"THE BLACK GOLD THAT CAME FROM THE SEA. A REVIEW OF OBSIDIAN STUDIES AT THE ISLAND OF USTICA, ITALY"

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Article history
Receveid **March 18, 2018**; accepted **December 13, 2018**.
Subject classification:
Archaeometry, Obsidian, Provenance studies, Ustica Island.

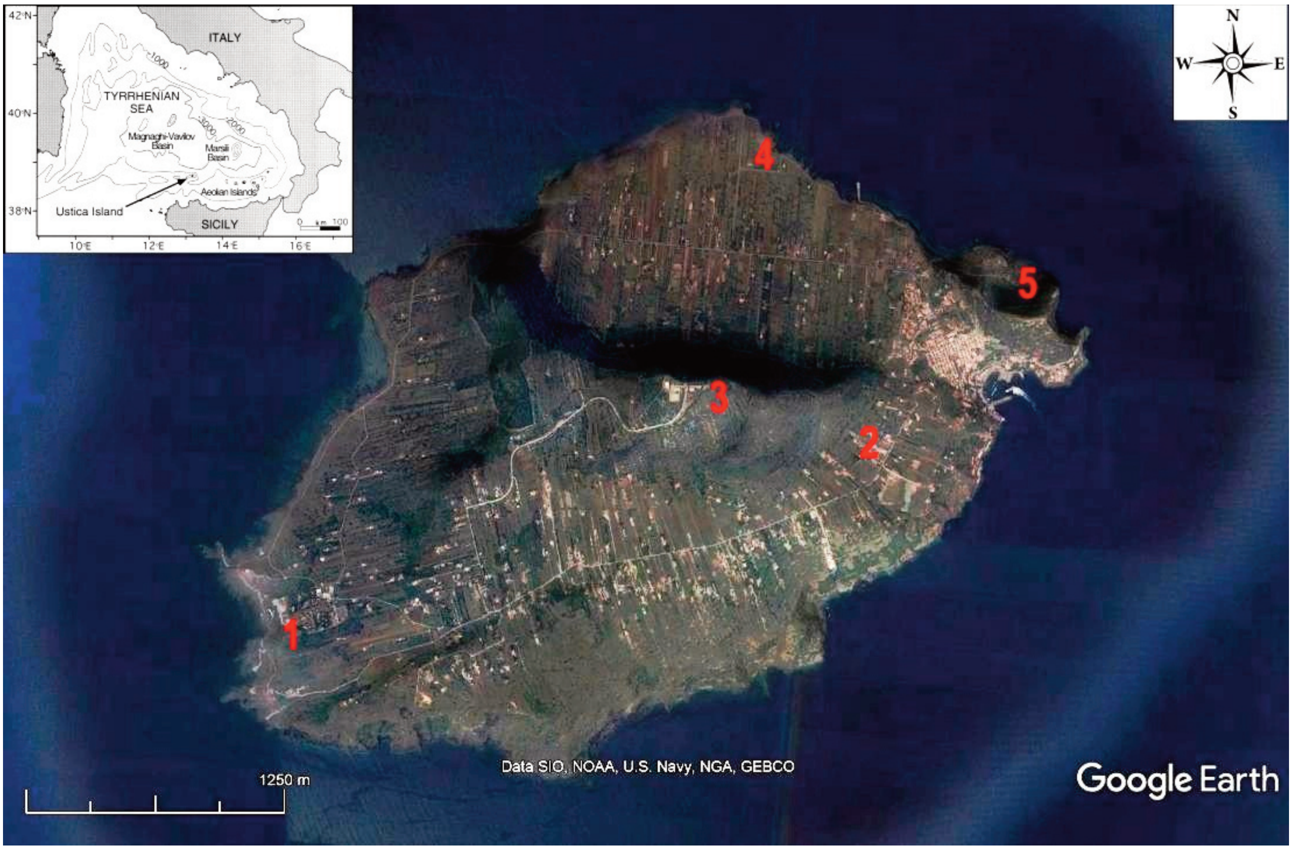
ABSTRACT
Volcanism has produced a natural glass called obsidian that during prehistoric times, from Neolithic to the age of metals, was considered a valuable raw material in order to produce efficient cutting tools. Ustica, a small and solitary island in the southwestern Tyrrhenian Sea, despite being volcanic, did not generate any obsidian. Yet the island's soils return large quantities of obsidian fragments, residues of prehistoric use. Where did this material, defined by some archaeologists as the Black Gold of prehistory, come from? This article reviews the archaeometric studies on Ustica's obsidians, carried out since the middle of the 1990s, to answer this question. The obsidians of Ustica have become a tracer of commercial and cultural exchanges in the heart of the Mediterranean Sea. The geochemical fingerprint of Ustica obsidians is revealing a network of relations and exchanges not only with neighboring Lipari but also with the most distant Pantelleria and Palmarola islands. A fact that, for a tiny island that was completely devoid of spring water resources, appears surprising, in relation to the prehistoric context.

1. INTRODUCTION

For more than five millennia, since Neolithic (6th millennium BC) to the Middle Bronze Age (1th millennium BC), Ustica, a tiny and solitary island located off the northern coast of Palermo (Figure 1), imported obsidian rocks from some distant sources of the peri-Tyrrhenian area [Foresta Martin et al., 2017]. During prehistory, before the onset of Metal Ages, the black volcanic glass was the privileged raw material used to obtain sharp and needful cutting tools or weapons, like knives, scrapers, arrows, and spearheads. Due to its usefulness, some archaeologists named obsidian the Black Gold of the prehistory [Lilliu, 1983; Tykot, 2002].

In the Central-Western Mediterranean, there were four main sources of obsidian that fed hundreds of prehistoric villages, all located on Italian Islands: Monte Arci (Sardinia), Palmarola (Pontine, Lazio), Lipari and Pantelleria (Sicily). Each source has its own geochemical fingerprint [e.g., Francaviglia, 1984; Tykot, 1996; Acquafredda et al., 1999; Barca et al., 2008; Le Bourdonnec et al., 2010] that permit to distinguish it from the others, allowing us to reconstruct the origin of the material used to build the obsidian tools. The import/export of obsidian fed economical and cultural exchanges. Nowadays, the attribution of obsidian archaeological finds to their geological sources is essential to reconstruct the maritime routes and the relationship between ancient and distant peoples [e.g., Cann and Renfrew, 1964; Francaviglia, 1984; Francaviglia and Piperno, 1987; Bigazzi et al., 1993; Williams-Thorpe, 1995; Tykot, 1996; Acquafredda et al., 1999; Le Bourdonnec et al., 2010].

