykot and colleagues included the collection of primary geological samples from the three different stratigraphical layers of Balata dei Turchi, and distinguish them chemically from each other and from two Lago di Venere subgroups (Tykot 2017).

In general, archaeologists and museum curators prefer methods which are minimally or non-destructive to archaeological artifacts. In the past 25 years, the methods used in the central Mediterranean include atomic absorption spectroscopy (AAS), laser ablation ICP mass spectrometry (LA-ICP-MS), proton induced X-ray emission (PIXE), scanning electron microscopy with an energy dispersive spectrometer (SEM-EDX), the electron microprobe with wave-length dispersive spectrometers (EPMA-WDX), and different varieties of X-ray fluorescence (XRF) energy and wavelength dispersive spectrometers, including lab-based, portable, and hand-held varieties (Crisci et al. 1994, De Francesco et al. 2008a, De Francesco et al. 2011, De Francesco et al. 2012, Freund 2014b, Freund 2016, Le Bourdonnec 2007, Le Bourdonnec et al. 2015, Pappalardo et al. 2013, Poupeau et al. 2009, Poupeau et al. 2010, Tykot 1997, Tykot 2002, Tykot 2004a, Tykot 2016).

Starting in 2007, a totally non-destructive, portable XRF spectrometer has enabled analyses to be conducted in museums and other locations, rather than transporting to laboratories, resulting in the analyses of many thousands of artifacts in the central Mediterranean (Figure 2). In a simple X-Y graph using three trace elements, it is possible to distinguish all of the Mediterranean island sources, as well as Carpathian and Aegean sources (Figure 3). Additional trace elements also enable the distinction of the Lipari, Melos, and Pantelleria subsources (Tykot 2017) (Figure 4).

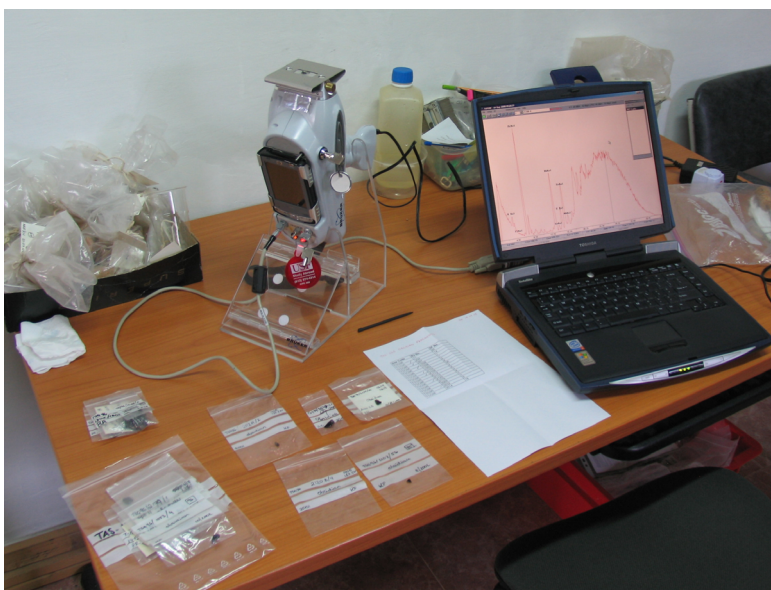


Figure 2. Non-destructive analysis by pXRF of a tiny obsidian artifact in Malta. Peaks of major and trace elements visible on the laptop.

