Journal of Archaeological Science: Reports 20 (2018) 284–292

Contents lists available at ScienceDirect

Journal of Archaeological Science: Reports

journal homepage: www.elsevier.com/locate/jasrep

Obsidian in the Tavoliere, Southeastern Italy — A regional study

Keri A. Brown[a,*], Robert H. Tykot[b], Italo Muntoni[c]

[a] Manchester Institute of Biotechnology, School of Earth and Environmental Sciences, University of Manchester, Manchester M1 7DN, UK
[b] Department of Anthropology, University of South Florida, Tampa, FL 33620-8100, USA
[c] Soprintendenza Archeologia, Belle Arti e Paesaggio per le Province di Barletta-Andria-Trani e Foggia, 71121 Foggia, Italy

ARTICLE INFO

Keywords:
Italy
Lithic analysis
Neolithic
Obsidian
Portable X-ray fluorescence analysis
Tavoliere

ABSTRACT

We used portable X-ray fluorescence analysis to perform elemental analysis of 111 obsidian artefacts from 32 Neolithic and two Late Neolithic/Bronze Age sites in the Tavoliere, Italy. This is the first detailed regional Neolithic study of obsidian in Italy. By comparing the elemental compositions with those of Mediterranean obsidian sources, we identified the Gabellotto of Lipari as the source for 99 artefacts and Palmarola as source for twelve artefacts. Within the Tavoliere, the Palmarola obsidian had a more westerly distribution, whereas the Lipari obsidian is more generally distributed. This pattern probably reflects the geographical origin of the obsidian and the trade and exchange networks necessary to bring material to the Tavoliere over land from the west. The obsidian pieces have very few or no signs of use-wear, implying that they may have been used only a few times, or even just once. We suggest that such limited use implies a role for obsidian in special rituals involving *rites de passage* such as cutting the umbilical cord of newborns or circumcision of boys.

1. Introduction

1.1. Purpose of the study

Obsidian is a lithic material, a shiny volcanic glass that has long been the focus of research in Neolithic studies in Italy. Artefacts have been assigned to sources using a variety of chemical methods since the 1960s, and the sources of Italian obsidian have been identified as the four islands of Lipari, Palmarola, Pantelleria and Sardinia, with a number of sub-sources within these islands further characterised. However, identifying the source of an obsidian artefact should be the start, not the totality, of research on this material. There are still many questions to do with what obsidian was used for and why it was necessary for Neolithic people to obtain this material from distant places when, for instance, flint could have done most tasks just as well. In this article, we look at the obsidian artefacts from a particular region of Neolithic Italy, the Tavoliere. This region lies at some distance from all the obsidian sources, yet this lithic regularly appears at Neolithic settlement sites. We show that obsidian is widely distributed across the Tavoliere, and we ask what its use could have been, considering that there are nearby sources of high quality tabular flint in the Gargano promontory to the north.

The number of obsidian finds in the Tavoliere has increased greatly in recent years. The five-year Tavoliere-Gargano Prehistory Project (2003–2007), directed by R. Whitehouse and S. Hamilton, Institute of Archaeology, University College London (Hamilton et al., in preparation), aimed to visit and explore as many of these settlement sites as possible. Although this project was mainly concerned with using a phenomenological approach to understanding these sites in their landscape (Hamilton et al., 2006), some field walking and surface collection of artefacts was necessary to confirm the presence of Neolithic occupation and to establish a rough chronology. During this surface collection, a number of pieces of obsidian were noted. A separate Tavoliere Ceramics Project (2013–2015) was undertaken, mainly to record and analyse Neolithic ceramics in the Tavoliere (directed by K. Brown, C. Alexander and R. Tykot) (Alexander et al., 2014, 2016), and again a number of obsidian pieces were collected as well. All 111 obsidian artefacts from these two projects were analysed using a portable X-ray fluorescence (pXRF) spectrometer for their trace element concentrations in order to identify the source of the obsidian. This set of analytical data, reported in this paper, is the largest body of information on obsidian distribution in the Neolithic of the Tavoliere and adds considerably to our knowledge of obsidian networks in southern Italy. We have also compiled the results of previous analyses of obsidian collected from Neolithic sites in order to present a fuller picture of obsidian distribution within the Tavoliere (Table 1). This previous work includes a recent article on Neolithic obsidian provenancing in Puglia (Acquafredda et al., 2017) that also presents results from the Murge region to the south of the Tavoliere, which seems to comprise of solely Lipari obsidian and are omitted from our study. We believe that our paper forms the first detailed regional Neolithic study of obsidian in Italy.

* Corresponding author.
E-mail address: keri.brown@manchester.ac.uk (K.A. Brown).

https://doi.org/10.1016/j.jasrep.2018.04.035
Received 20 February 2018; Received in revised form 25 April 2018; Accepted 30 April 2018

Table 1
Previous obsidian finds in the Tavoliere (not all have been subject to elemental analysis).

Site name	Site number[a]	Class	Lipari obsidian artefacts	Palmarola obsidian artefacts	Reference	Comments[b]
La Panetteria (Lucera, Foggia)	J1	II	1	0	Hallam et al. (1976)	NAA and OES
Il Casone (San Severo, Foggia)	J221	?	0	2	Hallam et al. (1976)	NAA and OES Unstratified
Lucera Castle (Foggia)	J10	?	2	1	Hallam et al. (1976)	NAA and OES Unstratified
Passo di Corvo (Foggia)	J198	IV	10	2 probable	Mello (1983)	Mossbauer and EPR
Monte Aquilone (Manfredonia)	J207	I	3	0	Arias-Radi et al. (1972)	)
Grotta Scaloria (Manfredonia)			1	0	Mello (1983)	Cult cave, EPR and Mossbauer
Masseria Candelaro	J204	II	25	6	Acquafredda and Muntoni (2004)	EDS, SEM and BSD analyses
Masseria Capo di Lupo					Cassano and Manfredini (1983)	3 unprovenanced, unstratified
Masseria Mischitelli					Cassano and Manfredini (1983)	3 unprovenanced, unstratified
Masseria San Chirico					Cassano and Manfredini (1983)	1 unprovenanced, unstratified
Posta D'Innanzi	J193	II			Cassano and Manfredini (1983)	4 unprovenanced unstratified
Masseria Santa Tecchia	J190	I			Cassano and Manfredini (1983)	4 unprovenanced, unstratified 1 unprovenanced, taglio 5
Masseria Belvedere II	J188	I			Cassano and Manfredini (1983)	1 unprovenanced, unstratified
Masseria Centonze (=Stazione di Amendola I)	J184	I			Cassano and Manfredini (1983)	1 unprovenanced, unstratified
Masseria Pedone					Cassano and Manfredini (1983)	1 unprovenanced, unstratified
Masseria Candelaro	J204	II			Cassano and Manfredini (1983)	2 unprovenanced, middle ditch 6 unprovenanced, internal ditch
Monte Aquilone	J207	I			Cassano and Manfredini (1983)	'Abundant obsidian'
Masseria Valente					Cassano and Manfredini (1983)	'Many bladelets'
Lagnano da Piede		I			Mallory (1984–1987)	8 unprovenanced, 7 from plough soil, 1 from ditch fill

[a] The Neolithic sites are identified by a J+ number that indicates a site in the catalogue of Neolithic settlement sites based on WWII RAF aerial photographs listed in Jones (1987).

