



Research Article

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Obsidian from the Site of Piano dei Cardoni, Ustica (Palermo, Italy): Preliminary Results on the First Occupation of the Island

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Abstract: New investigations on Ustica (Palermo, Sicily) originated from the need to improve our knowledge of the island's archaeological and environmental heritage. Through field surveys, particular attention was paid to human occupation in the Neolithic phases and focused on the less investigated southern side of the island. The systematic survey of the area of Piano dei Cardoni in 2018 brought to light a new Middle/Late Neolithic site, already partially documented in the literature. The island was settled for the first time during these phases, as also testified from the area of Punta Spalmatore. The presence of Serra d'Alto, incised dark burnished, and Diana styles suggests that the site and the archaeological assemblage dates from the mid to late 5th millennium BC, as confirmed by AMS dating. In addition to pottery, obsidian artifacts were also recovered, and a preliminary study of these materials is presented here. Portable XRF analyses on a sample of 41 obsidian artifacts, representing a high percentage of the lithic assemblage compared to chert tools, show that the provenance of the raw material is Gabelotto Gorge (Lipari) and Balata dei Turchi (Pantelleria). These results provide new insight into broader regional debates about obsidian technology and its exchange during the Neolithic and open an important consideration for sites that are far from the raw material sources.

Keywords: obsidian exploitation, island archaeology, Middle Neolithic, pXRF, Sicily

1 Introduction and Aims

New investigations on Ustica originated from the need to update knowledge on archaeological and environmental heritage, starting from systematic and non-systematic surveys of the area, with particular attention to human occupation in the Neolithic phases and focusing on the less investigated southern side of the island.

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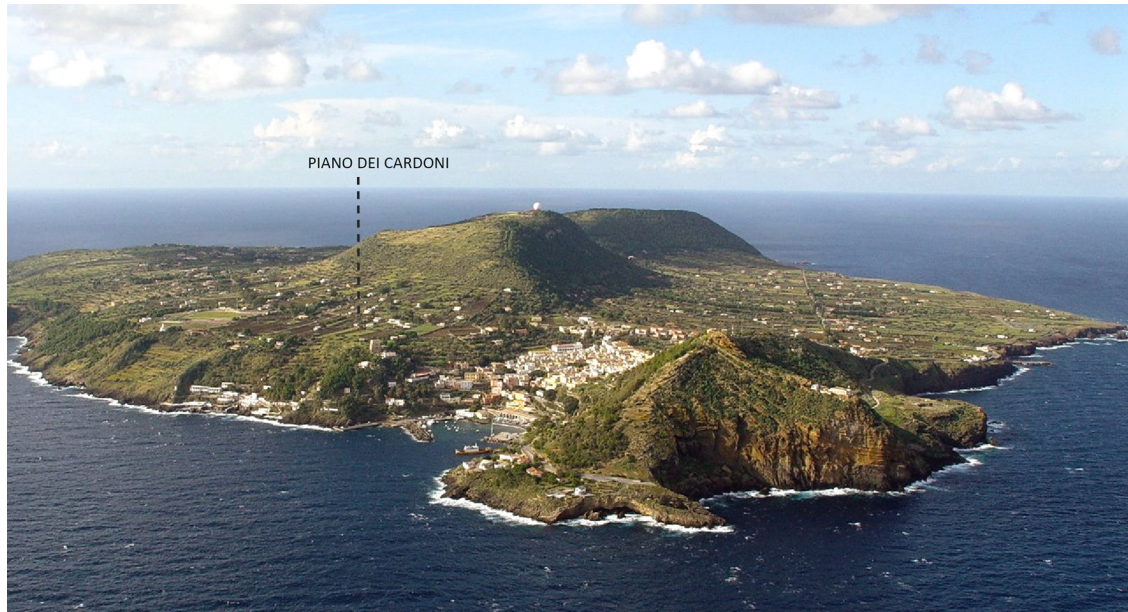


Figure 1: View of the island of Ustica from East and position of Piano dei Cardoni (Source: it.geonews.com).

Research on the island is developing in collaboration with the Section for Archaeological Heritage of the Superintendency of Cultural and Environmental Heritage Service of Palermo. They are a partner of the project Brains2islands, headed by the National Institute of Geophysics and Volcanology (INGV), Osservatorio Vesuviano. The broader project objectives are interdisciplinary and aim to understand the relationship between human settlement dynamics in the Southern Tyrrhenian Sea and geological and environmental variations from the Middle Holocene to today. Geographical, socio-economic, and cultural studies are the basis for understanding the “island landscape” of the volcanic islands (Aeolian, Ischia, Ustica, the Sulcitan archipelago) or close to volcanic areas such as Capri. The environmental risk to which they are subject is assessed using the topography and geology of the area together with the socio-cultural attributes.