In this paper, we review the story of the obsidian re-



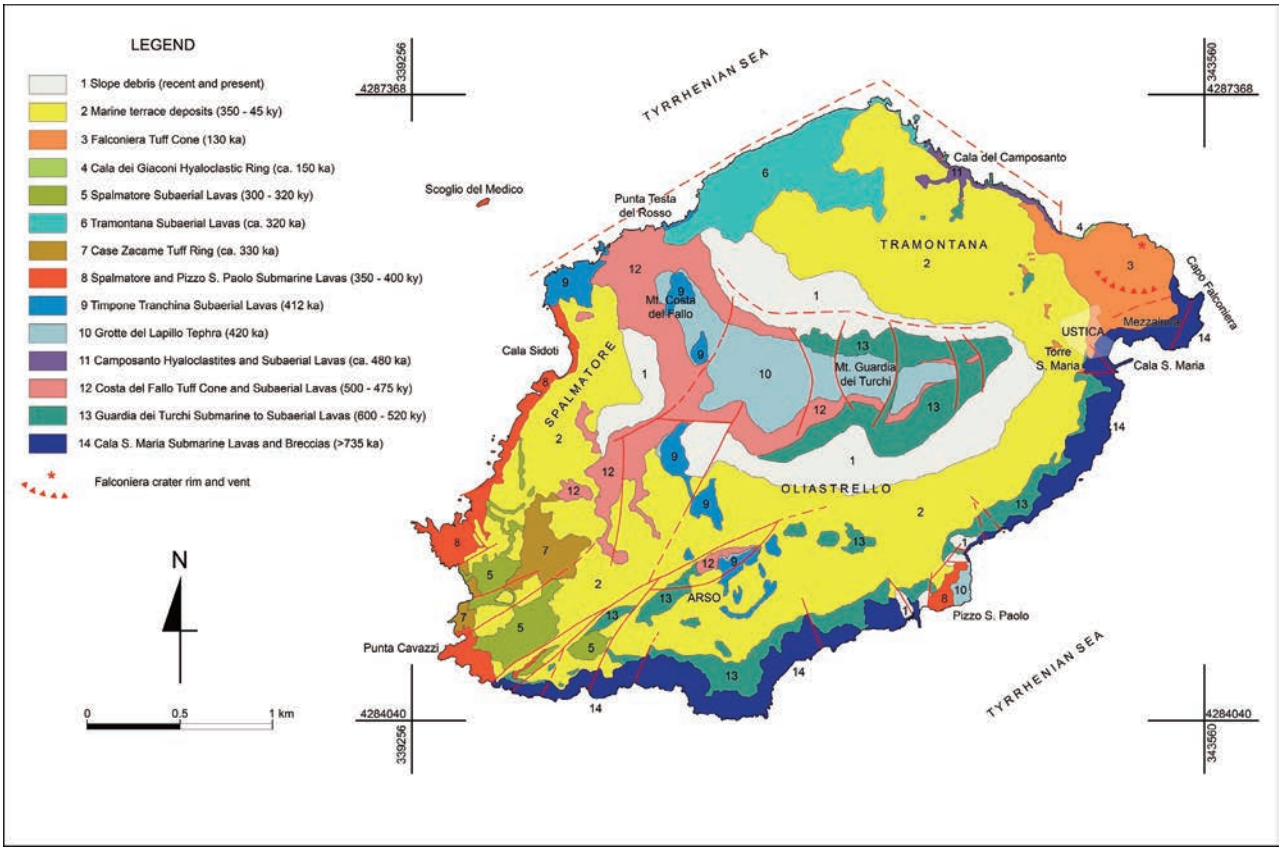
FUGURE 1. The Island of Ustica (after Google Earth). In the inset: the position of Ustica in the Tyrrhenian Sea (after Etiope 1999). The red numbers indicate the main archaeological settlements at Ustica Island: 1. Spalmatore-Pirozza, Neolithic Age; 2. Piano dei Cardoni, Eneolithic Age; 3. Culunnella, Ancient Bronze Age; 4. Faraglioni Village, Middle Bronze Age; 5. Omo Morto, Middle Bronze Age.

searches at Ustica, whose onset dates back to some decades ago, first briefly introducing its geological features and archaeological settlements, given the remarkable natural and historical heritage of this island, located in the heart of the Mediterranean Sea.

2. GEOLOGY OF USTICA

The island of Ustica, located in the Southern Tyrrhenian Sea, about 70 km north of Palermo, is a small land of volcanic origin, stretching about 2.7 km. by 4.5 km. It is the small top of a vast (~100 km^2) submerged volcanic complex that rises more than 2,000 m from the bottom of the sea (Figure 1). The origin of Ustica is related to extensional crustal faults, generated during the deformational events which accompanied the opening of the Tyrrhenian basin, in the course of the complex interaction between the African and the Eurasian plates. This mechanism led to the rise of a magma plume directly from the Earth's mantle, thus beginning the formation of Ustica seamount between the Lower and the Middle Pleistocene, about a million years ago [Romano and Sturiale, 1971; Cinque et al., 1988; de Vita, 1993; de Vita et al., 1998; Peccerillo, 2005]. Not far from Ustica, ~ 150 km eastward, the archipelago of the Aeolian Islands has a completely different origin, being linked to a subduction process, that is to say the sinking of the Ionian Plate beneath the Tyrrhenian one.

The Ustica volcanic activity was initially submarine, following the formation of several eruptive centers along a fault system oriented NE-SW; and then activity concentrated in a principal seamount. After about half a million years of underwater eruptive activity, the top of the seamount emerged, becoming the first subaerial volcano of the island, now Monte Guardia dei Turchi, 248 m a.s.l. (Figure 2). The subaerial volcanic activity continued with the formation of others eruptive centers characterized by various types of activity: effusive and explosive. About 426,000 years ago [de Vita, 1993], the Ustica volcanism recorded a sub-Plinian event which vent was located in the Tramontana area, with the formation of a high eruptive column and the fallout of ash that formed the thick pyroclastic deposits



FUGURE 2. Geological map of Ustica. After de Vita and Foresta Martin, 2017.

of Grotte del Lapillo. The island's volcanic activity ended about 130,000 years ago, with the explosive Falconiera hydromagmatic eruption and the formation of a tuff-cone, whose northern sector later collapsed into the sea. The southern part of Falconiera cone still resists, and represent the most easily recognizable Ustica's crater [Romano and Sturiale, 1971; de Vita, 1993; de Vita et al., 1998; de Vita and Foresta Martin, 2017].

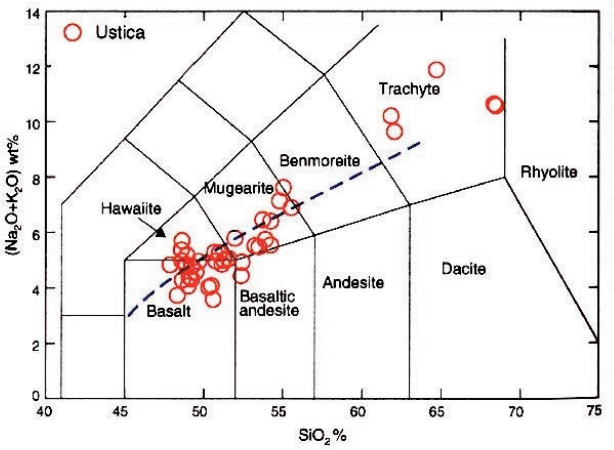
The Ustica volcanic history has been affected by several overlapping cycles of marine ingressions and regressions, resulting from the climate change and associated sea level variations during the Middle-Upper Pleistocene stages. These glacio-eustatic movements caused the stationing of sea-water on land, with the formation of the five typical sedimentary terraces recognized in the Piano dei Cardoni, Oliastrello, Tramontana, Arso and Spalmatore areas, respectively (Figure 2). Some sediments of these marine terraces are richly fossiliferous [de Vita and Orsi, 1994; Buccheri et al., 2014; de Vita and Foresta Martin, 2017].