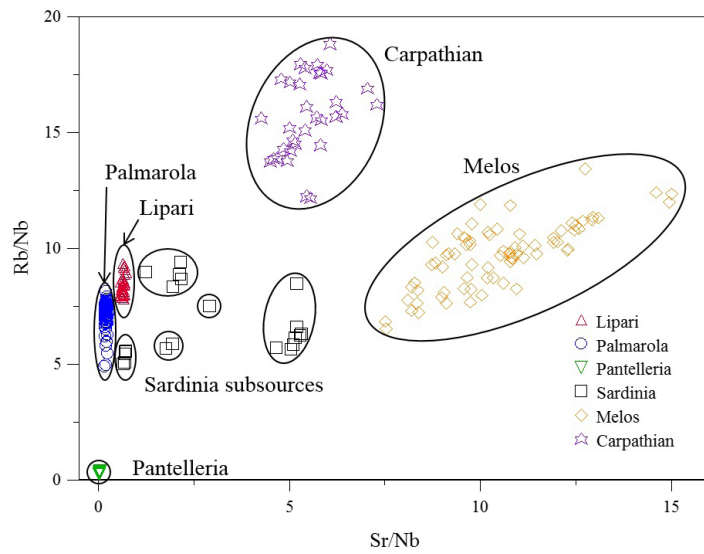


Figure 3. X-Y graph of trace element data distinguishing Mediterranean and European obsidian sources. Additional elements are also used to confirm artifact source assignment.

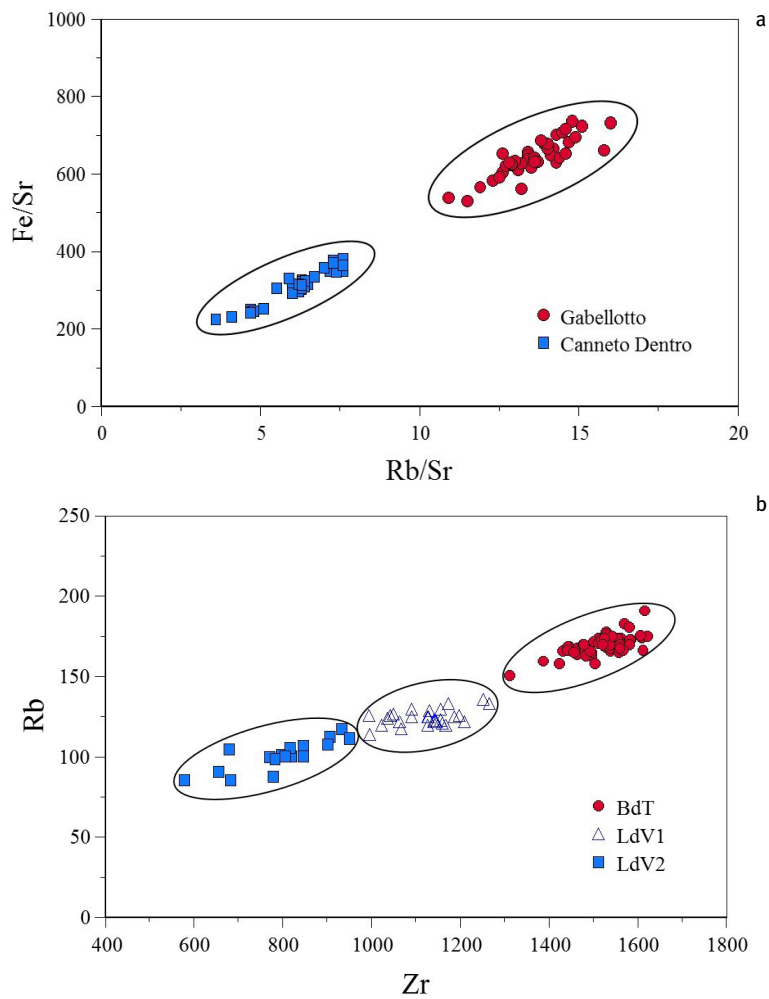


Figure 4. Simple X-Y graph of trace element data distinguishing (a) Lipari and (b) Pantelleria subsources.

