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Reports

Sardinian Obsidian Circulation and Early Maritime Navigation in the Neolithic as Shown Through Social Network Analysis

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ABSTRACT

Scholars typically argue that cultural interaction between the West Mediterranean islands of Sardinia and Corsica and the European mainland took place through the Tuscan Archipelago, via such intermediary islands as Elba and Pianosa. This path is posited as the prime route in and out of these islands for both people and objects throughout prehistory largely due to the belief that early—pre-sail—seafarers would have wished to avoid more treacherous open-sea voyages. This article tests this hypothesis using social network analysis (SNA) to identify the strengths of inter-site relationships through time based on the relative proportions of West Mediterranean obsidian raw materials at 79 Neolithic sites dating from the sixth to fourth millennia BC. We argue that similar patterns of obsidian consumption reflect similar procurement mechanisms and the likelihood of more frequent interactions between the people of these communities. As such, it becomes possible to reconstruct the relationships that mediated the distribution of obsidian across the landscape. Contrary to previous interpretations highlighting

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the role of Elba and Pianosa in the exchange of obsidian from the geological sources of Sardinia along the coast to northern Italy and France, our results suggest that obsidian also took a more direct open-sea path upwards of 200 km from Corsica to the coastal regions of Provence and Languedoc in southern France. These results are contextualized within broader patterns of obsidian circulation and use and have important implications for debates surrounding Neolithic obsidian procurement, exchange spheres, and early maritime navigation.

Keywords early maritime navigation, Neolithic, obsidian, social network analysis (SNA), West Mediterranean

INTRODUCTION

Debates about the prehistoric circulation of obsidian from the geological sources of Sardinia to mainland Italy and France (Figure 1) are typically predicated upon assumptions concerning the degree of sophistication of early maritime technology. Due to the lack of direct evidence for early watercraft, scholars often rely on indirect evidence for the use of boats in prehistory, including the colonization of distant islands (Ammerman 2010; Broodbank 2006; Cherry 1990) and the procurement of obsidian from island sources throughout the Mediterranean (Freund 2013; Perlès et al. 2011). These studies work under the assumption that in order to travel to a particular island or procure obsidian from an island source people required boat technology. Although evidence exists for inland maritime navigation in central Italy in the sixth millennium BC (Fugazzola Delpino and Mineo 1995; Robb and Farr 2005:25–26), the earliest direct evidence for open-water sailing in the West Mediterranean is found at the second millennium BC wreck site of *Pignataro di Fuori* off the coast of the Aeolian island of Lipari (Ciabatti 1984). As a result of these limitations, West Mediterranean scholars are fittingly cautious in their interpretations about the degree of maritime mobility in the Neolithic (ca. 6000–3500 BC).

Concerning the distribution of Sardinian obsidian, scholars have typically emphasized the role of the intermediary islands of the Tuscan Archipelago in the exchange of obsidian 'down-the-line' (Renfrew 1969) from the geological sources of Sardinia along the coast to northern Italy and France (Figure 1; Hallam et al. 1976; Le Bourdonnec et al. 2010; Terradas et al. 2014; Tykot 1996:; Tykot et al. 2005:; see Léa 2012; Vaquer 2007 as exceptions). Although Neolithic obsidian consumption in southern France is notably distinct from Italian sites to the east in terms of the obsidian sources represented and in the relative quantities of obsidian present, scholars have been hesitant to suggest a more direct link between either Sardinia or Corsica and southern France. For example, Tykot (1996:55) argues that "Sardinian obsidian could have reached southern France by several routes: directly from the Monte Arci supply zone; via Corsica; or via Tuscany and Liguria. The first and second choices would suppose much greater confidence and capability in open-water crossings than most scholars are willing to credit to Neolithic sailors." Instead, similarities in the consumption of other exchange objects such as amber (Phillips et al. 1977), axes (Petrequin et al. 2002), eclogites (Ricq de Bouard 1993), and Lipari obsidian (Guilane and Vaquer 1994) are highlighted as a means of demonstrating direct relationships between the residents of the French regions of Provence, Languedoc, and the Rhone Valley and northern Italy. Differences in raw material selection are explained as resulting from cultural preferences related to differential fracture characteristics and aesthetic properties (Lugliè 2009; Tykot 1996, 2011).

With the relatively recent discovery of a large quantity of obsidian at the Chasséen period (ca. 4400–3300 BC) site of Terres Longues near the coast of southern France, new evidence is emerging that challenges