[b] Abbreviations: EDS, energy-dispersive X-ray spectroscopy; EPR, electron paramagnetic resonance analysis; NAA, neutron activation analysis; OES, optical emissions spectrometry; SEM, scanning electron microscopy.

1.2. Neolithic settlement sites of the Tavoliere

The Tavoliere, a region located in northern Puglia, southeastern Italy, contains the densest concentration of Neolithic settlements yet identified in Europe (Fig. 1). These first were identified from aerial photography carried out by the Royal Air Force during WWII (Jones, 1987). Further research on the Italian Volo Base, taken in the 1950s for mapping purposes, has now raised the total of Neolithic ditched enclosures to at least 566 (Brown, 2001–2003). Whitehouse (2013) has suggested that as many as 800 sites may be present. Thanks to this aerial reconnaissance, we have an extremely detailed knowledge of settlement distribution in the Tavoliere. Unfortunately very few of these sites have been excavated and fewer still radiocarbon dated (Brown and Alexander, 2013; Whitehouse, 2013). What determinations there are suggest Neolithic occupation of the Tavoliere ca. 6100–4000 BCE, but the lack of determinations has made the recognition of phases of Neolithic development and contemporaneity between sites difficult to establish.

The sites consist of ditched enclosures – external enclosure ditches of 2–3 m deep and 2–3 m wide, with smaller C-shaped ditches within of 1 m depth and width. The C-shaped ditches are thought to represent individual social units as hut structures have been found within them. The ditched enclosures have been classified according to the size of the area they enclose (Jones, 1987):

- Class I sites are very small, with single or multiple circular ditches, less than 4 ha in area.
- Class II sites have more complex enclosure ditches, sometimes internal C-ditches, 4–7 ha in area.
- Class III sites are large, with single or multiple enclosure ditches, often filled with C-ditches, 7–14 ha in area.
- Class IV sites are extremely large sites with concentric ditches and/or outer enclosures. They may be filled with C-ditches, or apparently empty of internal features, up to 28 ha in area (size of the inner enclosure at the largest site of all, Passo di Corvo).

The vast majority of sites (95%) belong to Classes I and II while only twelve Class III and sixteen Class IV sites are known (Brown, 2001–2003; Whitehouse, 2013) and most of these are located in the northern half of the Tavoliere. One question that immediately arises is whether these extremely large sites could have controlled the procurement and distribution of obsidian in the Tavoliere.

1.3. Mediterranean obsidian sources

The existence of usable sources of obsidian on the Italian islands of Lipari, Palmarola, Pantelleria, and Sardinia, is long known (Fig. 2). Starting in the 1960s chemical and other analyses have successfully distinguished between these sources. Since then detailed studies have been done on the geological sources on Lipari (Tykot et al., 2006), Palmarola (Tykot et al., 2005b), Pantelleria (Francaviglia, 1988), and Sardinia (Tykot, 1997; Luglie et al., 2006), identifying and successfully discriminating among multiple subsources on each of these islands.

In Italy, analyses in the 1970s and 1980s of small numbers of

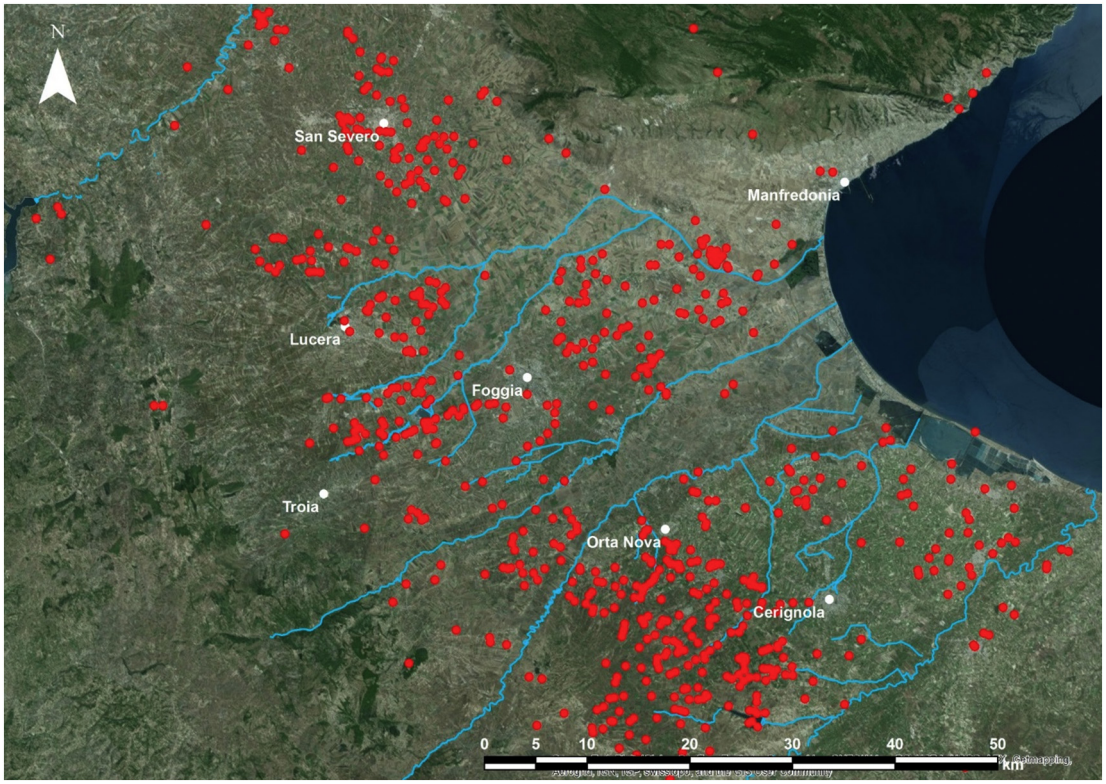

Fig. 1. Map of Tavoliere sites identified by aerial photography.
Site data from Carta dei Beni Culturali della Puglia (CBC).

artefacts from many archaeological sites provided an overall background on the spread of obsidian, but not for specific time periods or regions (Hallam et al., 1976; Williams-Thorpe et al., 1979; Bigazzi and Radi, 1981; Mello, 1983). Starting in the 1980s, chemical sourcing has also been performed on relatively large assemblages of obsidian artefacts (see Tykot, 2017a). These come from archaeological sites in Italy including Acconia (Ammerman, 1985), Grotta dell'Uzzo (Francaviglia and Piperno, 1987), Arene Candide (Ammerman and Polglase, 1997), Casale del Dolce (Petrassi and Zarattini, 1997), Gaione (Tykot et al., 2005a), Catignano (Pessina and Radi, 2006), Pulo di Molfetta (Acquafredda and Muntoni, 2008), and Colle Cera (Barca et al., 2008) (see Fig. 2). Nevertheless, there still are clear limitations in modeling trade and exchange patterns for particular regions and time periods, as has been accomplished much more for Sardinia, Corsica, and elsewhere (e.g. Tykot, 2004a). This is particularly the case for central and southern Italy (see Table 1), and this study in the Tavoliere adds important information about Neolithic networks for this area.