Despite the rather small surface area of the island (less than 9 km²), the pre- to protohistoric settlement pattern of Ustica is not well-defined, especially due to the absence of stratigraphic contexts. Besides, the geomorphological characteristics of the island, mostly flat, allow a potential occupation of almost the entire surface (Figure 1).

Piano dei Cardoni (PDC) represents one of the most densely occupied areas in the pre- to protohistoric stages. Near the dock of Cala Santa Maria, its importance lies in its strategic position of control of the southern area of the island and the possibility of exploiting for agricultural purposes the whole marine terrace where it is located. It is the only area of the island that covers all the phases from the Middle Neolithic to the Middle Bronze Age. The archaeological context of PDC represents the first obsidian assemblage on the island from stratigraphic units, after the one of I Faraglioni Village (Middle Bronze Age). Here the first study performed on the lithic assemblage found in the excavation trench of 2018 is presented, with a preliminary typological investigation and associated analyses for obsidian provenance. This research, which is one of other papers in the same issue about Ustica (Foresta Martin, Larocca, Micheletti, Pallara, & Acquafredda, 2020a; Foresta Martin, Barca, & Posedi, 2020b; Tykot & Foresta Martin, 2020),¹ can be inserted in the wider research area linked to networks of so-called marginal islands (i.e. Dawson, 2020;

¹ All the articles are published in the Special Issue “The Black Gold That Came from the Sea. Advances in the Studies of Obsidian Sources and Artifacts of the Central Mediterranean Area,” edited by Franco Italiano, Franco Foresta Martin & Maria Clara Martinelli (part 1) <https://www.degruyter.com/journal/key/OPAR/6/1/html>

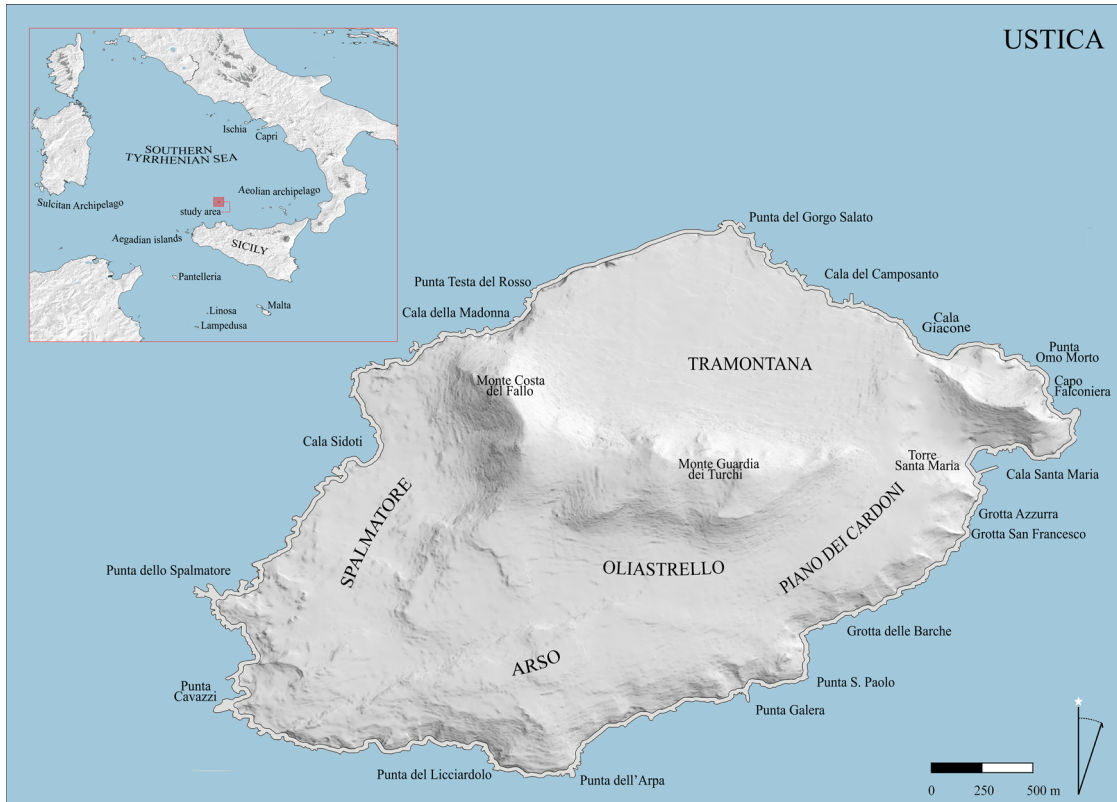


Figure 2: Ustica in the Southern Tyrrhenian and names of the areas of the island.