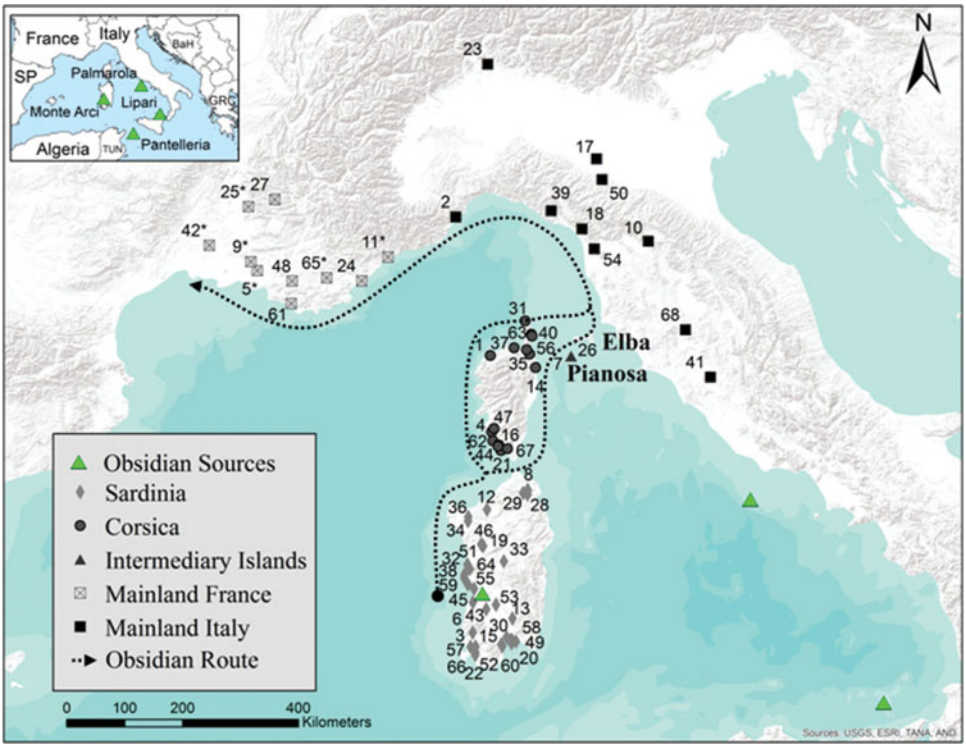

Figure 1. *Map of the West Mediterranean displaying the relevant archaeological sites and obsidian sources. Sites numbers correspond to those listed in the online supplement. Obsidian routes represents traditional conceptions surrounding the movement of obsidian from Sardinia to the mainland.*

previously held assumptions about early maritime navigation in the West Mediterranean (see Léa 2012; Léa et al. 2010). Building upon this tradition of scholarship, we use social network analysis (SNA) to situate Terres Longues within the broader landscape of Neolithic Sardinian obsidian distribution. While we do not deny that the people of southern France and northern Italy interacted with one another, we argue that strong similarities both in raw material selection and obsidian reduction strategies between communities in southern France, Corsica, and Sardinia have important implications, especially when considering the broader socio-economic circumstances of their occurrence. We argue that common traditions in how peoples of these regions procured and worked Sardinian obsidian strongly suggest that these communities interacted with one another. In order to test this hypothesis, we analyze the distribution of obsidian at 79 Neolithic sites dating from the sixth to fourth millennia BC. After collating previously published obsidian sourcing data (see online supplement), we use SNA to identify the strengths of inter-site relationships through time based on common patterns of obsidian exploitation. As such, it becomes possible to reconstruct the relationships that mediated the distribution of obsidian throughout these regions.

WEST MEDITERRANEAN OBSIDIAN CIRCULATION

Obsidian is an igneous rock and a type of volcanic glass that is usually black in color.

It is an excellent raw material for the flaking of tools and was widely exploited by past peoples of the West Mediterranean, frequently across vast geographic distances (Tykot 2011). Due to each source having a distinct chemical composition, an artifact's raw material can be sourced with relative ease by matching the elemental fingerprint with that of geological material of known origin. Obsidian characterization has thus become a well-developed and hugely successful component of archaeological provenance studies (see Pollard and Heron 2008).

While there are four obsidian sources in the West Mediterranean (Figure 1), only obsidian from the subsources of Sardinia's Monte Arci is known to have been exploited by people on the island itself. The Monte Arci obsidian source in west-central Sardinia is often classified as a single "source," but researchers have identified at least nine chemically distinct outcrops and secondary deposits (Lugliè et al. 2006; Tykot 1997), three of which are commonly reported in the archaeological literature. These include the geographically distinct SA, SB, and SC subsources (Figure 2). The differentiation between these subsources is archaeologically relevant because it has been shown that there were differences in these raw materials' exploitation through time and space. Table 1 provides a list of relevant periods and dates in Sardinian prehistory.

Despite the presence of Mesolithic populations on Sardinia and Corsica (ca. seventh millennium BC; see Costa et al. 2003; Sondaar et al. 1995), it is not until the beginning of the Neolithic (ca. 6000 BC) with the introduction of the first farming communities to the islands that we see evidence of Sardinian obsidian procurement locally (Lugliè et al. 2007, 2008; Tykot 1996), and by distant communities on Corsica and mainland Italy (Bigazzi and Radi 1998; Tykot et al. 2003).

Although a single blade of SA obsidian has been recovered at the Early Neolithic site of La Grande Baume in Provence (Figure 3; Crisci et al. 1994), it is not until the beginning of the Chasséen period (ca. 4400–3300 BC) that we see the earliest evidence for regular importation of Sardinian obsidian to southern France, now attested at over 100 sites

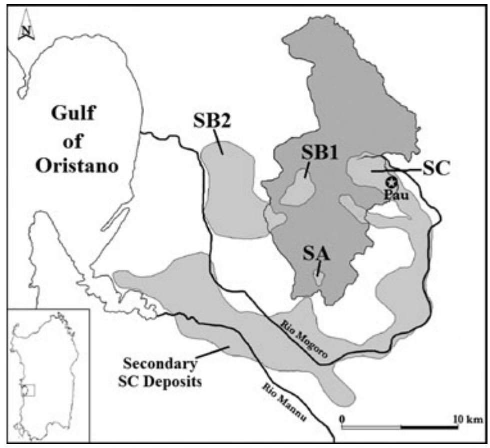

Figure 2. *Geological map of Monte Arci in west central Sardinia showing the relevant obsidian subsources (after Lugliè et al. 2006:1000).*

(Binder and Courtin 1994; Pollmann 1993). In contrast to Sardinia and Corsica, obsidian is relatively rare in the French regions of Provence, Languedoc, and the Rhone Valley as well as in northern and central Italy, and it is only at three sites in which obsidian comprises more than 14% of the lithic assemblage, namely Gaione, Grotta all'Onda, and Terres Longues (Ammerman et al. 1990; Bigazzi and Radi 1998; Léa et al. 2010).