3 Obsidian Artifacts

Archaeological artifacts dating to the Neolithic and also the Bronze Age have been found at more than 1000 sites in Italy, France, and nearby countries (Figure 5). Many of these sites are hundreds of kilometers away from the nearest source, indicating some kind of long distance trade and exchange. My research on obsidian began in Sardinia, on artifacts found at the Bronze Age site of Nuraghe Ortu Comidu, excavated in the later 1970s (Balmuth 1986). Thirteen of the 214 artifacts found had been analyzed by NAA (Mackey and Warren 1983), while I used AAS for 27 artifacts in 1986. The limitations in the number of artifacts tested in these two studies was due to the destructive nature and cost of the analytical methods available at that time; for the entire central Mediterranean, a total of ~350 obsidian artifacts had been analyzed from 1964–1986, in just a handful of different laboratories. Since then, the non-destructive analysis of obsidian artifacts (at least modest-sized) using XRF, at CNR-Rome (e.g. Francaviglia and Piperno 1987), the Università degli Studi della Calabria (e.g. Crisci et al. 1994), and later at the Università di Catania (e.g. La Rosa et al. 2006) and McMaster University (Freund 2014b, Freund 2016) has multiplied by many times the numbers of artifacts tested in the central Mediterranean. Other minimally-destructive methods have also been shown successful (SEM-EDS, PIXE, LA-ICP-MS) and many analyses conducted in particular at the CNRS-Université Bordeaux 3 (e.g. Le Bourdonnec 2007, Poupeau et al. 2010).



5a Sennixeddu (SC) natural obsidian blocks



5c Obsidian blade core from Calabria. 5 cm in length



5b Sardinia obsidian blades, scrapers, flakes



5d Obsidian blades (broken) from Calabria



5e Obsidian blades and other artifacts from Sicily

Figure 5. Obsidian blocks, cores and artifacts from Sardinia, Calabria, and Sicily.

3.1 Sardinia and Corsica

Following my survey and collection of Monte Arci geological samples in the late 1980s, successful distinction between the subsources was demonstrated using a microprobe with wavelength dispersive spectrometers, large artifact assemblages from many sites were tested, utilizing 15–18 tiny samples mounted on a single 1-inch disk with several artifacts analyzed per hour (Tykot 1992). The importance of identifying the specific subsurface (outcrop) that obsidian artifacts came from was fortified by the results obtained for the site of Filiestru Cave in northwestern Sardinia. Ninety artifacts from four different Neolithic time periods (Early Neolithic, Filiestru, Bonu Ighinu, Ozieri, ca. 5700–3200 BC) at the site were tested and clearly demonstrated chronological changes in subsurface selection, with obsidian from subgroups SB1 and SB2 being replaced by type SC (Tykot 1996). This study was expanded to many other prehistoric sites in the central Mediterranean,

specifically in Sardinia, Corsica, and in the Tuscan archipelago connecting to peninsular Italy. For the Early Neolithic artifact assemblages, all three major subgroups (SA, SB, SC) were regularly used at all of them, while for later Neolithic sites in Sardinia and Corsica the SC subgroup seems to dominate virtually all of the assemblages tested, including large collections from the Pigorini Museum and elsewhere (Lai et al. 2006, Tykot 2004b, Tykot 2007, Tykot 2010, Tykot et al. 2011).

Downslope from the original geological formation of type SC obsidian, at the site of Sennixeddu, an excavation was conducted after a large number of worked artifacts along with a large number of obsidian boulders were found during new road construction. We have identified an actual workshop where thousands and thousands of artifacts were being produced by the Neolithic people in that area, far more than needed by local residents, and likely being transported around Sardinia and beyond (Tykot et al. 2006). The lithic technotypology suggests that this site dates to the Late Neolithic, by which time much of the island was well-occupied by farming people with incipient territorial control, and who had craft and trade specialists. Lugliè et al. (2006) have also done a detailed survey along the Rio Mogoro and Rio Mannu, and this brings up the very large issue of access in particular to the coastline of the Gulf of Oristano and the more open water of the Mediterranean. Were people who lived in and around Monte Arci collecting and bringing obsidian to the coast where it was transported further? Or were there people from elsewhere visiting Sardinia, leaving their boat on the coast, and making their own trip to Monte Arci? These are very important for our understanding of what was going on in the past regarding this specific subsurface SC selection for Sardinia and Corsica, which continued into the Bronze Age as well at many Nuragic sites (Freund and Tykot 2011), while subsurface SA was dominating obsidian assemblages found at many Neolithic sites in southern France, presumably due to selection because of visual and perhaps physical properties of obsidian to supplement the mostly chert and other lithic material being used. That SA obsidian was not specifically selected in Corsica or the Tuscan Archipelago suggests perhaps direct, if only occasional, maritime contact between southern France and Sardinia, even specifically the Conca Cannas (SA) area, rather than down-the-line distribution that is argued for elsewhere in the central Mediterranean. The capability of maritime navigation and Monte Arci obsidian distribution during the Neolithic has been addressed further through social network analysis (Freund and Batist 2014).