Knodell et al., 2020) and trade of obsidian in Southern Tyrrhenian (Freund, 2018; Martinelli, Tykot, & Vianello, 2019; Tykot, 2017, 2019; Tykot, Freund, & Vianello, 2013). The identification of this site and the results from the obsidian analysis open new and interesting questions about the role of the island of Ustica in the mid-5th millennium BC. Its position and insular territory may have played a preferential role in the settlement dynamics of the Middle/Late Neolithic and in the working and circulation of obsidian from the Aeolian islands.

1.1 Geographical and Geovolcanological Context

The island of Ustica (Figure 2) is located 60 km north of the Sicilian coast, west of the Aeolian arc, and represents the top of a huge submerged volcanic complex that rises more than 2,000 m from the bottom of the Southern Tyrrhenian Sea.

The emerged part of the Ustica volcano covers an area of fewer than 9 km² and reaches a maximum elevation of 248 m a.s.l., with the peak of Mt. Guardia dei Turchi in the central part of the island. It is mainly composed of volcanic rocks and subordinately of marine and continental sedimentary deposits. Volcanic rocks were produced by both subaqueous and subaerial effusive and explosive eruptions (Cinque, Civetta, Orsi, & Peccerillo, 1988; de Vita, 1993; de Vita, Guzzetta, & Orsi, 1995; de Vita, Laurenzi, Orsi, & Voltaggio, 1998; de Vita & Foresta Martin, 2017; Romano & Sturiale, 1971). Marine sedimentary rocks consist of clayey sands, organogenic and detrital fossiliferous limestones, and carbonate concretions. They were sedimented during the Middle-Upper Pleistocene sea-level high-stands, related to glacio-eustatic movements, which also generated five orders of marine terraces (de Vita & Orsi, 1994). Carbonate speleothems, landslide deposits, loose detrital fans, and aprons, sometimes pedogenized, are sedimentary deposits of continental origin, related to the more recent geomorphological evolution of the island (de Vita, 1993). Volcanism at

Ustica is considered to be extinct, as it was active during the Pleistocene (Barberi, Borsi, Ferrara, Innocenti, 1969; Barberi & Innocenti, 1980), with the presently exposed eruptive products dating between 750 and 130 ky (de Vita *et al.*, 1998; de Vita & Foresta Martin, 2017). As volcanism was no longer active after the last eruption occurred at 130 ky, it is reasonable to assume that humans had to interact only with the exogenous morphodynamic processes, which characterized the evolution of the island in more recent times and still active at the present. No exposed evidence of the sea-level rise that occurred since the Last Glacial Maximum is present on the island, as the related level surfaces are presently below sea-level, at a depth comparable with other equivalent features in stable areas of the Mediterranean (Furlani *et al.*, 2017).

The investigated area of this study is located in the southern part of the island, in the PDC countryside, which is a flat area that represents the evolution of a marine terrace, connected to the Mt. Guardia dei Turchi slopes through a talus deposit. This terrace occupies an ENE–WSW trending land-stripe, which develops between 80 and 120 m of elevation a.s.l., with a 5% mean slope. The terrace slightly dips eastward, due to its tectonic displacement. The formation of the terrace is related to a transgressive–regressive cycle of Crotonian age (isotopic stage 9; 350 ky BP; Shackleton & Opdyke, 1973), as testified by ^{230}Th radiometric age determinations on carbonate concretions (de Vita *et al.*, 1998). The terrace surface was tectonically displaced from its original position and the detrital blanket continued its evolution in a subaerial environment, with the formation of a thick paleosol that also includes large rounded boulders, formed by *in situ* spheroidal weathering of Mt. Guardia dei Turchi lava blocks (de Vita, 1993). The excavated site is situated above and within this last detrital deposit.