While the long-distance procurement of obsidian by Corsican and Italian communities does continue into the Chalcolithic (see Bigazzi and Radi 1998; Randle et al. 1993), there is a sharp fall-off in the number of sites in which obsidian has been reported. This diminishment in the use of Sardinian obsidian mirrors the exploitation of the other sources in the West Mediterranean in that obsidian consumption became a more local phenomenon, largely restricted to communities within the immediate vicinity of the various sources and subsources (Freund 2014).

SOCIAL NETWORK ANALYSIS (SNA)

SNA is a technique that enables the organization and interrogation of relational data,

Table 1. **The periods, cultural phases, and absolute dates (calibrated) of Sardinian prehistory (after Tykot 1994:129).**

Period	Cultural phase		Absolute dates
Mesolithic	Grotta Corbeddu		11,000–6000 BC
Neolithic			
Early	Su Carroppu		6000–5300 BC
	Filiestru-Grotta Verde		5300–4700 BC
Middle	Bonu Ighninu		4700–4000 BC
	———San Ciriaco———		
Late	Ozieri		4000–3200 BC
Chalcolithic			
Early	Sub-Ozieri		3200–2700 BC
	Filigosa		
	Abealzu		
Middle	Monte Claro	Beaker A	2700–2200 BC
Late			
Bronze Age			
Early	Bonnanaro A	Beaker B	2200–1900 BC
Middle	Bonnanaro B		1900–1600 BC
	Nuragic I		1600–1300 BC
Late	Nuragic II		1300–1150 BC
Final	Nuragic III		1150–930 BC

often conceptualized as "nodes" (sites, points, artifacts) connected by a series of "edges" that represent links between points in a network. While edges often represent the presence or absence of a relationship between nodes, they can also measure the similarity between node attributes (i.e., archaeological assemblage data). This approach has been employed by archaeologists to examine inter-site relationships based on the dispersion of certain forms of material culture, which may in themselves be manifestations of socio-economic links (see Cochrane and Lipo 2010; Golitko et al. 2012; Knappett 2011, 2013; Mills et al. 2013).

In this study, we determined indices of similarity between contemporary sites based on comparisons of obsidian assemblage characterization data. This included site-by-site counts of artifacts made up of each type of obsidian in the West Mediterranean: SA, SB, SC, Lipari, and Palmarola (Figure 1). Because of the nature of our research question, only sites in which Sardinian obsidian was found were included in the analysis. In total, obsidian artifacts from 79 sites were analyzed (see online supplement for a complete list), including 16 sites from the sixth millennium BC, 24 from the fifth millennium BC, and 39 from the fourth millennium BC. Due to the low number of obsidian artifacts recovered at a number of nearby sites in southern France, results from these locations were combined. Since many sites in southern France contain only a small number of total artifacts, this pooling of data from nearby sites was performed as not to bias our sample in southern France towards a small number of very large Neolithic sites. Because of regional differences in chronology, we avoided using terminology such as Early, Middle, and Late Neolithic, instead conducting three separate analyses

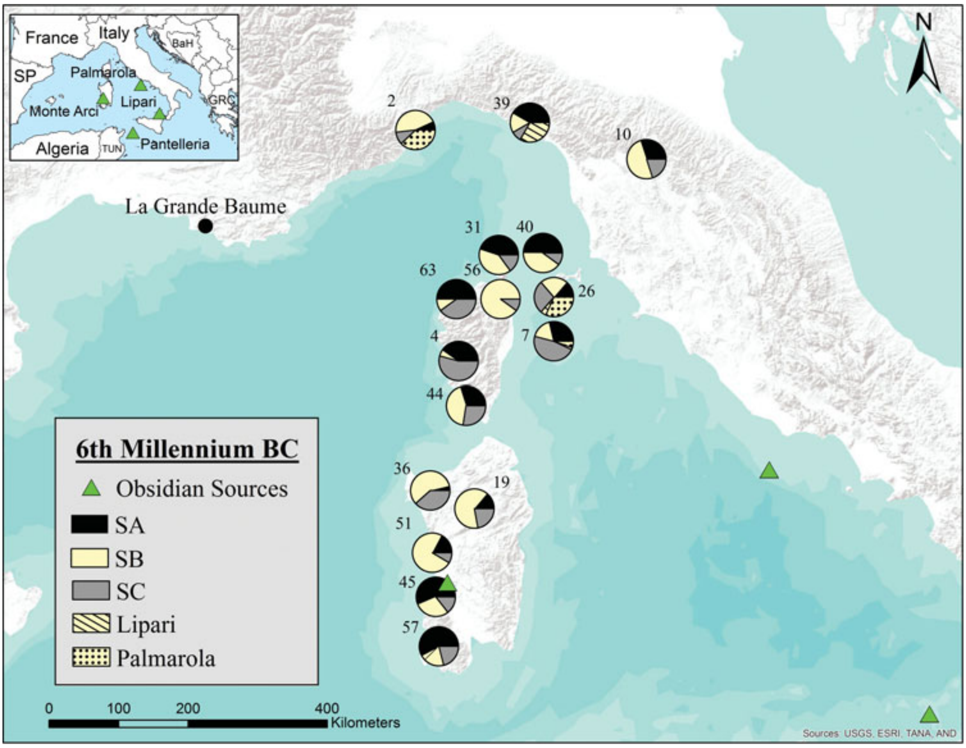

Figure 3. *Sixth millennium BC obsidian frequencies. Pie charts represent the distribution of obsidian at individual sites based on published obsidian sourcing data. Numbers correspond to sites listed in the online supplement.*

divided by millennia. Sites that were occupied for multiple millennia were included in both.