The Ustica volcanic rocks show a Na-alkaline affinity, ranging in composition from alkali-basalts to alkali-trachytes (Figure 3). The most evolved trachytic products of Ustica belong to the volcanic unit of Grotte del Lapillo, consisting of pumice and ash fall-out deposits, without subaerial effusive products, which instead are found as submarine lavas in the Colombara shoal. This unit represents the only silica-rich volcanic event that could have generated glassy/obsidianaceous rocks, which however have never been reported [Romano and Sturiale, 1971; Cinque et al., 1988; De Vita 1993; Bellia et al., 2000; Peccerillo, 2005].

Accordingly, the obsidian fragments found on Ustica do not derive from local geological outcrops but were imported from distant sources in prehistoric times [Foresta Martin et al., 2017].

3. PREHISTORIC SETTLEMENTS IN USTICA

The island of Ustica was inhabited during the prehistoric times, at least since Neolithic Age (6000 yrs BC) to Middle Bronze Age (1400-1200 yrs BC), as evidenced by many archaeological findings in various parts of the island [Spatafora and Mannino, 2008], (Figure 1). The human presence since so remote times raises such a wonder if you consider that the island lacks water resources (drinkable water is nowadays supplied by a de-



FUGURE 3. Total Alkali vs. Silica diagram of Ustica volcanic rocks. Modified after Peccerillo, 2005.

salination plant). Nevertheless, the abundance of ceramics attributable to well-known styles allows to constrain the existence of some human prehistoric settlements and to trace a reliable chronology of their existence.

3.1 NEOLITHIC AGE SPALMATORE VILLAGE

The Spalmatore area, in the southwest of the island, is until now the only place of Ustica with evidence of a Neolithic Age settlement. It stood on a small hill overlooking the sea called Pirozza, ~ 50 m a.s.l., near the area nowadays occupied by a large tourist resort. The evidence of the Neolithic Age village was found by the archaeologist G. Mannino [1998] who collected hundreds of ceramic fragments on the northern-eastern side of the Pirozza hill (Figure 1, Figure 4), both on the surface and through shallow excavations. The ceramic

FUGURE 4. The Pirozza hill, a promontory with a flat top on the western coast of the Island, in the Spalmatore district. It was the site of a Neolithic Village, about 6 thousand Yrs BC. After Mannino, 1998.

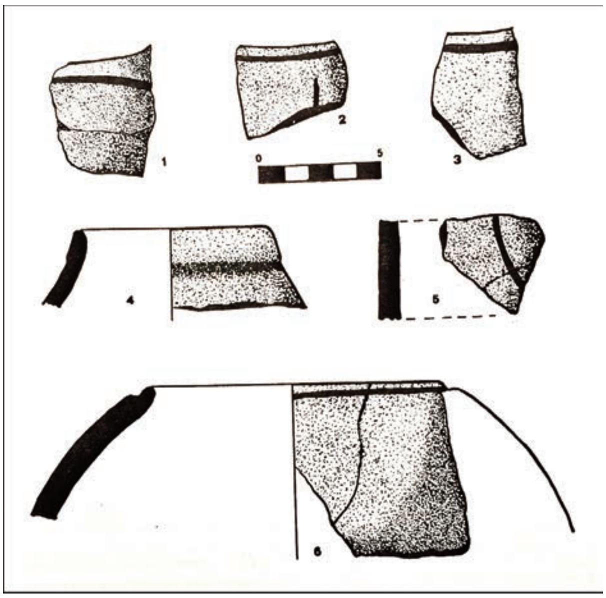
FUGURE 5. Neolithic ceramic shards and obsidian flakes exposed in a window of the Archaeological Museum of Ustica “Padre Carmelo Seminara”.

fragments have been attributed to three different Neolithic Age styles: Stentinello, Tricromico, and Diana, dated between 6th and 5th millennium BC (Figure 5). The typology of the Neolithic Age recognizable in these fragments have permitted to Mannino [1998] to hypothesize that the first inhabitants of Ustica came from some Neolithic villages in the neighborhoods of Palermo. In the same area, on the northern-eastern side of the Pirozza hill, some obsidian fragments were collected [Foresta Martin and Tykot, 2019]. In the future, it is hoped to reach some still intact portion of the Neolithic settlement through a campaign of archaeological excavations.

Anyway, in the surrounding of the Pirozza hill, a lot of most recent ceramic fragments were also found, with features of Eneolithic, Bronze, Greek and Roman Ages, suggesting that other prehistoric, protohistoric and historic settlements developed in the largest area now occupied by the tourist resort and beyond. The movement of soil during the construction of the tourist resort certainly contributed to the mixing of the ceramic fragments and probably caused the partial destruction of the underlying archaeological settlements [Mannino and Ailara, 2016].

3.2 ENEOLITHIC AGE AT PIANO DEI CARDONI, PETRIERA AND GROTTA AZZURRA

Piano dei Cardoni is a marine terrace in the south-eastern area of the island. At the end of last century, during a surface exploration in an agricultural field, G. Mannino [1991] collected some fragments of impasto ceramics and products of lithic industry. This material has been attributed to a Middle Eneolithic settlement (2800-2600 B.C.) which was probably placed in Piano dei Cardoni-Sopravia (Figure 1). However, in this area the most ancient ceramics are mixed with more recent ones. Probably the settlement survived until the Middle Bronze Age and, after a long hiatus, came back to life in the late Roman Age [Mannino, 1991; Spatafora and Mannino, 2008]. Even in Piano dei Cardoni the obsidian fragments collectible on the ground are not attributable to a specific chronological context: better, we can say that they span a time interval from Eneolithic to Middle Bronze. Fragments of Eneolithic impasto ceramics, attributable to style Conca d'Oro-San Cono-Piano Notaro (Figure 6), were found also in the Petriera area, in the eastern side of the island, and inside the Grotta Azzurra cave, in the southeastern coast. The Grotta Azzurra cave was frequented by inhabitants who used to collect in their vases small quantities of freshwater that dripped from the walls of the cave [Mannino, 1991; Mannino and Ailara, 2016].



FUGURE 6. Ceramic shards of Eneolithic Age, attributable to Conca d'Oro-San Cono-Piano Notaro style, found inside the Grotta Azzurra cave. After Mannino, 1991.

3.3 ANCIENT BRONZE AGE CULUNNELLA VILLAGE

In Ustica the Ancient Bronze Age is represented by a settlement on the flat top of Culunnella area (238 m a.s.l.), a small hill located in the center of the island which offers a panoramic 360° view of the horizon (Figure 1). The presence of ceramics with decorations in the Capo Graziano style (2000-1600 BC), widespread in the Aeolian island, was firstly found by G. Mannino [1991] and testifies the contacts with the Aeolian Archipelago. On the southeastern side of the Culunnella hill, at a lower altitude (150 m a.s.l.), the necropolis of the village was found, made of some graves of the artificial cave type [Mannino, 1991; Spatafora and Mannino, 2008]. These tombs are similar to those in the style of Capo Graziano culture. Until now the Culunnella archaeological settlement has never been excavated, and ceramics together with obsidian fragments were all collected on the surface of the ground.