1.2 Archaeological Investigations on the Island (Figure 3)

Ustica has been occupied since the Middle Neolithic, as documented by the finds of Punta Spalmatore and – with less probability – Grotta Azzurra, for which the materials are attributed to the Middle Copper Age (Mannino, 1979; Mannino & Ailara, 2016). The site of the tourist village in Punta Spalmatore, although its layout has largely destroyed the prehistoric settlement, allowed for the recovery of obsidian and ceramic materials clearly framed at the middle and final phase of the Sicilian Neolithic (Mannino, 1998), allowing for the first time, in 1997, to record the occupation of the island in these phases.

The occupation during the Copper Age is testified not only by the caves San Francesco and Azzurra, on the southern side of the island (Mannino & Ailara, 2014, 2016), but also by Piano dei Cardoni (Spatafora, 2009, 2016, Spatafora & Mannino, 2008), with materials of the early and middle phase.

Finally, the island was occupied during the Bronze Age. Apart from the village of I Faraglioni (Holloway, 1997, 2003; Mannino, 1982; Spatafora, 2012, 2016), we can assume that during the Middle Bronze Age the occupation was broadly spread on the whole island, while from the Middle Neolithic throughout the Copper Age (5th millennium–3rd millennium BC) the island was only partially occupied.

Obsidian materials from the island were examined only in one stratigraphic context (I Faraglioni Village, Middle Bronze Age) (Tykot, 1995); all the other analyses were performed on materials from private collections or random surface materials, whose chronology, unfortunately, cannot be assessed on a typological basis (Foresta Martin *et al.*, 2016; Foresta Martin & La Monica, 2019; La Monica, Rotolo, & Foresta Martin, 2019; Tykot & Foresta Martin, 2020). Obsidian from Pirozza, Spalmatore, on the south–western side of the island, likely belongs to the Neolithic phase (Foresta Martin & Tykot, 2019), although in the same site pottery from the Bronze Age phase also was found (Mannino, 1998).

New research on the island stems from the need to improve our knowledge of the island's archaeological and environmental heritage, starting from an extensive survey of Ustica, with particular attention to human occupation in the Neolithic phases, to understand the distribution and chronology of activity of this period.

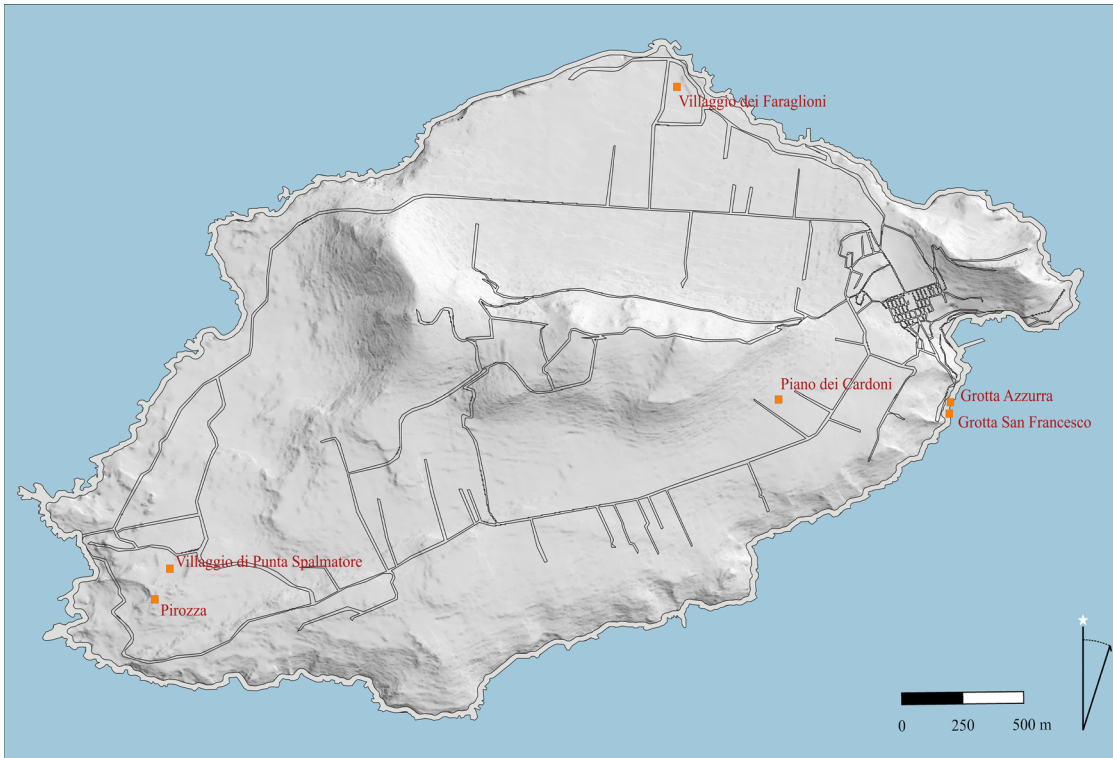


Figure 3: Name of the archaeological sites cited in the text.