Index values of similarity were determined using Brainerd-Robinson coefficients of assemblage similarity (Peeples 2011) to compare the proportions of artifacts made of each type of obsidian in the West Mediterranean. The Brainerd-Robinson formula calculates the similarity of assemblages at pairs of sites by determining how the percentages of artifact classes differ between them. It thus takes into account the uneven sizes of total artifact assemblages, and generates a value that can easily be represented as edges in a network. Using a "mini-max" model, a minimum threshold Brainerd-Robinson index value could be defined. The mini-max model ensures that the strongest connections are retained, while also maintaining the network's unified structure. This model defines a minimum edge weight value based on the premise that every node maintains a minimal amount of edges, while still having at least one link that connects it to the rest of the network (Cochrane and Lipo 2010:3890; Golitko et al. 2012:510). The refined set of edges was then binarized so that ties with values above the minimum edge weight value were simply counted as present, and those below the value were discounted as absent. As Peeples and Roberts (2013) note, determining a threshold value when defining binary relationships is ultimately an arbitrary decision. However, the mini-max model is the most effective for this study because it allows us to define a minimum Brainerd-Robinson value that emphasizes the strongest connections certain sites maintained with one another.

The relational data examined in these networks were prepared, analyzed, and visualized using UCINET and NetDraw software packages (Borgatti 2002; Borgatti et al. 2002). The 'factions' method included in this software was used to identify clusters of nodes that were more connected to each other than with other nodes in the network (Hanneman and Riddle 2005:189–192). These clusters represent groups of sites that share strong similarities in obsidian exploitation, as represented by their relative proportions of West Mediterranean/Sardinian raw materials. We argue that similar patterns reflect similar procurement mechanisms and the likelihood of more frequent interactions between the people of these communities.

RESULTS BY PERIOD

Sixth Millennium BC

Sixth millennium BC obsidian assemblages on Sardinia and Corsica are composed of varying proportions of all three Monte Arci obsidian subsource materials (Figure 3). While Sardinian obsidian is present in the Italian regions of Tuscany and Liguria, it is virtually absent from southern France. Raw materials from both Lipari and Palmarola are also found in Liguria in northern Italy and on the island of Pianosa, but they never reached Corsica or Sardinia.

The network map for sixth millennium BC sites (Figure 4) indicates strong similarities in raw material selection between sites in Sardinia and Corsica, which is further supported by similar reduction strategies oriented towards the production of flake tools and to a lesser degree blade technology (Bressy et al. 2008; Lugliè et al. 2007). In general, however, the faction analysis would suggest that the strongest links were at the intra-island level, rather than between communities on different islands.

Despite similarities in blade production throughout central and northern Italy (Ammerman and Polglase 1993; Vaquer 2007), these sites are not well connected to one another in terms the raw materials being used,

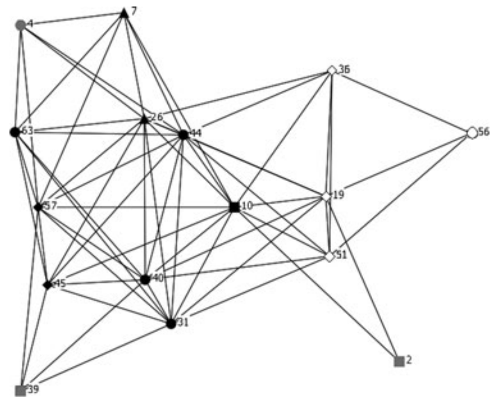

Figure 4. *Network graph constructed using Brainerd-Robinson coefficients for sixth millennium BC obsidian assemblages. Assemblages with less than nine artifacts were omitted. Nodes were connected at a threshold similarity of 124, the minimum value to connect all points into a single network. Nodes are labelled according to their numerical designations (see supplementary material), and a node representing combined sites in France is labelled with an asterisk. Nodes are coded by zone (shape: see legend to Figure 1) and faction (color: best fit achieved with three factions).*

instead showing stronger affinities with sites on Corsica and northern Sardinia. While there are links between Corsica, Sardinia, and central Italy, sites in central Italy are relatively isolated and share few links with other nearby communities. This indicates a stronger probability that people from central Italy interacted directly with Corsica and Sardinia than with contemporaneous sites on the mainland, likely due to the coastal nature obsidian distribution.

Fifth Millennium BC

By the fifth millennium BC, obsidian of type SC becomes prevalent at sites throughout Sardinia and Corsica, although SA and SB products are still common (Figure 5). Differences in the reduction of the various