3.2 Peninsular Italy and Croatia

In peninsular Italy it is no surprise to find that obsidian from multiple island sources were being used in the past, and a very large number of sites and artifacts have been tested (De Francesco et al. 2008b, De Francesco et al. 2012, Tykot et al. 2003, Tykot et al. 2005, Tykot et al. unpublished). The proportions of obsidian present at these sites from Sardinia, Palmarola, and Lipari, however, are based on many variables, including their physical properties, accessibility, distance from those islands, local topography and settlement patterns, the actual trade and transportation methods used, the distribution and exchange of other materials, and the contemporary socioeconomic system in which the movement of obsidian was embedded.

For the area around the Adriatic Sea, questions have been raised about the path of the spread of the Neolithic package about 6500–6000 BC, with domesticated plants and animals, ceramics, and a new way of life expanding from eastern to western Europe. Excavations in Croatia over the last 20 years have revealed significant quantities of obsidian, from sites on the Dalmatian islands to Istria in the north Adriatic, as well as at mainland sites in different parts of the country. Analyses by pXRF show that most of the obsidian is from Lipari, and is present starting in the Early Neolithic on islands like Susac, as well as on the mainland. A very small number of pieces from Carpathian sources do reach the Dalmatian coast, while dominating the obsidian assemblages in northeastern Croatia (Tykot 2014). Studies of obsidian from many Early through Late Neolithic sites on the Italian side of the Adriatic, including many sites in the Tavoliere, show that Lipari obsidian dominated those assemblages as well, but with Palmarola obsidian regularly present at about 10% (Brown and Tykot, submitted). A few pieces from Palmarola even reach one of the Adriatic islands and a site on the Croatian mainland. The discovery and excavation of Neolithic sites on Adriatic islands, the early arrival of the Neolithic in the Tavoliere region, and the presence of obsidian from Italian sources in Croatia strongly indicate trans-Adriatic travel in both directions (Forenbaher 2008, Tykot 2014).

The existence of islands in the middle of the Adriatic certainly facilitated otherwise longer distance open-water transport in prehistory. A quantitative assessment of the overall distribution of obsidian from the Italian island sources clearly indicate that travel along coast lines was most common, with Sardinian obsidian rarely, if ever, crossing directly eastward to Rome or further south. Nevertheless, a small number of Neolithic obsidian artifacts from Sardinia did reach the site of Pulo di Molfetta in Puglia (Acquafredda and Muntoni 2008), another in Calabria, and even one piece has been identified in Sicily. One exceptional discovery has been made on the tiny Adriatic island of Palagruza, where the lithic assemblage of a site dating to the Copper Age includes several pieces of obsidian from Melos in the Aegean, again demonstrating that at least occasional extra-long maritime transport occurred in antiquity (Tykot, in press).

3.3 Southern Italy and Sicily

In Calabria, a major survey of many Neolithic sites in Acconia by Ammerman (1985) revealed extensive obsidian artifacts, accounting for more than 90% of the lithics. In addition to a number of prepared cores coming from Lipari, many of the artifacts were large Stentinello blades, with only a small number having secondary modification (retouch). Despite a distance of more than 100 km from Lipari, these finds clearly indicate a high frequency of well-organized production and exchange early in the Neolithic.

In Sicily, such regularity in the distribution of Lipari obsidian also existed. Analytical studies done in the eastern half of the island have shown that all obsidian comes from Lipari and reinforces the visual assessments previous made (Cultraro and Pappalardo 2010, Iovino et al. 2008, Maniscalco et al. 2008, Nicoletti 1997, Pappalardo et al. 2013, Tykot et al. 2013).