3.4 MIDDLE BRONZE AGE FARAGLIONI VILLAGE AND OTHERS COEVAL SETTLEMENTS

The peak of prehistoric human presence in Ustica was reached during the Middle Bronze Age, between 1400-1200 yrs BC. The most important settlement of this period in Ustica was the Faraglioni Village ("faraglione" means a rock stack emerging from the sea). It was established on the north side of the island, in a stretch of coast characterized by a high cliff, about 20 m a.s.l. that forms a terrace overlooking the sea (Figure 1). Two "faraglioni" called Colombaio and Nerone stand just in front of the terrace, a few tens of meters away from the coast. The toponym of the archaeological village derives from these faraglioni [Spatafora and Mannino, 2008], (Figure 7).

FUGURE 7. Aerial view of Middle Bronze Age Faraglioni Village in the Tramontana district of the Island. On the top of the Colombaio stack (left), the biggest "faraglione" located in front of the cliff coast, foundations of huts and ceramic shards were found.

Several different archaeological excavations, carried out since the Seventies by G. Mannino [1970, 1979, 1982], R. Ross Holloway and S. Lukesh [1995, 2001], and F. Spatafora [2005] highlighted a settlement that has been defined as one of the best-preserved Middle

Bronze Age towns of the Mediterranean region [Counts and Tuck, 2009]. Landward the village was enclosed in a massive fortification wall which today delimits an area of about 7000 m^2 ; seaward the village was naturally protected by the high cliff. According to some authors, the inhabited wall-circled area may have been greater than today and probably a landslide occurred seaward in prehistoric times, as attested by the rubble of huts found at the foot of the cliff [Spatafora and Mannino, 2008].

FUGURE 8. Defensive walls, huts, and streets of the Middle Bronze Age Villaggio dei Faraglioni, at Ustica.

Inside the wall have been unearthed several huts placed next to one another, at the sides of the streets about one meter wide (Figure 8). The rational urbanistic plan of the village and the wealth of furnishing of the huts, testify a well-structured social and economic organization, as well as a high standard of living of the inhabitants. [Ross Holloway and Lukesh, 1995, 2001; Spatafora and Mannino, 2008].

The Faraglioni Village was also included into the Mediterranean trade: the connection with the contemporary Sicilian culture of Thapsos is self-evident in ceramics [Voza, 1972]. Evidence of long-distance contact was also found: a single fragment of Mycenaean ceramic and a few necklace beads in glass paste attest a relationship with populations of the continental Greek Bronze Age. Moreover, some ceramic shards with incised decoration in Apennine style document the participation of Ustica in the Tyrrhenian routes with the Italian peninsula [Ross Holloway and Lukesh, 1995, 2001; Spatafora and Mannino, 2008].

Traces of huts and pottery have also been found on the top of the largest stack, the Colombaio, which stands about 60 meters away from the coast. Thus it has been hypothesized that Colombaio was once connected to the mainland by a promontory and that after a landslide it remained isolated. But Furlani and Foresta Martin [2019, this Volume] show that during the Bronze Age the sea level was lower than the present one and that the Colombaio could be reached on foot, without the need to hypothesize the existence of a promontory or of a natural bridge.

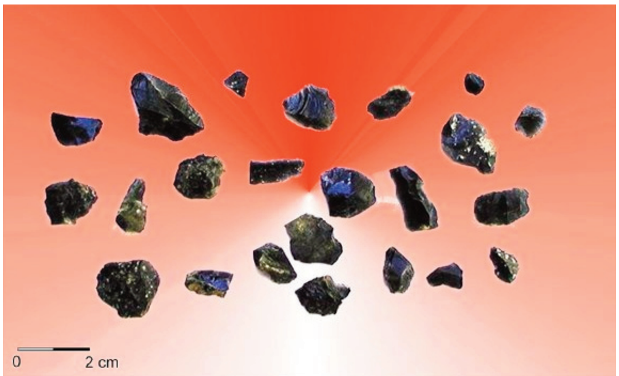
Evidence of life in the Faraglioni Village vanished around 1250-1200 BC, when the inhabitants left abruptly, abandoning all belongings in their homes. For this sudden disappearance, two hypotheses were advanced: (i) a hostile invasion from the sea, or (ii) a natural disaster that induced the population to find a safer place. After this dramatic event, Ustica remained uninhabited for many centuries, until the Hellenistic-Roman period, when we find new traces of an intense human presence on the island [Spatafora and Mannino, 2008].

Vast sectors of the Faraglioni Village are still unexplored, and many remains to be unearthed about the life of the inhabitants and their relationship with others small coeval settlements at Ustica. There is evidence of small Middle Bronze Age communities at Punta dell'Omo Morto, in the eastern zone of the island; at Case Vecchie, upper Ustica town; and in the Spalmatore area, in the western part of the island [Spatafora and Mannino, 2008].

Hundreds of obsidian fragments were collected during excavation campaigns in the Faraglioni Village, both *in stratu* and on the surface, attesting that the use of this material in Ustica was still intense during Middle Bronze Age [Tykot and Foresta Martin, 2017].

4. OBSIDIANS IN USTICA: CHARACTERISTIC AND DISTRIBUTION

Ustica's volcanism did not erupt obsidians; therefore, all the obsidian flakes collected in Ustica were imported from foreign sources, since the Neolithic age. Ustica's obsidian flakes have the typical appearance of black to grey volcanic glasses, some of which marked by very tiny crystals (microlites) or whitish pumice veins. Only in a few cases, the flakes have the shape of intact tools:



FUGURE 9. Typical obsidian flakes that can be found at Ustica, on the surface of the island's farmland.

blades, scrapers, arrowheads, and other human artifacts; more frequently, they are processing waste, or processed objects then reduced into smaller fragments (Figure 9), [Foresta Martin et al., 2017].

The obsidian distribution on Ustica is well but not exclusively correlated with the existence of the archaeological sites aforementioned. The largest concentrations of obsidian fragments can be found in the areas around Piano dei Cardoni-Sopravia and Tramontana-Villaggio dei Faraglioni. In these locations, especially after plowing or after heavy rains it is possible to pick up on the farmland surface something like 10-20 fragments in one hour. But the soil is rich of obsidian also in some areas hundreds of meters away from the well known archaeological settlements. For example, plenty of obsidian flakes occur in the Tramontana-Sopravia, 500-800 m south to the Villaggio dei Faraglioni, an area which extends to the slopes of Monte Guardia dei Turchi. The dispersion of obsidian in the wide district of Tramontana could be due to the existence of other small settlements outside the walls of the village. In particular, the plenty of obsidians processing waste collectible in Tramontana-Sopravia could be explained with the existence of an obsidian workshop in that area. The obsidian flakes dispersion on Utica's soils could be due either to natural transport phenomena, such as the recurrent autumnal-winter floods that have occurred over the millennia, and/or the impressive handling of the land carried out by human activities in the last centuries.