2 The Archaeological Context

2.1 Methods

The archaeological field survey carried out on Ustica allowed us to verify and quantify known and unknown prehistoric sites through a selective strategy of sampling and a systematic fieldwalking activity (Bevan & Conolly, 2013; Francovich, Patterson, & Barker, 2000). Previous archaeological explorations occurred in the late 1990s when the Archaeological Heritage Department of Superintendency of Palermo undertook surveys using traditional methodologies to locate all the archaeological evidence of the island (Mannino & Ailara, 2016). The second step was to create a GIS platform, based on open-source software, which includes gathering and relating all these dates as maps, landscape layers, and existing and new archaeological evidence of Ustica.

Such a framework led to a clearer understanding of the archaeological potential of Ustica, guiding us towards a second more extensive and detailed survey of PDC, one of the most promising areas of the south-eastern part of the island. Following the varying shape and dimension of the modern fields, 78 material collection areas (MCA) were detected and each area was numbered and geotagged via a GPS smartphone on the Google Maps Android application. The distribution of archaeological materials (mostly lithics and pottery) was represented in a preliminary map of the density and distribution of materials using different intensity colours for each MCA. Subsequently, to exploit the archaeological potential of these large material scatters, one of the fields with a major presence of sherds was identified and chosen for a test trench of 1×1 m (area 1).



Figure 4: Position of the 2 excavation areas (area 1, 2017 and area 2, 2018–2019).

2.2 Results

After the first test trench in 2018 highlighted the presence of archaeological materials dating to the end of the Neolithic/beginning of the Copper Age and Middle Bronze Age, an area of about 36 sqm was opened in 2019 (area 2), to allow a further comprehension of the context. The sample pit was opened in a peripheral area of the concentration of archaeological materials (Figure 4).

The area revealed the presence of a settlement of about 20,000 sqm (2 ha), according to the distribution of the potsherds and obsidian artifacts. The area has an approximately oval shape and stands in the middle-upper part of the flat area derived from the marine terrace (see par. 2). The distribution of potsherds is quite similar in terms of density to the one of obsidian artifacts (Figure 5).

Unfortunately, archaeological layers were superficial, and most cultural evidence was probably destroyed, at least for the most recent phases.

The presence of a settlement is nonetheless confirmed and its features are still under reconstruction. Even though a clear floor layer has not yet been found, the site preserves some remains of wall structures mostly made by earthen elements, some pits, and several tools for daily activities (Figure 6). Pottery is represented by dark burnished ware, red burnished incised ware (Diana style), and painted ware (usually red-on-white, attributable to the style of Serra d'Alto). In terms of chronology, pottery is attributable to a Middle Neolithic/early phase of Late Neolithic, mid 5th millennium BC (Speciale, Larosa, Battaglia, & Vassallo, 2020a), with comparisons with north-western part of Sicily and Aeolian islands (see i.e. Cavalier, 1979; Martinelli & Quero, 2013; Tinè & Tusa, 2012; Traverso, 2012); pottery remains of a previous phase, attributable to the first half of 5th millennium, are present. The chronology of material culture is confirmed by 5 unpublished AMS datings (Beta Analytics Lab). Bioarchaeological remains (animal bones and vegetal remains) are quite preserved and under investigation.