2. Materials and methods

A total of 111 obsidian artefacts from 34 Tavoliere sites were analysed in this study. These included 61 artefacts from 23 sites visited by the Tavoliere-Gargano Prehistory Project (2003–2007) (these being the sites, out of 174 visited in total, that produced obsidian), and a further 50 artefacts from 14 sites (of which three were also sampled in 2003–2007) from which obsidian was collected during the more recent Tavoliere Ceramics Project (2013–2015). All of the sites were Neolithic, except for two Late Neolithic/Bronze Age settlement sites in the Valle dell'Inferno, Gargano, visited in 2003–2007, which yielded five obsidian fragments that are included in this study. For site locations and details of obsidian samples, see Results Fig. 6 and Table 2. Obsidian from the 2003–2007 project is retained at the Institute of Archaeology, UCL, while obsidian collected in 2013–2015 is retained by the Soprintendenza Archaeogia della Puglia at Foggia Museum.

Since the 1960s, many different methods of elemental analysis have been used successfully for obsidian sourcing in the Mediterranean. Instrumental neutron activation analysis, inductively coupled plasma (ICP) mass spectrometry, and several types of X-ray analysis continue to be used, including scanning electron microscopy, which is limited to major/minor elements (Tykot, 2004b). The homogeneity of obsidian and the relatively modest number of sources in continental Europe and the Mediterranean islands have allowed these methods to distinguish between sources, while measuring trace elements distinguishes subsources for each (Tykot, 1997, 2002; Bellot-Gurlet et al., 2005; Le Bourdonnec et al., 2005; Barca et al., 2007; De Francesco et al., 2008; Poupeau et al., 2009).

Starting in 2007, pXRF analysis has been used on central Mediterranean obsidian, taking advantage of its ability to perform rapid non-destructive analyses on thousands of artefacts in museums and excavation storage facilities when taking samples out of the country and/or performing destructive analysis is not permitted (Tykot, 2017b). This type of instrument has become widely used in recent years, with successful studies done in several parts of the world (Cecil et al., 2007; Craig et al., 2007; Nazaroff et al., 2010; Phillips and Speakman, 2009). In this study, the obsidian artefacts were analyzed using a Bruker Tracer pXRF spectrometer. Obsidian is quite homogeneous, so other than having a clean surface, no sample preparation was necessary and the analysis was entirely non-destructive. Within the instrument a special filter of 12 mil Al, 1 mil Ti and 6 mil Cu was used to enhance the precision of measurements for the trace elements Rb, Sr, Y, Zr, and Nb, which are widely used to identify source groups for obsidian and other materials. The area analyzed for each sample was about 3 × 5 mm in diameter, with settings of 120–180 s 40 kV and 10 μA current. The exact same instrument and calibration software has been used on geological samples from all of the obsidian sources in the central Mediterranean, Aegean, and central Europe, clearly distinguishing them, and assigning many obsidian artefacts to specific subsources (Tykot, 2010, 2017b; Tykot et al., 2011, 2013; Freund and Tykot, 2011) (Figs. 3 and 4). Test

Fig. 2. Map showing obsidian sources in the central Mediterranean and archaeological sites in peninsular Italy and Croatia with ten or more analysed obsidian artifacts. Sites in red analyzed in this study. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

studies also have been done on standards and shared pieces of obsidian to allow comparison of these results with those from other analytical methods, and these data have been incorporated into calibration software. Repeated analyses show precision of 2% or less relative standard deviation (RSD), and accuracy within one sigma relative to the RGM-1 and NIST SRM-278 international obsidian standards (Speakman, 2012).

3. Results

A total of 61 obsidian artefacts collected from the Tavoliere-Gargano Prehistory Project (2003–2007) were tested, with 55 assigned to Lipari, and six to Palmarola. From the Tavoliere Ceramics Project (2013–2015) a further 50 obsidian artefacts were collected and analysed, with 44 coming from Lipari and six from Palmarola (Table 2 and Supplementary Table 1). An additional six artefacts collected during 2003–2007 turned out not to be obsidian, but 4 consisted of dark colored flint, as shown by high silicon readings and low trace element values. All of the Lipari artefacts came specifically from Gabellotto, which was the major subsource utilized (Fig. 5). Lipari obsidian was found at all but two of the 34 sites surveyed, while Palmarola obsidian was found at only nine of the 34 sites, seven of these sites also yielding Lipari obsidian (Fig. 6).

It is understandable that those inexperienced with lithic materials would collect the dark coloured fint in error for obsidian. It is interesting that this obsidian look-alike occurs at Neolithic sites in the northern half of the Tavoliere plain (J40, J193, J193, J224). One possible source for this flint might be river pebble flint, but these pieces seem to be of good quality flint. Tabular flint was mined in the Gargano in the Neolithic and is usually greyish-brown or yellowish-brown in colour. However, black tabular flint occurs near Pugnochiuso on the

Table 2
Sources of obsidian artefacts as determined by pXRF analysis.

Site name	Site number[a]	Class	Survey years[b]	Lipari obsidian artefacts	Palmarola obsidian artefacts	Total obsidian artefacts	Comment
Lo Squarto/Alma Dannata I	M15	I?	2013–15	2		2	
Fornovecchio	M13	I	2003–07	2	1	3	
Inferno East	Inferno		2003–07	1		1	Late Neolithic/Early Bronze Age site
Inferno West	Inferno		2003–07	4		4	Late Neolithic/Early Bronze Age site
Cava Petrilli	J4	I	2003–07	4	1	5	
Masseria Schifata	J19	IV	2013–15	1	1	2	
Masseria Palmori	J20	IV	2003–07	2		2	
Masseria Palmori	J20	IV	2013–15	4		4	
Masseria Fragella	J39	II	2013–15	6		6	
Masseria San Marcello	J40	I	2003–07	2	1	3	
Santa Caterina-Tortorella	J42	III	2003–07	2		2	
Santa Cecilia I	J49	I	2003–07	2		2	
Santa Cecilia II	J49	I	2013–15	9	3	12	
Masseria S. Cecilia	J50	IV	2013–15		1	1	
Posta Torrebianca	J56	I	2003–07	1		1	
Masseria Bongo	J71	III	2003–07		1	1	Obsidian core
Masseria Bongo	J71	III	2013–15	1	1	2	
Masseria La Quercia	J72	II	2003–07	6		6	
Masseria La Lamia	J73	?	2003–07	13		13	
Masseria la Vedova II	J114	I	2013–15	2		2	
Posta Barone Grella	J155		2013–15	1		1	
Tressanti	J160	I	2003–07	1		1	
La Marana di Salpi	J161	I	2013–15	1		1	
Castiglione III	J172	III	2003–07	2		2	
Castiglione III	J172	III	2013–15	1		1	
Stazione di Amendola I	J184	I	2003–07	1		1	
Masseria Santa Tecchia	J190	I	2003–07	1		1	
Posta D'Inanzi	J193	II	2003–07	2		2	
Passo di Corvo	J198	IV	2013–15	12		12	
Monte Aquilone	J207	I	2003–07	5		5	
Posta Fontanarosa	J211	I	2013–15	1		1	
Motta del Lupo	J216	III–IV	2003–07	2		2	
Masseria San Giusta	J218	I	2003–07		1	1	
Masseria Scoppa	J224	I	2003–07	1		1	
Madonna del Oliveto	J235	III–IV	2003–07	1	1	2	
Volturino	VI		2013–15	3		3	
Total				99	12	111	

[a] The Neolithic sites are identified by a J+ number that indicates a site in the catalogue of Neolithic settlement sites based on WWII RAF aerial photographs listed in Jones (1987). M13 is a site discovered on the RAF coverage by K. Brown.