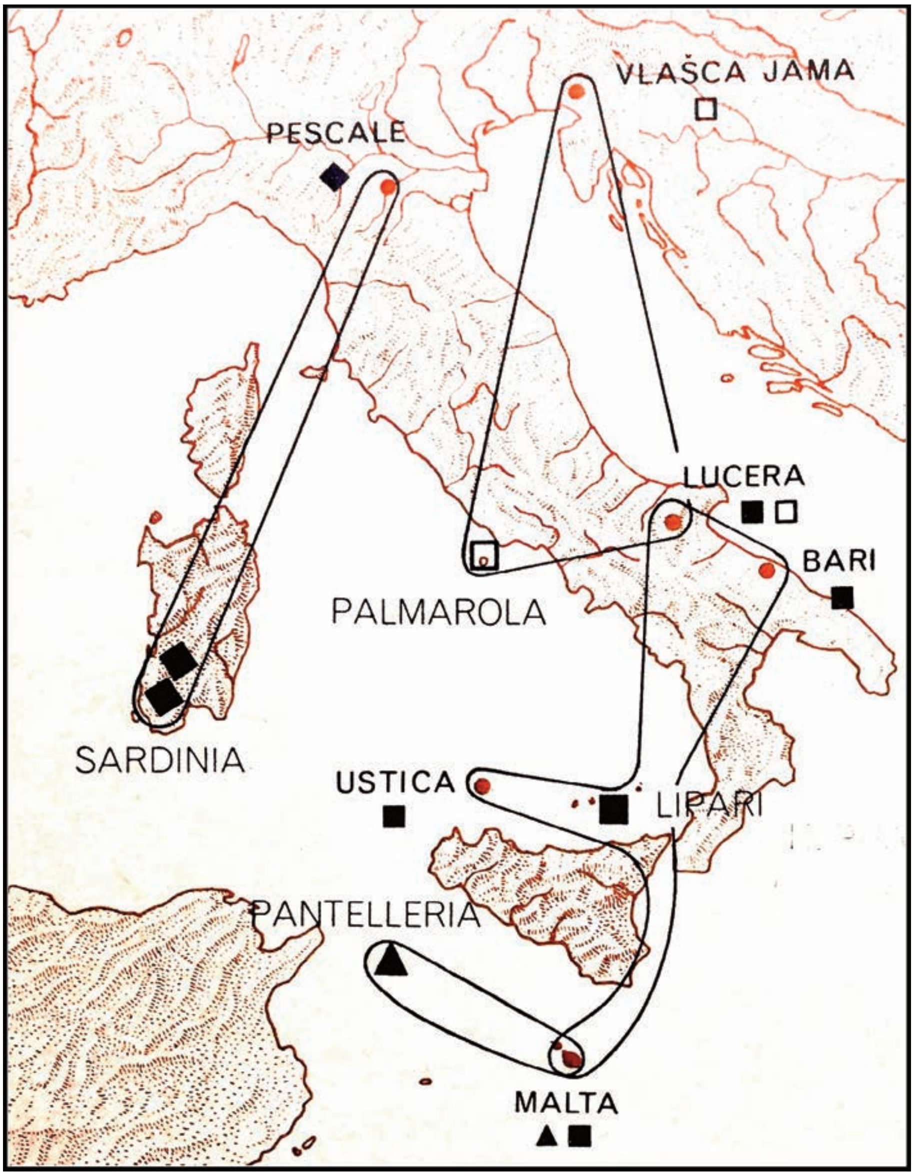
Furthermore, we have to investigate if the abundance of obsidian flakes existing in the Villaggio dei Faraglioni area indicates the persistence of long-distance obsidian commerce during the Middle Bronze Age. Or should we, rather, take into account the possibility that Faraglioni's inhabitants used to collect and reuse lithic tools from the nearby abandoned prehistoric settlements?

5. OBSIDIANS IMPORTS FROM LIPARI AND BEYOND

For a long time, the common belief of researches was that the obsidian fragments found in Ustica were all imported from the neighboring island of Lipari. This conviction is well represented by a map (Figure 10) that accompanied a historical article by Dixon, Cann and Renfrew published on Scientific American [1968], in which the authors summarized their pioneering research on the characterization of obsidian through the analysis of trace elements. In this map, the island of Ustica is included in the exclusive Lipari's area of prehistorical obsidian trade, along with some other Mediterranean archaeological settlements [Dixon et al., 1968].

This belief, due to the limited number of obsidian analyzed at that time, persisted until the mid-90s, when R. Tykot received by R. Ross-Holloway a dozen obsidian fragments collected in Ustica on the surface outside the Faraglioni Village. The analysis of the major elements carried out by means of an electron microprobe (Table 1) demonstrated that 11 of them were attributable to Lipari and 1 to Pantelleria [Tykot, 1995], an island situated on the opposite side of Sicily (south) respect to Ustica and to the Aeolian Archipelago.

In the years following the Tykot's finding, nobody carried out further geochemical analysis on Ustica obsidians. At that time, relying only on visual recognition methods that allow one to distinguish the obsidian from Pantelleria thanks to their greenish color in transmitted light [Cann, 1964], one of the authors of this paper (FFM) began to analyze optically several dozens of obsidian fragments easily collectible on the surface of Ustica's farmland, especially after plowing and after heavy



FUGURE 10. Obsidian trade routes after Dixon et al. [1968]: for a long time it was thought that Ustica was supplied only by Lipari.

rains. Through this survey was possible to verify whether Tykot's finding was a unique case or the first evidence of a significant prehistoric trade between Ustica and Pantelleria. The results of this rough statistical survey led to evaluate that about 10 % of the one hundred obsidian ubiquitous fragments collected in Ustica and visually examined seemed to have been imported from Pantelleria; but this assessment had to be confirmed by geochemical analyses [Foresta Martin and Ailara, 2004; Foresta Martin, 2014]. The first opportunity to address this problem with appropriate analytical tools came in the early 2000s when, on behalf of Centro Studi e Documentazione Isola di Ustica, FFM promoted a research agreement between the Soprintendenza per i Beni Culturali e Ambientali in Palermo and Landis-Infn Laboratory in Catania, with the purpose of analysing almost two hundreds obsidian fragments collected in the Faraglioni Village and kept in the Archaeological Museum of Torre Santa Maria in Ustica [Foresta Martin and Ailara, 2004]. The analyses carried out by G. Pappalardo with a portable XRF instrument built in the Landis Laboratory, allowed to determine the concentration of five trace elements: Rb, Sr, Y, Zr, Nb. Before performing these analyses, FFM optical observations allowed to distinguish provenances and to attribute 90% of the specimens to Lipari, and 10% to Pantelleria. The pXRF analyses gave the following results: Lipari 168 (86%); Pantelleria 17 (9%); Undetermined 10 (5%). No sub-sources discrimination was made [G. Pappalardo, personal communication]. A few years later, some of the pXRF analyses made in Ustica were published by L. Pappalardo et al. [2013] as a