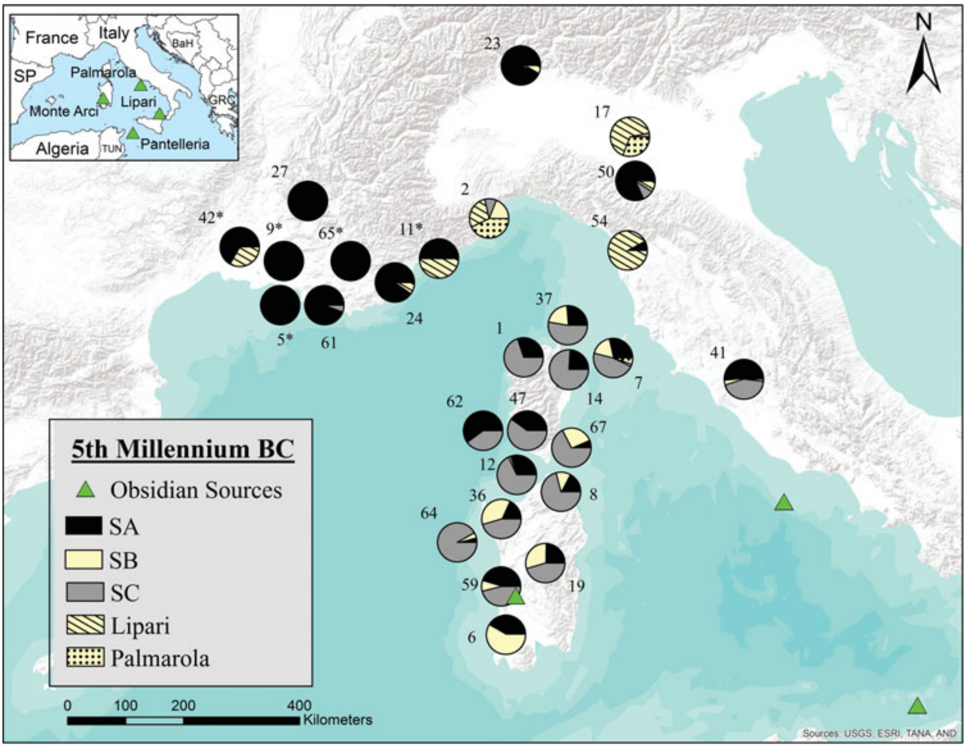

Figure 5. *Fifth millennium BC obsidian frequencies. Pie charts represent the distribution of obsidian at individual sites based on published obsidian sourcing data. Numbers correspond to sites listed in the online supplement. *Sites in which results were combined for network analysis due to low absolute counts.*

Sardinian subsources are also apparent, with SC obsidian being restricted to use on Sardinia and Corsica and SA obsidian being specifically prepared as polyhedral blade cores for export to Corsica and the mainland (Lugliè 2009; Lugliè et al. 2011; Vaquer 2007).

Three of the six sites on mainland Italy included in this analysis are dominated by Lipari and Palmarola obsidian. This includes the coastal site of Arene Candide in Liguria, less than 100 km from Provence. The other three sites both in central Italy and in the northern region of Lombardy are composed of high quantities of SA and to a lesser degree SC obsidian. Large blades of Lipari obsidian were likely acquired as finished products from sites farther south towards Sicily while obsidian from Palmarola and Sardinia was acquired as cores used for the creation of smaller blades and bladelets, often through bipolar percussion (Ammerman and Polglase 1993; Polglase 1990). In southern France, the overwhelming majority (92%) of obsidian is of the SA type. Most of the French material consists of pressure-flaked blades (Costa 2007:57), with related cores found at two of the eight sites, namely Terres Blanches and Terres Longues.

The network map (Figure 6) highlights these distinctions. There are certain sites in northern Italy including Spazzavento, Gaione, and Arene Candide, in which Lipari and Palmarola obsidian comprise the majority of the obsidian assemblage. Spazzavento and Arene Candide are near the coast while Gaione is inland, yet they all share direct links to one another, with Arene Candide sharing

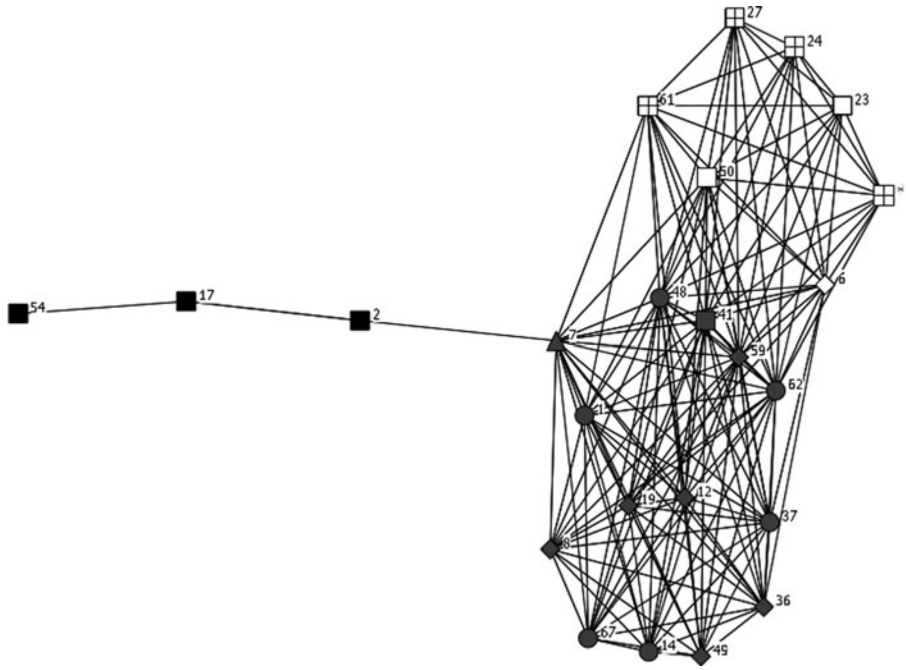

Figure 6. *Network graph constructed using Brainerd-Robinson coefficients for fifth millennium BC obsidian assemblages. Assemblages with less than nine artifacts were omitted. Nodes were connected at a threshold similarityof 67, the minimum value to connect all points into a single network. Nodes are labeled according to their numerical designations (see supplementary material), and a node representing combined sites in France is labeled with an asterisk. Nodes are coded by zone (shape: see legend to Figure 1) and faction (color: best fit achieved with three factions).*

a link with the site of Cala Giovanna on the island of Pianosa.

All of the sites in southern France are well connected to one another and share stronger links with sites in Corsica and Sardinia than with sites in Italy. The northernmost site of Isolino di Varese in Lombardy only shares links with sites in southern France, suggesting a higher probability that the residents of the site interacted with their contemporaries in France than their contemporaries farther south in Italy.