[b] Survey years refer to the Tavoliere-Gargano Prehistory Project (2003–2007) and the Tavoliere Ceramics Project (2013–2015).

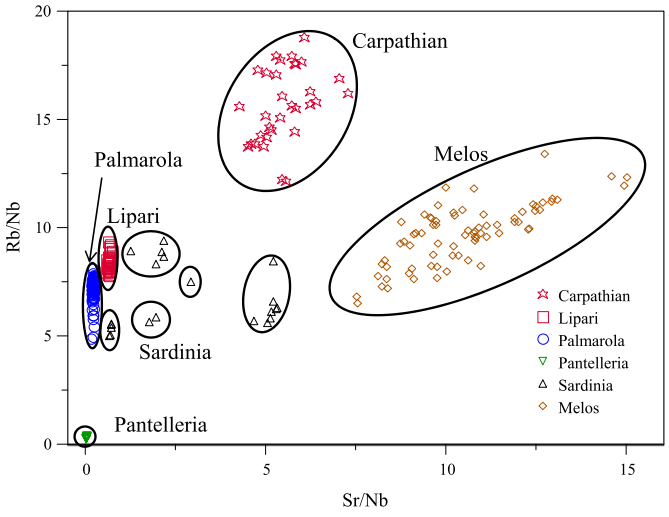

Fig. 3. Graph showing distinction between Mediterranean obsidian sources.

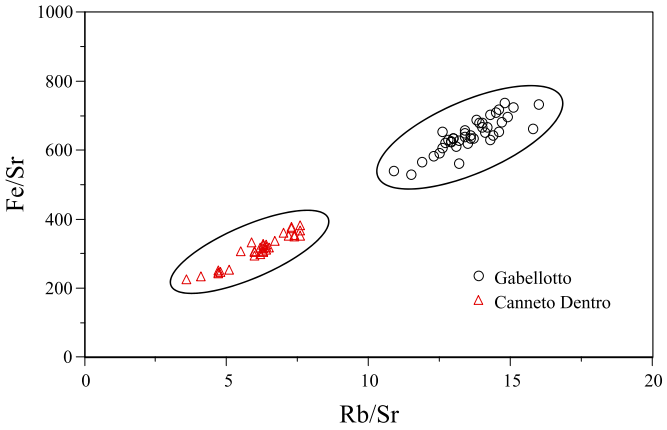

Fig. 4. Graph showing distinction between Lipari subsources.

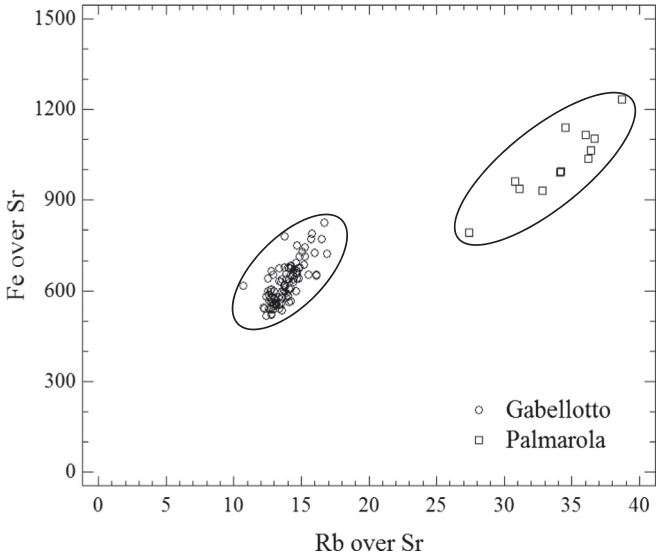

Fig. 5. Graph showing assignment of Tavoliere obsidian artifacts to Lipari-Gabellotto or Palmarola.

eastern coastline of the Gargano and this hypothesis can be tested on a future visit to the Tavoliere by pXRF analysis of this flint source.

Two other pieces of non-obsidian were collected from sites J168 and J72 – these have low silicon readings and may not in fact be flint at all. This material has not yet been identified.

4. Discussion

4.1. Frequency of obsidian at Neolithic sites in the Tavoliere

Early work on obsidian seemed to show that this lithic material occurred rarely at Tavoliere Neolithic sites, with only one or a few pieces having been found. However, these were mainly surface, unstratified finds. When sites have been subject to large-scale excavation, such as Passo di Corvo (Tinè, 1983) and Masseria Candelaro (Cassano and Manfredini, 2004), obsidian finds have been more plentiful. At Masseria Candelaro, a total of 92 obsidian pieces were recovered, some from the surface but mostly from the excavation of ditches and subsurface features. The difference between excavation and surface collection must therefore be borne in mind when considering obsidian frequency at Neolithic sites. It is likely that the frequency of obsidian at Tavoliere sites was much greater in the later Neolithic when compared with the earlier Neolithic. It is known that Lipari itself sees a huge increase in obsidian extraction and processing in the Late Neolithic. But by this period settlement numbers seem to be greatly reduced in the Tavoliere. We have a poor radiocarbon record for the Tavoliere so it is impossible to see this increase ourselves, but it holds for the rest of Italy. The large Class III and Class IV sites are probably Middle Neolithic in date, from the few dates available (Whitehouse, 2013). In addition, it is probable that all Neolithic sites had access to obsidian, while possibly the larger Class III and IV sites had greater access than the smaller Class II and II sites, reflecting a settlement hierarchy based on size. Further fieldwork research needs to be done to explore this hypothesis. Alternatively, the amount of obsidian may reflect settlement population numbers in some way if obsidian artefacts can be considered as personal possessions kept on the person but discarded after death. This latter suggestion could explain the presence of a single Sardinian obsidian artefact at Pulo di Molfetta (Acquafredda and Muntoni, 2008), and the two pieces of unprovenanced obsidian found at the flint mine of Defensola (Galiberti et al., 2001). As Robb (2007: 204) puts it, “we have to imagine a constant sparingly-used, low-level trickle of obsidian sleeting horizontally through Neolithic societies, rather than curated heirlooms descending through time.” The vast majority of obsidian found at Tavoliere sites consists of small bladelets and flakes, which is clearly different from the larger and wider blades found at sites in Sicily, which is much closer to Lipari and its geological obsidian (Freund et al., 2015). The only obsidian cores found on the Tavoliere both come