Findspot	Lab. No.	Description	Attrib.	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	MgO	CaO	Na_2O	K_2O	BaO	Total
Ustica	1715	flake	Li	74.55	12.77	0.08	1.61	0.03	0.71	4.10	5.16	0.00	99.00
Ustica	1716	small flake	Li	74.59	12.70	0.07	1.63	0.02	0.71	4.11	5.16	0.01	99.00
Ustica	1717	small blade	Li	74.25	12.64	0.08	1.60	0.05	0.87	4.30	5.22	0.00	99.00
Ustica	1718	blade	Li	74.40	12.81	0.09	1.57	0.05	0.73	4.13	5.20	0.02	99.00
Ustica	1719	small chunk	Li	74.71	12.75	0.08	1.51	0.03	0.69	3.96	5.26	0.02	99.00
Ustica	1720	blade fragment	Li	74.37	12.75	0.09	1.80	0.04	0.81	4.01	5.13	0.01	99.00
Ustica	1721	core trim?	Li	74.69	12.74	0.08	1.57	0.03	0.70	4.04	5.16	0.00	99.00
Ustica	1722	small blade	Li	74.70	12.61	0.08	1.68	0.03	0.69	4.03	5.18	0.00	99.00
Ustica	1723	blade	Li	74.63	12.77	0.07	1.58	0.03	0.70	4.05	5.16	0.00	99.00
Ustica	1724	small chunk	Li	74.64	12.71	0.07	1.62	0.02	0.70	4.09	5.17	0.00	99.00
Ustica	1725	chunk	Li	74.78	12.62	0.08	1.65	0.02	0.69	4.04	5.12	0.01	99.00
Ustica	1726	arrowhead	Pa2	66.17	10.89	0.61	8.35	0.17	0.57	7.49	4.73	0.03	99.00

TABLE 1. Composition in wt% oxide of 12 obsidian artifacts from Ustica, determined by Tykot [1995] using an Electron Microprobe with wavelength dispersive spectrometry: 11 specimens originate from Lipari (Li) and 1 from Pantelleria (Pa2). After Tykot, 1995.

part of a broader search on the provenance of obsidian in several Sicilian prehistoric settlements.

6. THE PARISH COLLECTION AND THE SINGLE PALMAROLA FIND

In 2012, during the reorganization of some archaeological findings preserved in the Museum of San Ferdinando Re Parish in Ustica, a box containing about 350 obsidian fragments was exposed in a window of the permanent exhibit. These flakes were collected in the last decades of the 1900s by the late parson C.G. Seminara, Honorary Inspector of the Soprintendenza per i Beni Culturali in Palermo, in the course of surface surveys on the main archaeological areas of Ustica, in the Spalmatore, Tramontana and Piano dei Cardoni districts. Unfortunately, no specific information about the sampling location of each flake has been found, but it can generally be said that this collection spans a time interval from the Neolithic to the Bronze Age. The abundance of these flakes induced FFM to systematically analyze them for a study on the procurement sources of Ustica's obsidian [Foresta Martin, 2014].

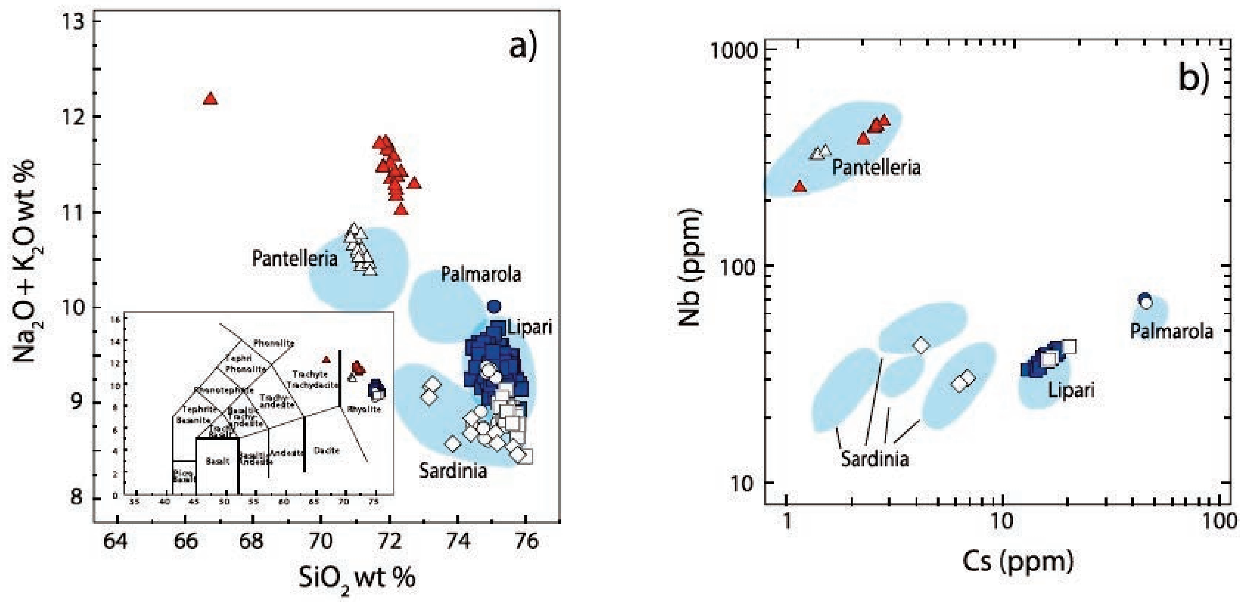
In 2015, on behalf of the newly formed Laboratorio Museo di Scienze della Terra Isola di Ustica, FFM promoted the formation of a group of researchers from the Istituto Nazionale di Geofisica e Vulcanologia and from the Palermo University, Dipartimento di Scienze della Terra e del Mare (DISTEM). The initiative aimed at developing a multidisciplinary study for the characterization of a first set (170 specimens) of the Parish obsidian collection, coupling physical (density and magnetic properties) and geochemical analyses. Together with the Ustica's archaeological obsidians, it was analyzed a group of samples representative of the four prehistoric obsidian sources exploited in the Central Mediterranean area: Lipari, Pantelleria, Monte Arci and Palmarola [Foresta Martin et al., 2017].

At first, the study of physical characteristics such as color, opacity, textural heterogeneity, and density was performed. It confirmed the presence of two main sources: i) transparent obsidians with grey to black coloration, various amount of microliths or microlith-free, and a mode density of 2.35 g/cm^3, that are attributable to Lipari's sources, but which may include others provenances not distinguishable with this type of analysis; ii) dark greenish to black obsidians, with a mode density of 2.47 g/cm^3, attributable to Pantelleria's sources [Foresta Martin et al., 2017].