Over the past several years, several thousand artifacts from many prehistoric sites in southern Italy (Calabria) and Sicily have been analyzed using a pXRF, mainly to investigate the use of the different Lipari obsidian subsources, as well as the importance of dark green peralkaline obsidian from Pantelleria which came from several subsources (Tykot et al. 2013). In Calabria and eastern Sicily, nearly all of the obsidian comes from Lipari, with over 98% specifically from Gabellotto Gorge. Obsidian from Canneto Dentro is found however in small quantities at a number of different sites in Sicily, while quite rarely in southern Italy, suggesting some differences in the acquisition and dispersal of Lipari obsidian.

In addition, there seem to be noticeable differences between Calabria and eastern Sicily (Freund et al. 2015). While for both regions primary reduction occurred in the Lipari source area by local populations, with preformed cores then transported to both eastern Sicily and Calabria, communities in eastern Sicily appear to have maintained a widespread tradition of pressure flaked, distinctively wide blade production. Furthermore, it does not appear that sites in eastern Sicily acted as redistribution nodes as is observed for Calabria and elsewhere in peninsular Italy (Ammerman and Andrefsky 1982).

In northwestern Sicily, earlier studies of the Neolithic layers at Grotta dell'Uzzo, as well as at inland Neolithic sites in central-western Sicily near Milena, had shown that Pantelleria was the source for up to 40% of the obsidian artifacts (Francaviglia and Piperno 1987, La Rosa et al. 2006, Boscaino et al. 2012). Recent studies along the southern and western coast of Sicily also demonstrate that during the Neolithic significant amounts of Pantelleria obsidian were in use, and even account for more than 50% of the lithics at the inland site of Casalichio (Tykot et al. 2013). Pantelleria remains about 10% or more of the obsidian found at the island of Ustica, well north of Sicily, from the Neolithic through the Bronze Age, and even one from Palmarola has been found there too (Foresta Martin et al. 2017). Research is in progress on the typotechnology of the obsidian artifacts in western Sicily in order to compare Pantelleria vs. Lipari obsidian production and use.

3.4 Tunisia and Malta

Unsurprisingly, given Pantelleria's location, its obsidian accounts for all the Neolithic obsidian artifacts from the Tunisian sites of Hergla (Mulazzani et al. 2010) and the island of Zembra, as well as the Italian island of Lampedusa. While all of the Hergla obsidian was assigned to the major Balata dei Turchi subsurface group, the obsidian found at the two island sites comes from both Balata dei Turchi and Lago di Venere. Lago di

Venere appears to account for about 10% of the Pantelleria obsidian used overall in the past, including at sites in Sicily. This informs us with some information, perhaps, about the accessibility and potential territorial control of these different subsources, and where the primary reduction of the raw material was occurring.

There is a significant amount of both Pantelleria and Lipari obsidian found at archaeological sites excavated in Malta, including the long-occupied (Ghar Dalam through Tarxien) residential/ritual site of Skorba, on Malta proper, and the Tarxien phase burial complex of Xaghra (Brochtorff Circle) on Gozo. For the site of Skorba, analyses conducted by pXRF confirm the visual identifications made by Trump (1966), with nearly 80% coming from Lipari and 20% from Pantelleria, while also indicating that all of the Lipari obsidian artifacts came from Gabello, with not a single one from Canneto Dentro. A great surprise, however, was the results for obsidian artifacts from Xaghra, which had not been visually assessed beforehand, with more than 70% coming from Pantelleria. This major difference in source usage must represent selection for particular purposes.

4 Discussion

Over the past 50+ years, quite a lot has been accomplished with obsidian studies in the central Mediterranean, from the surveys and characterization of the multiple island sources and their subsources, to the highly successful analysis and sourcing of large numbers of artifacts from many different sites and time periods. The analysis of nearly 15,000 artifacts gives us a very good idea about the general distribution of obsidian from each of the geological sources and subsources and how they changed over time. In the central Mediterranean, obsidian use began with the introduction of a Neolithic lifeway, including the establishment of year-round settlements, domestic animal husbandry and agricultural management, and production and use of ceramics, and continued for more than 4500 years during which time ranked and complex societies, increased boat technology, and metallurgy developed.