Fourth Millennium BC

In general, the fourth millennium BC is characterized by the continuation of trends that began in the fifth millennium BC. Based on Figure 7, it is clear that SC obsidian becomes the predominant subsource used by residents of both Sardinia and Corsica. This corresponds with the development of SC workshops located at the quarry, which produced core blanks that were circulated amongst populations on Sardinia and Corsica (Luglié 2003; Tykot et al. 2006). Although Lipari obsidian is present at the Corsican site of A Fuata (Le Bourdonnec et al. 2010), obsidians from Lipari and Palmarola are restricted to sites on the mainland. Ninety-four percent of obsidian from southern France is of the SA type.

The network map (Figure 8) distinguishes two distinct groups of similarity. The first is composed of the sites in southern

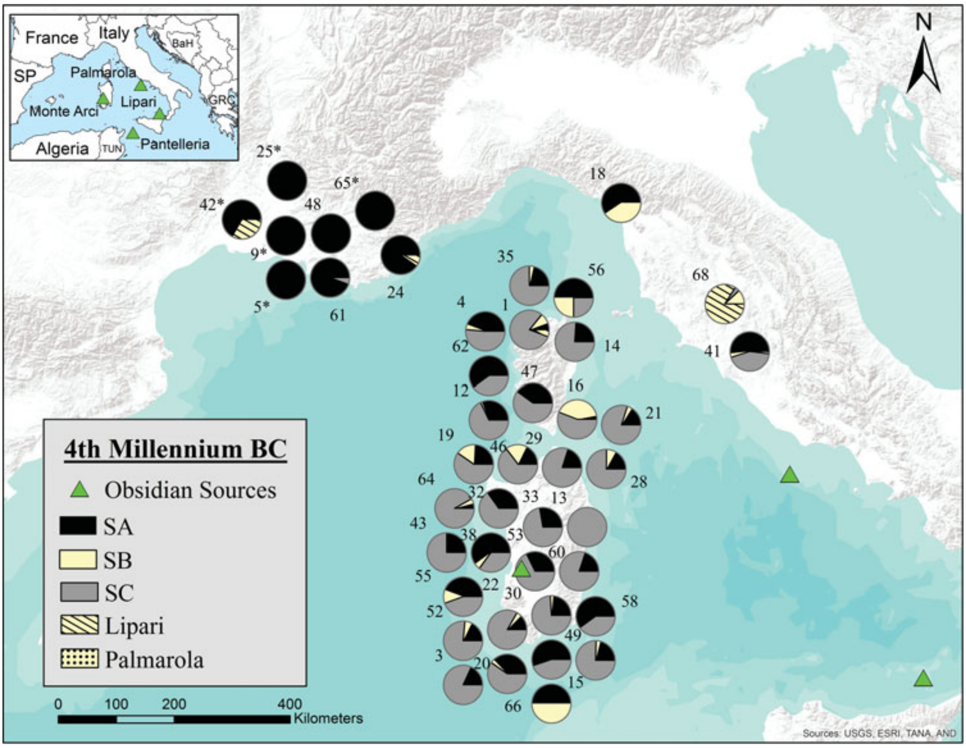

Figure 7. *Fourth millennium BC obsidian frequencies. Pie charts represent the distribution of obsidian at individual sites based on published obsidian sourcing data. Numbers correspond to sites listed in the online supplement. *Sites in which results were combined for network analysis due to low absolute counts.*

France, with Terres Longues having the only links with Sardinia and Corsica. The second group includes the site of Grotta all'Onda in Tuscany, which is isolated from other sites on mainland Italy and shares connections with the Corsican site of Strette and the Sardinian site of Tracasi. Strette also shares a link with the Italian site of Poggio Olivastro in central Italy. In general, obsidian exploitation at sites in Corsica and Sardinia is very similar and lacks many of the regional distinctions that were present in earlier periods.

DISCUSSION

The network analysis clearly demonstrates changing patterns of obsidian consumption through time. What begins in the sixth millennium BC as a relatively homogenous web of similar practices becomes a multi-facetted network of connections in later time periods. When considered within the broader patterns of obsidian circulation and use, these dynamic relationships require a recontextualization of the prehistory of obsidian exploitation in the West Mediterranean.

Distribution Routes

Because of broad similarities in both the composition of obsidian assemblages and in the reduction of the raw materials in the sixth millennium BC, our results do not completely refute previous interpretations emphasizing the role of the Tuscan Archipelago in the transport of obsidian from the geological sources of Monte Arci along the west coast of Sardinia to Corsica and mainland