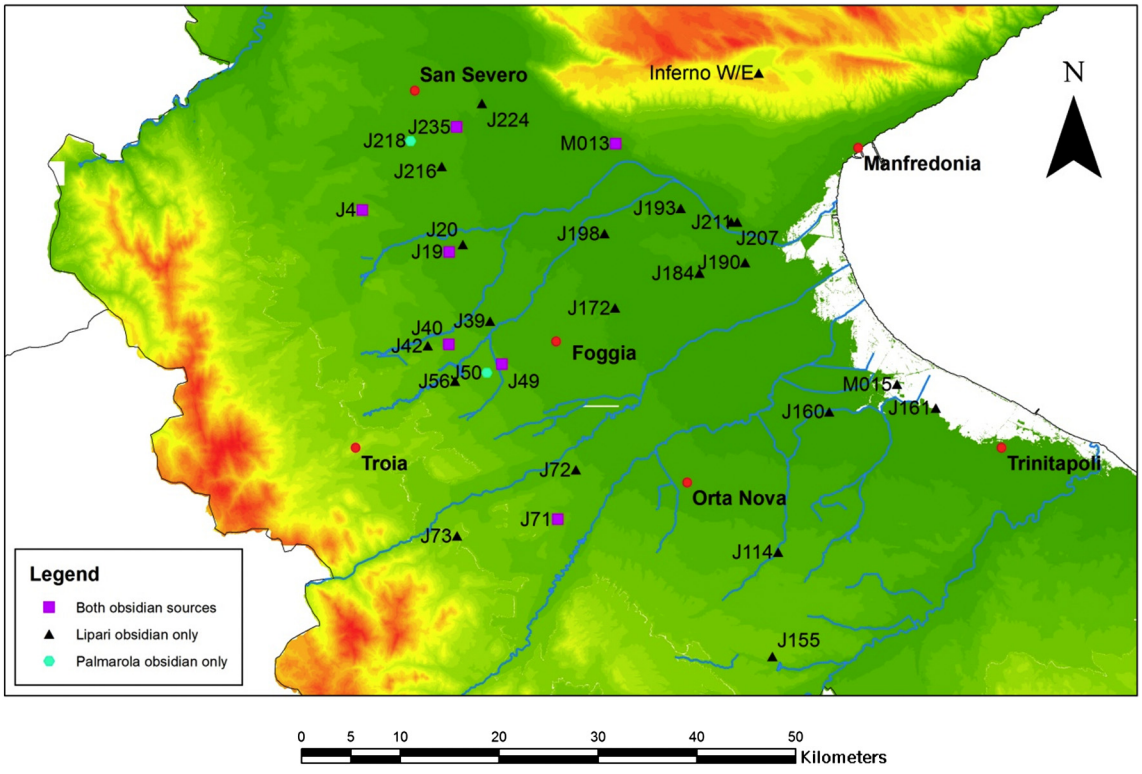

Fig. 6. Map showing the sites in the Tavoliere from which obsidian was obtained, with sources indicated.

Fig. 7. Core of Palmarola obsidian found at Masseria Bongo (J71).

from major Class III sites. A core of Lipari obsidian was found as a surface piece at Masseria Candelaro (Acquafredda and Muntoni, 2004), while a core of Palmarola obsidian was similarly a surface find at Masseria Bongo during the Tavoliere-Gargano Prehistory Project (2003–2007) (Fig. 7). The latter core seems to have had only a few bladelets struck from it before being abandoned. This may be due to a fault in the core running down its length, which may have only become apparent after the removal of the outer bladelets. Obsidian cores are thus extremely rare finds in the Puglian Neolithic in general because they can be worked until no more bladelets can be struck, then smashed to produce flakes (see Robb, 2007: 192ff). Obsidian surface finds depend on the recent ploughing of the site – for example, Masseria La Quercia (J72) had been visited several times during the Tavoliere-Gargano Project, but it was only on the final visit that seven obsidian pieces were found.

Mention must be made of the obsidian finds from Grotta Scaloria, a cult cave site where the upper cave shows some use as an infrequent habitation and where a group of disarticulated human remains, representing between 21–33 individuals, and maybe more, was buried dating to 5500–5200 BCE (Robb et al., 2015). Very fine cut marks were present on over 5% of the bone assemblage, indicating that a defleshing method was used to clean these bones. It has been suggested that obsidian and flint tools would have been used for this task. Very few obsidian artefacts were recovered – one from Trench 10 containing the human burial group, while a further eight came from other trenches in the cave (Elster et al., 2016). A residual core and a blade were found outside the cave. None of these obsidian pieces has been sourced. There are thought to be no deliberate associations between the obsidian and the burials – no intentional placement was discerned so it seems that obsidian was not considered to be an item for accompanying human burials. Obsidian has not been found with other human burials or partial skeletal remains that have been found occasionally in the outer enclosure ditches and internal C-ditches of some settlement sites.

4.2. Distribution of obsidian from Lipari and Palmarola

For the Tavoliere as a whole, roughly one-tenth (11%) of the obsidian recovered by survey (2003–2015) is from Palmarola. The vast majority is from the Lipari-Gabellotto subsource. However, of the 92 obsidian artefacts found at just one excavated site, Masseria Candelaro, 6 out of 31 (19%) tested were from the Palmarola source (Acquafredda and Muntoni, 2004). Overall, past work on provenancing (see Table 1) has shown that out of 81 obsidian artefacts tested, 69 were from Lipari (85%; subsource not given) and twelve from Palmarola (15%). As the numbers of obsidian finds have increased, a reflection of the increase in fieldwork in recent years, the total percentage of Palmarola obsidian artifacts now stands at 13% of all 192 provenanced obsidian artefacts in the Tavoliere. Only one piece of Palmarola obsidian has yet been found south of the Ofanto River, the southern geographical boundary of the Tavoliere region, at the site of Balsignano in Bari (Acquafredda et al., 2017). As more work is done on the Neolithic sites of the Tavoliere, this percentage of Palmarola obsidian may change, but we would confidently expect that it would remain a modest constituent of obsidian assemblages in the Tavoliere.

Is there any pattern to the distribution of obsidian from these two sources? Palmarola obsidian has a more westerly distribution, whereas the Lipari obsidian is more generally distributed over the Tavoliere. Palmarola obsidian also does not seem to occur in the southeastern area of the Tavoliere, i.e. south of the River Carapelle. This is the area with the dense concentration of the smaller ditched enclosures, with the exception of site J155. The Palmarola distribution probably reflects the geographical origin of the obsidian and the trade and exchange networks necessary to bring this source to the Tavoliere over land from the west. This in fact may be the first time we can see the likely route for an imported lithic in the Tavoliere; a few pieces from Palmarola even continue further east, reaching one of the Adriatic islands and a site on the Croatian mainland (Tykot, 2014). Lipari obsidian may have reached the Tavoliere both over land from the toe of Italy's boot, and by maritime coastal travel up the Adriatic.

4.3. What is so special about obsidian in the Neolithic?

Obsidian has been called the black gold of the Neolithic. Its appearance, shiny and black, and its distant sources have combined to make us attach a special value to it and somehow we have assumed that this valuation also existed in Neolithic societies. Finding very small numbers of pieces of obsidian at great distances from their source may be interpreted as the end of the line in long-distance exchange during the Neolithic, and in some cases as exotica (Tykot, 2011). Indeed the isolated island locations of obsidian sources necessitates sea travel to collect this material and adds to its fascination for Neolithic scholars and scientists alike. Whether the location determines the desirability of a lithic source is a possibility that has been considered by scholars working on other lithic materials, such as stone axe ‘factories’ in Britain. There are arguments for and against. Lipari was the greatest provider of obsidian for the whole of Italy so it is not surprising that it is found in greater amounts than obsidian from Palmarola, which has more restricted distribution over central Italy and the Dalmatian coast. The Southern Italian ‘greenstone’ axes studied by O’Hare (1990) have a smaller range of movement and would seem to be involved in much more local exchanges than obsidian - for example no sea travel would have been involved.