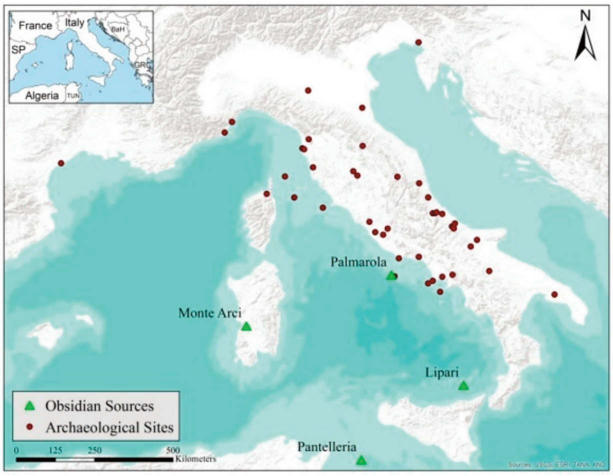
At the same time, several types of rock magnetic measurements were performed: χ (mass specific magnetic susceptibility), NRM (natural remanent magnetizations) and IRM (isothermal remanent magnetization). These analyses indicated two main sources, Lipari and Pantelleria, but didn't exclude the possibility of other provenances, notably from Palmarola (Latium) and Monte Arci (Sardinia). To solve these ambiguities, major elements analyses were performed using an electronic microprobe (EMPA). In a TAS diagram (Figure 11a), Ustica's archaeological obsidians tend to gather in two main groups, which correspond to glasses with different peralkalinity index (P.I.=molar [$(Na_2O+K_2O)/Al_2O_3$]): i) Lipari group, characterized by high silica, lesser alkali, and P.I.<1.0; ii) Pantelleria's group, characterized by slightly low silica, higher alkali, and P.I. ≥ 1.5. One sample (UST-49) is characterized by an alkali content (P.I. = 1.04), higher than the Lipari's group and lower than the Pantelleria group; this sample could be attributed to Palmarola island. But Lipari's group tend to be scattered, overlapping also Palmarola's and Sardinia's (Monte Arci) compositional fields. In order to refine these results was carried out a trace elements investigation through Laser Ablation ICP-MS, selecting 33 samples representative of Lipari and Pantelleria, plus the ambiguous cases. Trace elements composition highly enhanced the previously observed differences, without confusing overlapping. As evidenced by discriminant diagram Cs vs Nb, three sources can be clearly distinguished: Lipari, Pantelleria, and Palmarola (Figure 11b). In this set of archaeological obsidian flakes, no samples from Monte Arci have been recognized. It was concluded that in the set of the 170 analyzed specimens about 87.7% come from Lipari; 11.7% from Pantelleria; and 0.6% from Palmarola [Foresta Martin et al., 2017].

LA-ICP-MS analysis has confirmed to be the most effective way to distinguish primary sources for obsidian fragments, allowing to find, for the first time, the occurrence of obsidian flakes from Palmarola, not only in Ustica but also in Sicily mainland. This result, although so far it appears sporadic, extends southward the known diffusion area of obsidians from Palmarola, that until now was limited to northern- central Italy and the Adriatic coast [Barca et al., 2008; Freund, 2014], (Figure 12).

Another set of 130 obsidian fragments from the Parish collections was sent to R. Tykot of the University of South Florida, Tampa, thus establishing a collaboration with him and the Laboratorio Museo di Scienze della Terra. The nondestructive chemical analysis carried out with a pXRF Bruker Tracer III-SD, allowed to determine 19 major, minor and trace elements, thanks to which it was possible to attribute the provenances of the obsidian set. The results indicate that 110 (85,2%) of the specimens came from Lipari and 19 (14,7%) from Pantelleria. Applying the discriminatory diagram FeOtot /Sr vs. Rb/Sr proposed by Tykot [2013, 2017] it was also possible to assign 107/110 of the Lipari obsidian to the Vallone del Gabellotto sub-source, the most exploited



FUGURE 11. a) Position in the TAS diagram of a set of 170 archaeological obsidian collected at Ustica (red and blue symbols), and geological samples (white symbols). Light blue areas are the compositional fields of Lipari, Pantelleria, M.Arci and Palmarola obsidian sources, after literature. This diagram well differentiates Pantelleria from the other sources but shows some overlaps between the fields of: Lipari and M.Arci; Lipari and Palmarola. b) The ambiguity shown in the a) diagram is solved by discriminant diagrams with trace elements, i.e. Cs vs. Nb. Thanks to trace elements discrimination it was possible to get confirmation of the first evidence of a Palmarola obsidian flake in Ustica and in Sicily. After Foresta Martin et al., 2017.



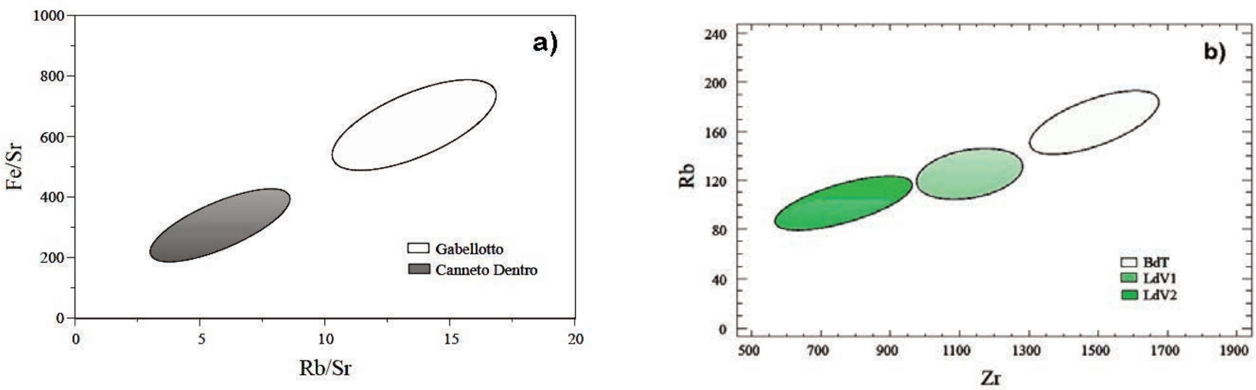
FUGURE 12. Distribution of Palmarola obsidians at Mediterranean archaeological sites before the discovery of a single Palmarola obsidian flake at Ustica. After Freund, 2014.

during the Neolithic period [Freund, 2017; Vianello and Tykot, 2017]; and 3/110 to the Canneto Dentro sub-source (Figure 13a). Similarly, by applying the diagram Rb vs. Zr proposed by Tykot [2017] in order to discriminate among Pantelleria sub-sources, it was possible to establish that 19/19 obsidian from Pantelleria belongs to the Balata dei Turchi sub-source [Tykot personal communication], (Figure 13b). As regards the typology of the samples, the 78% can be classified as *chunks*, i.e. unworked pieces of obsidian; the 21% as *flakes*, i.e. fragments without a specific shape but possibly used as a tool; and only 1% looks like a blade [Tykot personal communication].

Still another group of 20 obsidians of the Ustica-Parish collection was part of a master degree thesis [La Monica, 2016] at the University of Palermo. The main topics of this study were the mineralogical and petrographical characterization of the obsidian set, and the measurement through the FT-IR spectrometry of the amount of H_2O present in the samples. The preliminary results of this work are presented in this Volume [La Monica et al., 2018].