The lithic assemblage is composed not only of obsidian tools, but also of chert (likely imported from the north-western area of Sicily) and a wide variety of lava millstones; they are mostly local volcanic rocks used

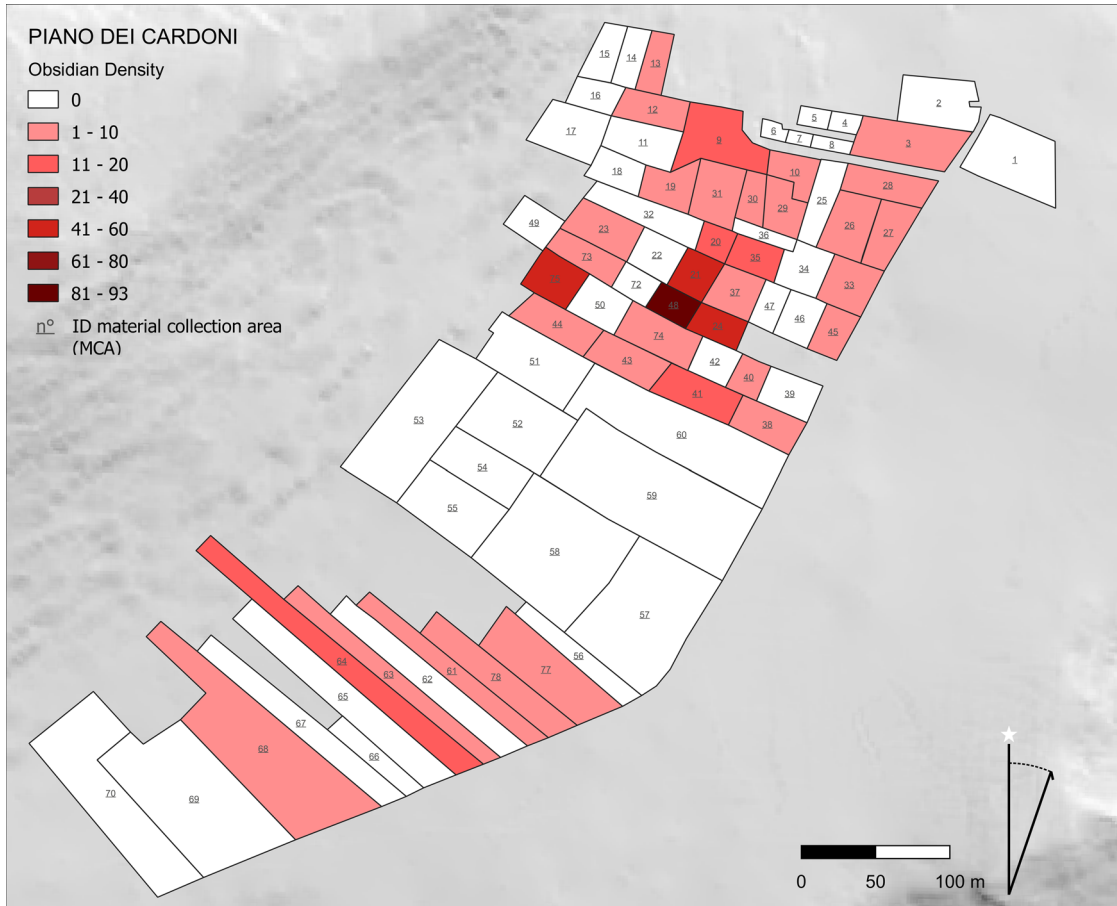


Figure 5: Surface distribution area of obsidian items collected in 2017–2018, from 0 (white) to dark red (93 items).

as mullers, querns, mortars, hatchets, pestles, and smoothing tools. Most of these raw materials were locally collected and likely originated in Monte Guardia dei Turchi, while some of the small hatchets were obtained by lava slabs originating in the area of Tramontana, on the northern side of the island (Speciale et al., 2020b).

3 Obsidian Assemblage

3.1 Methods

The functional study of lithic artifacts is still ongoing. A total of 41 obsidian artifacts were selected from the record of 2018 and 2019 investigations. Samples were taken from the most reliable stratigraphic units and also the surface, choosing both blades, bladelets, flakes, and debris. The visual analysis of macroscopic physical features included the observation of the fragments in white, reflected light. Samples were then analysed by K. Freund using a Bruker Tracer 5 g pXRF instrument (provided by R. Tykot) operating at 50 kV and 35 μ A for 90 s and using a filter that enhances precision for trace elements (Rb, Sr, Zr, and Nb) already shown to be successful for central Mediterranean obsidian sourcing (see Freund, Tykot, & Vianello, 2015; Freund, Tykot, & Vianello, 2017; Tykot et al., 2013; Tykot, 2019). Source assignments were achieved by calibrating the raw analytical data against standard obsidian reference materials to determine the actual concentrations; the results then being compared with data generated from Mediterranean geological



Figure 6: Area 2, view from North-East.

obsidian samples using the same instrumentation. More detailed information on the use of this pXRF is provided in Tykot and Foresta Martin (2020, this Special Issue).