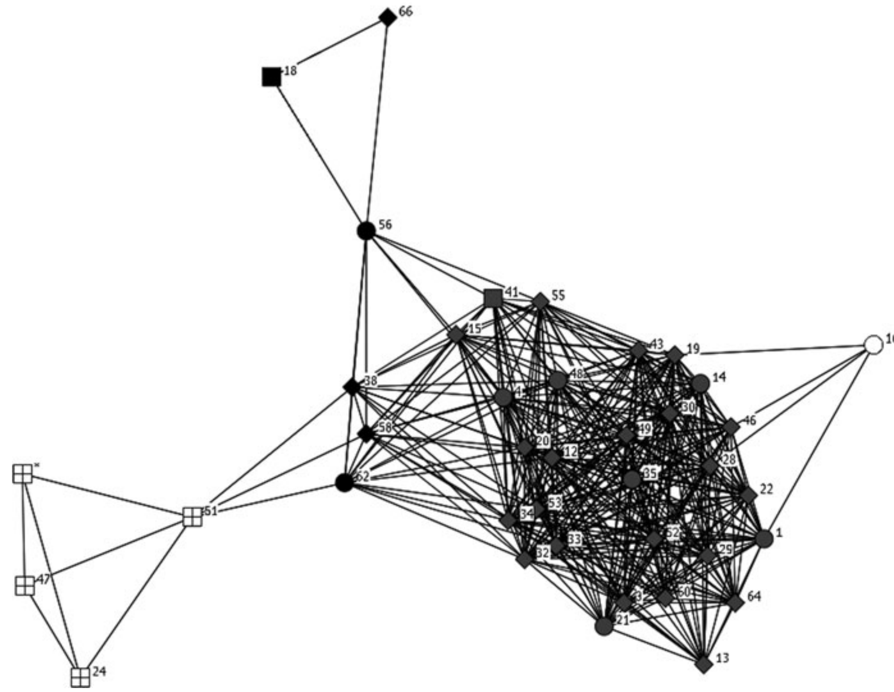

Figure 8. *Network graph constructed using Brainerd-Robinson coefficients for fourth millennium BC obsidian assemblages. Assemblages with less than nine artifacts were omitted. Nodes were connected at a threshold similarityof 131, the minimum value to connect all points into a single network. Nodes are labeled according to their numerical designations (see supplementary material), and a node representing combined sites in France is labeled with an asterisk. Nodes are coded by zone (shape: see legend to Figure 1) and faction (color: best fit achieved with three factions).*

Italy. Although the site of Cala Giovanna on the island of Pianosa shares the only link with Arene Candide in the fifth millennium BC, our results demonstrate that sites on the islands of Elba and Pianosa were not well connected to other sites in Italy. This suggests that boats traveling from Corsica to central Italy did not necessarily stop at intermediary islands to exchange obsidian. This could be due to the fact that residents of these islands traveled directly to Corsica to obtain obsidian. Nevertheless, more data are needed from a larger diversity of sites on these islands before more concrete interpretations can be made.

Despite the presence of a single blade of SA obsidian at the sixth millennium BC site of La Grande Baume in Provence, we see no evidence to suggest that it was obtained directly from Corsica or Sardinia, especially when considering that Lipari obsidian is often found at other contemporaneous sites throughout southern France and Italy. By the second half of the fifth millennium BC, however, obsidian is found at a large number of sites in southern France, mainly of the SA type. While we do not deny that comparatively smaller amounts of Lipari obsidian were obtained from sites in Liguria and elsewhere in northern Italy, we disagree with previous suggestions that obsidian from Sardinia was acquired in a similar manner, especially when considering that SA obsidian is absent from Italian coastal sites such as Arene Candide. Moreover, certain sites in southern France such as Terres Longues contain more obsidian than all of the sites in northern Italy combined.

Instead, the network analysis demonstrates strong similarities in raw material selection between sites in southern France and those in Corsica and Sardinia. These connections are further supported by differences in the reduction of the various Sardinian subsources, with SC obsidian being prepared as core blanks that were circulated amongst populations on Sardinia and Corsica, and SA obsidian being specifically prepared as polyhedral blade cores for export to Corsica and eventually southern France (Léa 2012; Lugliè 2009; Lugliè et al. 2011; Vaquer 2007). Since the production of SA blades is common in Corsica and southern France, but not at sites in Italy, it is far more likely that obsidian was being transported directly from Corsica to mainland France. By the fourth millennium BC these similarities extend to other material culture, including the production of distinctively long pressure-flaked chert blades (Costa and Pélegrin 2004; Léa 2005).

Exchange Mechanisms

Figure 9 shows a map of the total number of obsidian artifacts recovered from the analyzed sites where Sardinian obsidian was recovered (fifth–fourth millennia BC). Although the map is certainly biased in that many sites are not completely excavated, we believe that it still accurately represents the distribution of obsidian across space. It is immediately evident that certain sites contain far more obsidian artifacts than the surrounding areas, most notable Terres Longues on the coast of southern France (site 61)—the only French site in the network analysis to share direct connections with Sardinia and Corsica in the fourth millennium BC (Figure 8). Léa et al. (2010) argue that the large number of artifacts ($n = 4{,}548$) at the site when compared with contemporary sites in the surrounding area suggest that it acted as a center of redistribution of raw materials to people in the surrounding areas. Léa (2012:168) further argues that similarities in the archaeological distribution of Bedoulian flint and obsidian opens the possibility that pressure-flaked obsidian bladelets were created at the site from preformed cores and core-on-flakes and then introduced into preexisting networks of flint exchange. This redistributive model has also been proposed at the sites of La Cabre ($n = 70$) and Giribaldi ($n = 57$) in southern France (Binder and Courtin 1994), although Giribaldi is devoid of Sardinian material. This model may also be pertinent to explain obsidian distribution in mainland Italy considering that sites such as Gaione ($n = 99$) and Pescale ($n = 950$) contain more than 80% of all known obsidian in northern Italy (Polglase 1990; Tykot et al. 2005; Williams Thorpe et al. 1979). Nevertheless, we must be careful to avoid simple explanations in which obsidian is simply taken from the quarry to the site. For example, evidence from southern Italy suggests that much of the primary reduction of obsidian raw materials coming from the island source of Lipari occurred at specialized coastal sites before being transported to larger redistributive centers farther inland (Ammerman 1985; Ammerman and Andrefsky 1982).

As previously mentioned, obsidian is a relatively rare occurrence in southern France and northern and central Italy, infrequently comprising more than 14% of lithic assemblages. Therefore, its accumulation in large quantities at a small number of archaeological sites has important social implications. While the exchange of obsidian across the West Mediterranean is often conceptualized as a means of creating and maintaining social relations (Tykot 2011), we argue that it should additionally be viewed as a means of reifying social distinction and power. The role of redistribution in the establishment and maintenance of such inequalities has been emphasized by a number of scholars (e.g., Earle 1977; Hodder 1982; Shanks and Tilley 1987) and has been applied in the context of obsidian circulation at sites in the American Southwest (Bayman 1995), the Hawaiian Islands (McCoy 2011), and the Aegean (Carter 2008).