7. EXTENDING SEARCHES ON OBSIDIAN SOURCES

In June 2016, after the International Obsidian Conference of Lipari, F. Foresta Martin and R. Tykot carried out in Ustica the geochemical characterization of several obsidian assemblages, well differentiated by collecting locations and - with some uncertainties - chronologically defined. Nondestructive analyses of major, minor and trace elements on 447 obsidian fragments were performed with a portable XRF instrument. The abundant material analyzed included 113 fragments collected at the Middle Bronze Age Villaggio dei Faraglioni and now preserved in the Torre Santa Maria museum of Ustica. In addition to these archaeological findings, 284 other fragments were examined, collected on the surface of Ustica farmlands in 6 different areas of the island: Villaggio di Spalmatore, Piano dei Cardoni Sopravia, Culunnella, Villaggio dei Faraglioni, Tramontana Sopravia, Oliastrello. Except for the last two, these areas can be associated with the main prehistoric settlements of Ustica to date known [Tykot and Foresta



FUGURE 13. a) Trace elements discriminant diagrams proposed by Tykot [2013] for distinguishing: a) Lipari obsidian subsources of Gabellotto and Canneto dentro; b) Pantelleria obsidian subsources of Balata dei Turchi, Lago di Venere 1 and 2. Elliptical fields represent the areas in which are concentrated the samples, analyzed by means of a pXRF instrument.

Martin, 2017], (Figure 1). The importance of the Spalmatore area, indicated as the site of a Neolithic village, perhaps the first human settlement on the island of Ustica [Mannino, 1998; Spatafora and Mannino, 2008], has pushed Foresta Martin and Tykot [2019] to develop a specific study on the obsidian assemblage here collected and on the geomorphological context in which they are located.

Table 2 summarizes the number, the percentage and the provenance of the obsidian artifacts collected in each of the 6 Ustica areas. Regarding the source of Lipari, the sub-sources of Gabellotto and Canneto Dentro were recognized; regarding Pantelleria, the sub-sources of Balata dei Turchi, Lago di Venere 1 and Lago di Venere 2 were recognized. Each of the sub-sources has been defined by applying the aforementioned discriminating diagrams. Overall, about 85% of the obsidian artifacts tested in this study come from Lipari, and 15% from Pantelleria. For the Lipari obsidian all but a few come from the major Gabellotto geological source, while for Pantelleria most are from Balata dei Turchi, but some from the Lago di Venere geological sources [Tykot and Foresta Martin, 2017].

an exception: in the rest of prehistoric Sicily, the imports of obsidian from Lipari seemed to prevail by far. More recently, the results of XRF analyses on hundreds of archaeological obsidians, performed by Tykot and collaborators, have highlighted a geographical distinction relating the two main import sources of Lipari and Pantelleria: prehistoric settlements of Eastern Sicily made their imports exclusively from Lipari; while other settlements in Central-Western Sicily supplied themselves also from the Pantelleria outcrops, as well as from Lipari. The supply from Pantelleria was particularly abundant in a few settlements on the west coast of Sicily or in proximity to it; i.e. Pantelleria obsidian account for 79% of the lithics at the Grotta Maiorana of Paceco (Trapani) and 57% of the lithics at the inland site of Casalicchio (Agrigento). But in overall average, out of a total of 1882 obsidians analyzed by Tykot and belonging to 28 Sicily 's archaeological sites, about 93% are attributable to Lipari and 7% to Pantelleria [Tykot et al., 2013; Tykot, 2017a,b; Tykot and Foresta Martin, 2017].

Ustica, despite its location off the northwest coast of Sicily, seems to have been more open to commercial exchange with Pantelleria than many other Sicilian sites. We can assume that the trades with Lipari were made both through direct navigation (indeed on a clear day Aeolian islands are visible from Ustica and vice versa), or through exchanges mediated by the prehistoric settlements near Palermo. Trades with Pantelleria could only be carried through mediated exchanges, perhaps with the same Grotta dell'Uzzo or other settlements in the northwestern coast of Sicily, also these visible to the naked eye from Ustica, when the weather conditions are good. More in detail, Table 3 shows that when the number of specimens examined at Ustica is

Provenance / Site	Spalmatore	P.Cardoni	Culunnella	Faraglioni	Tram.Sopra	Oliastrello
Lipari/Gabellotto	25 (89,3%)	81 (84,4%)	3 (100%)	175 (88,4%)	201 (87%)	6 (54,5%)
Lipari/Canneto	0	0	0	0	0	0
Pantelleria/Bdt	1 (3,6%)	15 (15,6%)	0	20 (10,1%)	29 (12,6%)	5 (45,5%)
Pantelleria/Ldv1	2 (7,1%)	0	0	3 (1,5%)	0	0
Pantelleria/Ldv2	0	0	0	0	1 (0,4%)	0
Total	28 (100%)	96 (100%)	3 (100%)	198 (100%)	231 (100%)	11 (100%)

TABLE2. Provenance of 447 obsidian fragments collected in 6 different sites of Ustica. After Tykot and Foresta Martin, 2017.

This new extensive source analysis, while confirming the dominance of Lipari on imports of Ustica obsidians, also showed a consistency of trade from Pantelleria greater than first estimated. It is interesting to compare these data with what is known so far about the presence of obsidian from Lipari and Pantelleria in other archaeological Sicilian sites. We know from pioneering researches of Francaviglia and Piperno [1987] and Francaviglia [1988], that a large percentage (39%) of obsidian from Pantelleria with respect to Lipari was found in the Neolithic settlement of Grotta dell'Uzzo, in north-western Sicily, near Trapani. This was considered sufficiently high to give a significant statistical, the sourcing percentages of the sites are comparable [Tykot and Foresta Martin, 2017].

8. CONCLUSIONS

Extensive investigation on the origin of the archaeological obsidian collected in the island of Ustica, has led to the discovery that this tiny and lonely island north of Palermo, while achieving most of the imports of volcanic glasses from Lipari (85% and more), made also procurements from Pantelleria [Tykot, 1995] and occasionally from other distant sources, as the island of Palmarola in Latium [Foresta Martin et al., 2017]. Moreover, this evidence is in line with previous findings of a few ceramic shards of Apennine origin, which attest the participation of the Middle Bronze Faraglioni Village in the Tyrrhenian traffic and his contacts with the Italian peninsula [Spatafora and Mannino, 2008].

Geochemical characterization on hundredths of obsidian samples shows that the use of this material in the various archaeological sites of Ustica persisted from the Neolithic to Middle Bronze Age, without the decline that occurred in other contemporary settlements of Sicily [Tykot and Foresta Martin, 2017; Foresta Martin and Tykot, 2019]. For example, in the Middle Bronze Age Village of Portella di Salina, an Aeolian Island a few km away from the most exploited obsidian source of Lipari, the use of obsidian tools had already set in that period, and very few obsidian fragments have been found during the archaeological excavations [Martinelli, 2005]; while in the coeval Faraglioni Village of Ustica hundreds of *in stratu* and *on surface* obsidian fragments were collected [Holloway and Lukesh, 1995,2001].

All these considerations lead to the conclusion that the island of Ustica is proving to have been an unsuspected crossroads of obsidian trade in the Tyrrhenian Sea during the prehistory, from Neolithic to the Bronze Age.

Acknowledgements. Authors are gratefull to S. G. Rotolo, R. H. Tykot, F. Spatafora, V. Ailara, G. Calderaro, L. Tripoli and A. Russolillo for their precious collaboration and support that have made possible to carry on the complex researches on Ustica's obsidians. Authors are grateful to reviewers and editors, whose comments and suggestions improved this manuscript.

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