It has been suggested that obsidian tools were superior to flint ones because of a sharper cutting edge (Tykot, 2011; Robb, 2007). However, the cutting edge of obsidian can quickly break with use, and the generally small size of the artefacts (confined to very small flakes and bladelets) limits their range of uses. Tykot (2011) has suggested that if

obsidian represents a very low percentage of the total lithic assemblage of a site then it is unlikely to have been an important component of daily life. This is a functionalist view of obsidian, which has dominated obsidian studies until recently and has been critiqued by Robb (2007: 197ff.). The possible uses of obsidian must be considered if we are to understand why this material was transported over such long distances (Passo di Corvo, the largest site, is 250 km from Palmarola and 340 km from Lipari in a straight line). These uses may include ritual ones that may not be part of daily life but which were still of great importance to the Neolithic users of this material. One potential example of this is the Defensola A flint mine where two obsidian bladelets were found (Galiberti et al., 2001); the occurrence of obsidian in a flint mine clearly needs a special explanation, such as ritual use (Whitehouse, 2005) or as a personal possession which was lost in the mine.

The obsidian pieces recovered from Neolithic sites seem to have very few or no signs of use-wear, implying that they may have been used only a few times, or even just once. Such limited use would fit in with a role for obsidian in special rituals involving *rites de passage* such as cutting the umbilical cord of newborns or circumcision of boys. There is a certain amount of ethnographic evidence for these uses from diverse societies around the word. In the Pacific islands, small obsidian flakes were used for a variety of cutting surgical applications. Tattooing, bloodletting, trepanation, and circumcision have been recorded in historic times (Elkin, 1935; Krieger, 1932; Nilles, 1943; Specht, 1981; Watson, 1986). The evidence from Mesoamerica is documented by the Spanish chroniclers, although some caution is needed in deciphering the terminology used, for example in the *Relation de Michoacan* (1539–1541). This document describes obsidian as a sacred material, yet archaeologically it is found abundantly and readily available. It does not seem to follow that a sacred material should be a scarce material (Darras, 1998). Again, obsidian was used for cutting purposes, bloodletting, haircutting and animal and human sacrifice, and it is interesting that there seems to be an association between obsidian and healing/therapeutic properties and water (Darras, 1998). Another study of other Mesoamerican Spanish sources also cites the therapeutic or healing aspects of obsidian (Álvarez Palma and Gianfranco Cassiano, 2009). Again, obsidian was available to all. Its uses in Mesoamerican societies include haircutting, surgery, bloodletting, circumcision and umbilical cutting. With this latter operation, it was recommended to use a new, sharp razor, which was later thrown into water sources. There were also applications of ground or powdered obsidian in poultices, abrasive mixtures and infusions, which of course would leave no archaeological traces.

In the Tavoliere, there seems to have been no hierarchy involved in the distribution of obsidian: Class I and II sites seem to have the same access to obsidian as Class III and IV sites, and it is found in both the northern and southern halves of the Tavoliere plain. It may be possible that the largest sites did somehow control the distribution of obsidian to smaller sites as the only two cores found on the Tavoliere both come from larger sites – Masseria Bongo (J71, Class III) and Masseria Candelaro (J204, Class II/III). Alternatively, the presence of obsidian cores at these sites may not be significant – only more finds will confirm if any pattern is present. The presence of rough or prepared cores would indicate that bladelets and flakes were struck as and when required, especially as the Grotta Scaloria core was reduced and the Palmarola core seems to have been only struck a few times before being discarded, and indeed obsidian may have been transported to the Tavoliere as cores. The general availability of obsidian at Neolithic sites in the Tavoliere suggests that access to this lithic was a significant feature of Neolithic life, and down-the-line trade and exchange of obsidian may be inadequate as an explanation of the acquisition of obsidian by Neolithic people in the Tavoliere. The steady need for obsidian for recurring ritual uses may in fact have resulted in a more organized trade in this lithic to ensure supplies.

5. Conclusion

In this paper, the major conclusion is that it appears that in the Tavoliere everybody had access to obsidian if they required it. It may have been exotica but was certainly not treated as such, e.g. not curated, not placed with human burials, not placed in other ritual contexts. Obsidian is found in excavations of ditches, and scattered on the surface of ploughed sites, seemingly discarded after its short use-life. This may be an aspect of its use in rituals, possibly becoming polluted after use and needing to be discarded in liminal places such as enclosure ditches and C-ditches, perhaps as the Mesoamericans disposed of obsidian used for umbilical cutting in water. We may be unable to identify the precise uses of obsidian in the Tavoliere but we can begin to recognise that obsidian was special, but maybe not *that* special, to the Neolithic users in the Tavoliere. Our modern perceptions of obsidian have coloured our interpretations of this lithic and its role in Neolithic society, at least in this region of Italy.

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jasrep.2018.04.035.

Acknowledgements

We appreciate the cooperation and permissions from the Soprintendenza Archeologia della Puglia for conducting the surveys and collecting the obsidian artifacts studied here. Funding for the 2003–07 and 2013–15 surveys were obtained from the British Academy, the Institute of Archaeology (University College London), the McDonald Institute for Archaeological Research (Cambridge University), and the University of South Florida. We also wish to thank Craig Alexander for creating the maps in Figs. 1 and 6, and Ruth Whitehouse for reading and commenting on the text. Special thanks to Terry Brown for help in preparing our manuscript for publication. Any errors remain our own.

References

Acquafredda, P., Muntoni, I., 2004. Provenienza delle ossidiane mediante analisi chimiche non distruttive. In: Cassano, S.M., Manfredini, A. (Eds.), Masseria Candelaro: Vita Quotidiana e Mondo Ideologico in una Comunità Neolitica del Tavoliere. Claudio Grenzo Editore, Foggia, Italy, pp. 358–364.

Acquafredda, P., Muntoni, I.M., 2008. Obsidian from Pulo di Molfetta (Bari, Southern Italy): provenance from Lipari and first recognition of a neolithic sample from Monte Arci (Sardinia). J. Archaeol. Sci. 35, 947–955.

Acquafredda, P., Muntoni, I.M., Pallara, M., 2017. La provenienza dell'ossidiana nel Neolitico della Puglia. In: Radina, F. (Ed.), Preistoria e Protostoria della Puglia. Studi di Preistoria e Protostoria – 4 Istituto Italiano di Preistoria e Protostoria, Firenze, pp. 808–814.

Alexander, C., Brown, K.A., Muntoni, I.M., Tykot, R., 2014. Archaeometry of Neolithic Tavoliere ceramics: preliminary results of a new project. In: d'Italia, Archeoclub (Ed.), 34th Atti del Convegno Nazionale sulla Preistoria-Protostoria-Storia della Daunia (San Severo 16–17 Novembre 2013). Sede di San Severo Archeoclub San Severo, San Severo, pp. 131–140.

Alexander, C., Brown, K.A., Di Miceli, A., Mattioli, T., Freund, K.P., Hofer, M., Muntoni, I.M., Tykot, R., 2016. The archaeometry of Neolithic Tavoliere ceramics: a project update. In: d'Italia, Archeoclub (Ed.), 36th Atti del Convegno Nazionale sulla Preistoria-Protostoria-Storia della Daunia (San Severo 15–16 Novembre 2015). Sede di San Severo Archeoclub San Severo, San Severo, pp. 33–44.

Álvarez Palma, A.M., Gianfranco Cassiano, V., 2009. Terapéutica a través de la obsidiana. Dimensión Antropológica 45, 99–129.

Ammerman, A.J., 1985. The Acconia Survey: Neolithic Settlement and the Obsidian Trade. Institute of Archaeology, University of London, London.

Ammerman, A.J., Polglase, C.R., 1997. Analyses and descriptions of the obsidian collections from Arene Candide. In: Maggi, R. (Ed.), Arene Candide: A Functional and Environmental Assessment of the Holocene Sequence (Excavations Bernabo Brea-Cardini 1940–50). Il Calamo. Memorie dell'Istituto Italiano di Paleontologia Umana, Roma, pp. 573–592.