While obsidian undoubtedly served a functional and utilitarian purpose in many regions in the West Mediterranean, its function in southern France and perhaps elsewhere

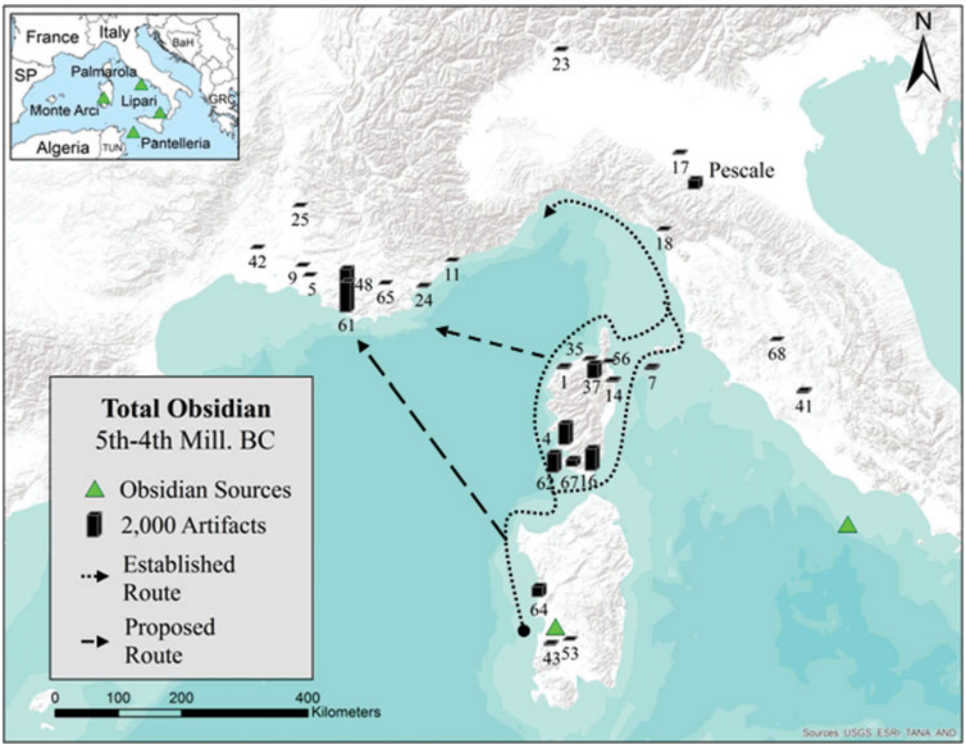

Figure 9. *Map showing the frequencies of the total number of recovered artifacts at individual sites. Bar size corresponds with artifact counts. Note: Counts due not necessarily correspond with the number of analyzed artifacts.*

was more complex. Due to the difficulty in procuring obsidian from distant regions and in producing pressure-flaked blades, we argue that certain groups or individuals used their control over this esoteric knowledge as a means of institutionalizing their own power (see Price and Feinman 1995). In this context, certain sites acted as "gateway communities" (see Carter 2004; Hirth 1978) or "central nodes" (see Mizoguchi 2009; Peregrine 1991), where restricted practices resulted in the subsequent redistribution of obsidian to the surrounding areas.

While evidence for social inequality is lacking from burials at other—often smaller—Chasséen period sites (see Beeching 2003; Duday and Vaquer 2003; Mahieu 1992), this pattern of increasing sociocultural complexity during the Middle Neolithic is mirrored in corresponding archaeological data. Milisauskas and Kruk (2002) highlight technological innovation, demographic growth, improved subsistence, warfare, and novel ideologies and beliefs as key factors in the emergence of complexity during this time. In the future, it will be necessary to explore these issues in more detail.

CONCLUSIONS

Based on a network analysis of obsidian distribution at 79 Neolithic sites dating from the sixth to fourth millennia BC, our results uphold previous interpretations emphasizing the role of "down-the-line" exchange in the distribution of obsidian from the geological sources of Monte Arci to sites in Corsica and mainland Italy in the sixth millennium BC. However, by the fifth millennium BC, we argue that obsidian also reached southern France directly from Corsica. This is supported by the absence of SA obsidian at coastal sites in northern Italy and by similarities in source use and reduction strategies oriented towards the production of SA blades at sites in Corsica and southern France. While scholars have often been cautious in their interpretations about the degree of maritime mobility in the Neolithic, there is strong evidence that Neolithic mariners were capable navigators by as early as the fifth millennium BC, traveling upwards of 200 km across open water.

This study further underscores the role of French sites such as Terres Longues and La Cabre in the redistribution of obsidian to the surrounding areas. We argue that obsidian consumption in these regions was a restricted practice, where certain groups or individuals accumulated obsidian and used their control over esoteric knowledge as a means of institutionalizing their own power.

Our results therefore highlight a dynamic Neolithic landscape in the West Mediterreanean, an arena in which the procurement, reduction, and use of obsidian varied through both time and space. What begins in the sixth millennium BC as a relatively homogenous web of similarities becomes a multifaceted network of connections in later time periods. When contextualized within broader patterns of obsidian circulation and use, these results have important implications for debates surrounding Neolithic obsidian procurement, exchange spheres, and early maritime navigation.

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SUPPLEMENTAL MATERIAL

The following supplemental material is available for this article: Table of Obsidian Sourcing Studies and Corresponding References. Supplemental material can be found at http://www.dx.doi.org/10.1080/15564894.2014.881937

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