From the beginning of the Neolithic period, obsidian was transported hundreds of km from the island sources, found in assemblages along with flint/chert and other lithics. Other materials such as greenstone also traveled great distances. While in some cases decorative pottery styles (e.g. Cardial Impressed Ware, Stentinello) also had great distribution, in most cases the vessels themselves were produced much more locally. For the socioeconomic networks characteristic of the Neolithic in the central Mediterranean, it is unlikely that obsidian was directly obtained from sources that were a hundred or more kilometers distant, but rather through some kind of down-the-line exchange which involved the movement of other materials in both directions. The total quantity of obsidian which was distributed over great distances was modest at best, and unlikely to have been the primary purpose of the travel/transport overall. Nevertheless, there are some exceptions, including the site of Terres Longues in southern France (Léa 2012) and several in peninsular Italy (Robb and Farr 2005), where larger-than-usual proportions of obsidian suggest redistribution patterns having been developed during the Neolithic.

In most cases, the directions traveled are not simply linear, but a complex pattern based on (1) the terrain from the obsidian source to the island coast; (2) sea travel directions affected by wave and wind patterns which changed seasonally along with safety practices staying near coastlines or other islands; and (3) from arrival at a coastal area, the terrain and existing travel patterns to inland sites. The potential interest in obsidian cores or finished products would also have been affected by the availability of alternative lithic materials and the particular characteristics of obsidian that may have been advantageous for certain tasks or activities.

5 Conclusion

A very large number of obsidian artifacts has been sourced, and detailed publications for specific excavated sites (e.g. Vallone Inferno, Venafrò) or areas (e.g. Abruzzo, Ustica) which also include lithic technotypology and contextual information are forthcoming. For the assemblages from surveyed sites, there are limitations which must be taken into consideration when making interpretations about specific practices that took

place within a span of several thousand years. What implications do our obsidian studies actually have in addressing economic, sociopolitical, and other situations and how they changed over time and vary over space in the central Mediterranean? Can we test whether obsidian was a special material when found in small percentages hundreds of kilometers from its source (Tykot 2011)?

Determining the source of obsidian artifacts is just one step in putting the puzzle back together (Ammerman et al. 1978, Ammerman and Polglase 1993, Tykot and Ammerman 1997). First, what kinds of contexts are the lithic materials coming from, and was this from formal excavation or surveys and surface collections? Like many other archaeological materials, the obsidian assemblages come from cave sites, open-air settlements, and burial contexts. Obsidian sourcing studies also must be integrated with typotechnological and usewear studies, and compared with other lithics that were present. We need intensive studies of the *chaîne opératoire*, including the acquisition of the raw material, its production, specialization involved, and of course where it ends up in the archaeological record. This will provide a much better understanding of the use of obsidian in the past.

Quantitative and statistical incorporation of lithic typology, the percentage of obsidian in overall lithic assemblages and specific contexts, with sourcing data, should be pursued and further address what we observe for differences between Lipari and Sardinia obsidian, the two dominant island sources in the central Mediterranean, and the interplay with obsidian from Palmarola and Pantelleria. Some such studies have begun, but many more are needed (Freund and Tykot 2011, Freund et al. 2015, Freund et al. 2017, Le Bourdonnec et al. 2014, Le Bourdonnec et al. 2015, Lugliè et al. 2011). Only a small number of use-wear and residue analyses have been done to directly assess the usage of obsidian in the central Mediterranean (Hurcombe and Phillips 1998, Iovino 2000, Iovino 2002, Setzer 2012, Setzer and Tykot 2010, Tykot et al. 2006).

Obsidian studies in Italy and neighboring countries over the past 50+ years have revealed some surprising results regarding the distance and regularity of distribution, as well as differences in the overall operational sequence in different regions and time periods, thus informing us about variability in human socioeconomic practices. Yet there really is a lot more work that should be done on obsidian studies in the Neolithic through Bronze Age central Mediterranean.

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