Arias-Radi, G., Bigazzi, G., Bonadonna, F.P., 1972. Le tracce di fissione. Un metodo per lo studio delle vie di commercio dell'ossidiana. Origini 6, 155–169.

Barca, D., De Francesco, A.M., Crisci, G.M., 2007. Application of laser ablation ICP-MS for characterization of obsidian fragments from Peri-Tyrrhenian area. J. Cult. Herit. 8, 141–150.

Barca, D., De Francesco, A., Crisci, G.M., Tozzi, C., 2008. Provenance of obsidian artifacts from site of Colle Cera, Italy, by LA-ICP-MS method. Periodico di Mineralogia 77, 41–52.

Bellot-Gurlet, L., Poupeau, G., Salomon, J., Calligaro, T., Moignard, B., Dran, J.-C., Barrat,

J.-A., Pichon, L., 2005. Obsidian provenance studies in archaeology: a comparison between PIXE, ICP-AES and ICP-MS. Nucl. Instrum. Methods Phys. Res. 240, 583–588.
Bigazzi, G., Radi, G., 1981. Datazione con le tracce di fissione per l'identificazione della provenienza dei manufatti di ossidiana. Rivista di Scienze Preistoriche 36, 223–250.
Brown, K.A., 2001–2003. Aerial archaeology of the Tavoliere: the Italian Air Photographic Record and the Riley Archive. Accordia Res. Paper. 9, 123–146.
Brown, K.A., Alexander, C., 2013. Once is not enough: were there two Neolithic colonisations of Southern Italy? A Bayesian analysis of the radiocarbon evidence. In: Pearce, M., Whitehouse, R. (Eds.), Rethinking the Italian Neolithic: Proceedings of a Conference Held at the Institute of Archaeology, UCL, London. Accordia, London, pp. 31–56.
Cassano, S.M., Manfredini, A., 1983. Studi sul Neolitico del Tavoliere della Puglia: Indagine Territoriale in un'Area-Campione. BAR International Series, Oxford, pp. 160.
Cassano, S.M., Manfredini, A. (Eds.), 2004. Masseria Candelaro: Vita Quotidiana e Mondo Ideologico in una Comunità Neolitica del Tavoliere. Claudio Grenzo Editore, Foggia, Italy.
Cecil, L.G., Moriarty, M.D., Speakman, R.J., Glascock, M.D., 2007. Feasibility of field-portable XRF to identify obsidian sources in Central Petén, Guatemala. In: Glascock, M.D., Speakman, R.J., Popelka-Filcoff, R.S. (Eds.), Archaeological Chemistry: Analytical Methods and Archaeological Interpretation. ACS Publication Series 968 American Chemical Society, Washington, DC, pp. 506–521.
Craig, N., Speakman, R.J., Popelka-Filcoff, R.S., Glascock, M.D., Robertson, J.D., Shackley, M.S., Aldenderfer, M.S., 2007. Comparison of XRF and pXRF for analysis of archaeological obsidian from southern Peru. J. Archaeol. Sci. 34, 2012–2024.
Darras, V., 1998. La obsidiana en la relación de Michoacán y en su realidad arqueológica: del símbolo al uso o del uso de un símbolo. In: Darras, V. (Ed.), Génesis, Culturas y Espacios en Michoacán. Centro de Estudios Mexicanos y Centroamericanos, Mexico, pp. 61–88.
De Francesco, A.M., Crisci, G.M., Bocci, M., 2008. Non-destructive analytic method using XRF for determination of provenance of archaeological obsidians from the Mediterranean area: a comparison with traditional XRF methods. Archaeometry 50, 337–350.
Elkin, A.P., 1935. Primitive medicine men. Med. J. Aust. 30 (November), 3–10.
Elster, E.S., Isetti, E., Robb, J., Traverso, A. (Eds.), 2016. Archaeology of Grotta Scaloria: Ritual in Neolithic Southeast Italy. Monumenta Archaeologica 38. The Cotsen Institute of Archaeology Press, Los Angeles.
Francaviglia, V., 1988. Ancient obsidian sources on Pantelleria (Italy). J. Archaeol. Sci. 15, 109–122.
Francaviglia, V., Piperno, M., 1987. La repartition et la provenance de l'obsidiene archaeologique de la Grotta dell'Uzzo et de Monte Cofano (Sicile). Revue d'Archèomètrie 11, 31–39.
Freund, K.P., Tykot, R.H., 2011. Lithic technology and obsidian exchange networks in Bronze Age Nuragic Sardinia (Italy). Archaeol. Anthropol. Sci. 3, 151–164.
Freund, K.P., Tykot, R.H., Vianello, A., 2015. Blade production and the consumption of obsidian in Stentinello Period Neolithic Sicily. C.R. Palevol 14, 207–217.
Galiberti, A., Sivilli, S., Tarantini, M., 2001. La miniera neolitica della Defensola (Viestе-Foggia): lo stato delle ricerche. Origini 23, 85–110.
Hallam, B.R., Warren, S.E., Renfrew, C., 1976. Obsidian in the Western Mediterranean: characterisation by neutron activation analysis and optical emission spectroscopy. Proc. Prehist. Soc 42, 85–110.
Hamilton, S., Whitehouse, R., Brown, K., Combes, P., Herring, E., Seager Thomas, M., 2006. Phenomenology in practice: towards a methodology for a 'subjective' approach. Eur. J. Archaeol. 9, 31–71.
Hamilton, S., Seager Thomas, M., Whitehouse, R., 2018. Sensory and Social Landscapes of the Prehistory of Northern Puglia, South Italy. Accordia Research Institute, London In preparation.
Jones, G.D.B., 1987. Apulia. Vol. I: Neolithic Settlement in the Tavoliere. Thames and Hudson, London.
Krieger, H.W., 1932. Design areas in Oceania. Proc. Nat. Muse. Smithsonian Inst. 79, 1–53.
Le Bourdonnec, F.-X., Delerue, S., Dubernet, S., Moretto, Ph., Calligaro, Th., Dran, J.-C., Poupeau, G., 2005. PIXE characterization of Western Mediterranean and Anatolian obsidians and Neolithic provenance studies. Nucl. Instrum. Methods Phys. Res. 240, 595–599.
Luglie, C., Le Bourdonnec, F.-X., Poupeau, G., Bohn, M., Meloni, S., Oddone, M., Tanda, G., 2006. A map of the Monte Arci (Sardinia Island, Western Mediterranean) obsidian primary to secondary sources. Implications for Neolithic provesance Studies. C.R. Palevol 5, 995–1003.
Mallory, J., 1984–1987. Lagnano da Piede I – an early Neolithic village in the Tavoliere. Origini 13, 193–290.
Mello, E., 1983. Indagini scientifiche per l'individuazione della provenienza dei manufatti di ossidiana. In: Tinè, S. (Ed.), Passo di Corvo e la civiltà neolitica del Tavoliere. Sagep Editrice, Genova, pp. 122–124.
Nazaroff, A.J., Prufer, K.M., Drake, B.L., 2010. Assessing the applicability of portable X-ray fluorescence spectrometry of obsidian provenance research in the Maya Lowlands. J. Archaeol. Sci. 37, 885–895.
Nilles, J., 1943. Natives of the Bismarck Mountains, New Guinea. Oceania 14, 104–123.
O'Hare, G., 1990. A perliminary study of polished stone artefacts in prehistoric southern Italy. Proc. Prehist. Soc. 56, 123–152.
Pessina, A., Radi, G., 2006. La diffusione dell'ossidiana nell'Italia centro-settentrionale. In: Atti della XXXIX Riunione Scientifica dell'Istituto di Storia e Protostoria. Vol. 1. pp. 435–460.
Petrassi, L., Zarattini, A., 1997. Il valore dell'ossidiana e le vie terrestri, ipotesi dopo i primi risultati della fluorescenza ai raggi X. In: Zarattini, A., Petrassi, L. (Eds.), Casale del Dolce. Soprintendenza Archeologia per il Lazio, Roma, pp. 191–208.
Phillips, S.C., Speakman, R.J., 2009. Initial source evaluation of archaeological obsidian from the Kuril Islands of the Russian Far East by portable XRF. J. Archaeol. Sci. 36, 1256–1263.
Poupeau, G., Le Bourdonnec, F.-X., Dubernet, S., Delerue, S., 2009. Instrumental methods of obsidian characterization and prehistoric obsidian provenance studies: the current status. In: Sternke, F., Eigeland, L., Costa, L.-J. (Eds.), Non-Flint Raw Material Use in Prehistory: Old Prejudices and New Directions. Archaeopress, Oxford, pp. 35–42.
Robb, J., 2007. The Early Mediterranean Village: Agency, Material Culture and Social Change in Neolithic Italy. Cambridge University Press, Cambridge.
Robb, J., Elster, E., Isetti, E., Knusel, C.J., Tafuri, M.A., Traverso, A., 2015. Cleaning the dead: neolithic ritual processing of human bone at Scaloria Cave, Italy. Antiquity 89, 39–54.
Speakman, R.J., 2012. Evaluation of Bruker's Tracer Family Factory Obsidian Calibration for Handheld Portable XRF Studies of Obsidian. The University of Georgia, Athens.
Specht, J., 1981. Obsidian sources at Talasea, West New Britain, Papua New Guinea. J. Poly. Soc. 90, 337–356.
Tinè, S., 1983. Passo di Corvo e la civiltà neolitica del Tavoliere. Sagep, Genova.
Tykot, R.H., 1997. Characterization of the Monte Arci (Sardinia) obsidian sources. J. Archaeol. Sci. 24, 467–479.
Tykot, R.H., 2002. Chemical fingerprinting and source-tracing of obsidian: the Central Mediterranean trade in black gold. Acc. Chem. Res. 35, 618–627.
Tykot, R.H., 2004a. L'esatta provenienza dell'ossidiana e i modelli di diffusione nel Mediterraneo centrale durante il Neolitico. In: Castelli, P., Cauli, B., Di Gregorio, F., Lugliè, C., Tanda, G., Usai, C. (Eds.), L'ossidiana del Monte Arci nel Mediterraneo: recupero dei valori di un territorio. Tipografia Ghilarzese, Ghilarza, pp. 118–132.
Tykot, R.H., 2004b. Scientific methods and applications to archaeological provenance studies. In: Martini, M., Milazzo, M., Piacentini, M. (Eds.), Physics Methods in Archaeometry. Proceedings of the International School of Physics "Enrico Fermi" Course CLIV. Società Italiana di Fisica, Bologna, Italy, pp. 407–432.
Tykot, R.H., 2010. Sourcing of Sardinian obsidian collections in the Museo Preistorico-Etnografico 'Luigi Pigorini' using non-destructive portable XRF. In: Lugliè, C. (Ed.), L'Ossidiana del Monte Arci nel Mediterraneo. Nuovi Apporti sulla Diffusione, sui Sistemi di Produzione e Sulla loro Cronologia. Atti del 5° Convegno internazionale (Pau, Italia, 27–29 Giugno 2008). NUR, Ales, pp. 85–97.
Tykot, R.H., 2011. Obsidian finds on the fringes of the Central Mediterranean: exotic or eccentric exchange? In: Vianello, A. (Ed.), Exotica in the Prehistoric Mediterranean. Oxbow Books, Oxford, pp. 33–44.
Tykot, R.H., 2014. Obsidian use and trade in the Adriatic. In: Visentini, P., Podrug, E. (Eds.), The Adriatic, a Sea without Borders: Communication Routes of Populations in 6000 BC. 171–181. Udine, Civici Musei di Udine, pp. 224–225.
Tykot, R.H., 2017a. A decade of portable (hand-held) X-ray fluorescence spectrometer analysis of obsidian in the Mediterranean: many advantages and few limitations. MRS Adv. 2, 1769–1784.
Tykot, R.H., 2017b. Obsidian studies in the prehistoric Central Mediterranean: after 50 years, what have we learned and what still needs to be done? Open Archaeol. 3, 264–278.
Tykot, R.H., Ammerman, A.J., Bernabò Brea, M., Glascock, M.D., Speakman, R.J., 2005a. Source analysis and the socioeconomic role of obsidian trade in Northern Italy: new data from the Middle Neolithic site of Gaione. Geoarchaeol. Bioarchaeol. Stud. 3, 103–106.
Tykot, R.H., Setzer, T., Glascock, M.D., Speakman, R.J., 2005b. Identification and characterization of the obsidian sources on the island of Palmarola, Italy. Geoarchaeol. Bioarchaeol. Stud. 3, 107–111.
Tykot, R.H., Iovino, M.R., Martinelli, M.C., Beyer, L., 2006. Ossidiana da Lipari: le fonti, la distribuzione, la tipologia e le tracce d'usura. In: The Adriatic, a Sea without Borders: Communication Routes of Populations in 6000 BC, Firenze, 25–27 November 2004. Firenze, pp. 592–597.
Tykot, R.H., Lai, L., Tozzi, C., 2011. Intra-site obsidian subsource patterns at Contraguda, Sardinia (Italy). In: Turbanti-Memmi, I. (Ed.), Proceedings of the 37th International Symposium on Archaeometry, 13th–16th May 2008, Siena, Italy. Springer, Berlin, pp. 321–328.
Tykot, R.H., Freund, K.P., Vianello, A., 2013. Source analysis of prehistoric obsidian artifacts in Sicily (Italy) using pXRF. In: Armitage, R.A., Burton, J.H. (Eds.), Archaeological Chemistry VIII. ACS Symposium Series 1147pp. 195–210.
Watson, V., 1986. Obsidian as tools and trade: a Papua New Guinea case. Burke Museum Contrib. Anthrop. Nat. Hist. 4, 1–10.
Whitehouse, R., 2005. Extraction and exchange of flint in Neolithic Southeast Italy. In: Attema, P., Nijboer, A., Zifferero, A. (Eds.), Papers in Italian Archaeology VI. Communities and Settlements from the Neolithic to the Early Medieval Period. Archaeopress, Oxford, pp. 545–553.
Whitehouse, R., 2013. The chronology of the Neolithic Ditched settlements of the Tavoliere and the Ofanto Valley. In: Pearce, M., Whitehouse, R. (Eds.), Rethinking the Italian Neolithic. Accordia Research Papers 13pp. 57–78.
Williams-Thorpe, O., Warren, S.E., Barfield, L.H., 1979. The sources and distribution of archaeological obsidian in Northern Italy. In: Preistoria Alpina. 15. Museo Tridentino di Scienze Naturali, pp. 73–92.