3.2 Results: Obsidian Technology and Composition

In the PDC site, 37 obsidian items have been randomly collected from surface soil deposit and another 19 obsidian items have been found from the 2018 survey at “field n.64” located in the PDC area.

From the PDC stratigraphic excavation of 2018, a total of 102 obsidian items, including tools, fragments, and technological waste products, have been found; the excavation of 2019 added other 905 items to the record. Broken blades and bladelets, flakes and flake fragments, microliths, broken scrapers, chips, and angular waste attest that the production of the obsidian lithic industry took place at the site. Bulb percussion analysis suggests that the knapping process was by direct percussion through a hard hammer. The only residual core, a simple bidirectional one and almost completely exhausted, found at PDC shows bidirectional knapping through direct percussion. Most knapped obsidian production found from stratigraphic units at PDC reflects the need for regular blade and bladelet production.

Obsidian lithic analysis is ongoing using of soil microelement analysis and surface alteration wear to detect artifact function and life cycle(s). A preliminary analysis on some obsidian blade fragments highlights a relation to vegetal and faunal processing. From a techno-typological point of view, the 41 obsidian artifacts sampled can be classified mainly as blade fragments: eleven are proximal, eight mesial, and four are distal. Six artifacts are related to angular waste (or debitage) and nine are undetermined fragments. Seven artifacts, finally, show a simple marginal retouch that the micro-wear analysis will define as intentional or merely the result of use wear. One burin is also present (Figure 7).

The majority of the sample is grey to black in colour and shows a medium to high transparency index: 3–5 on a scale from 0 to 5; observed in white, transmitted light, this group exhibit a grey or light-grey colour



Figure 7: Piano dei Cardoni obsidian assemblage: Selection of 19 artifacts from Lipari source and two from Pantelleria source (18.7 and 18.2).

(Table 1). Only seven artifacts show phenocrysts (millimetric spherical structures). Of the three artifacts, characterized by a transparency index equal to 0, two (2018.2 and 2018.7), exposed to an intense white light, exhibit a greenish colour filtering through at the thinner edges, allowing us to hypothesize a provenance from Pantelleria, at a mere visual observation (Foresta Martin & Tykot, 2019), lately confirmed by pXRF analysis as further explained.

The obsidian findings from the PDC stratigraphic excavation are of good source quality, while from the surface findings lower quality obsidian raw material is attested. Of the 41 analysed artifacts employing the pXRF, 39 can be traced to the Gabelotto Gorge sub-source on the island of Lipari. None of these artifacts originated from Canneto Dentro. Two artifacts in the assemblage came from Pantelleria, both from the Balata dei Turchi sub-source. Analytical data are in Table 2. Nevertheless, the two obsidian items from Pantelleria are from a surface collection and cannot be attributed to a specific time period.

4 Discussion

4.1 Obsidian and Its Significance in the Site

The presence of obsidian at the site, whose occupation spans about 400 to 500 years, is quite impressive. There is no evidence so far of seasonal occupation and all the data point to a year-round settlement. Ongoing bioarchaeological analyses testify to a varied economy, based on agricultural production (attested also by the relatively large number of querns, mortars, etc.) as well as the great exploitation of animal sources (both domestic mammals than avi- and ittio-faunas). Wear analysis will reveal the degree to which obsidian was used in these activities. Obsidian may have been selected for specific activities, due to its properties compared to chert.

Table 1: Visual features of the Piano dei Cardoni obsidian artifacts (the transparency index is expressed in a scale from 0 to 5)

Sample	Description	Colour	Phenocrysts	Transparency	Worked
2019-1	Blade M F	Black	N	3	Y
2019-2	Blade P F	Black	N	3	N
2019-3	Blade P F	Black	N	4	Y
2019-4	Angular waste	Black	N	4	N
2019-5	Angular waste	Black	N	0	N
2019-6	Angular waste	Black	N	3	N
2019-7	Burin	Dark-grey	N	3	Y
2019-8	F	Dark-grey	N	4	N
2019-9	Blade P F	Dark-grey	N	2	N
2019-10	Angular waste	Black	N	2	N
2019-11	Blade P F	Dark-grey	N	3	N
2019-12	Blade M F	Dark-grey	N	3	N
2019-13	Blade D F	Dark-grey	N	5	Y
2018-2	Blade P F	Black-green	N	1	Y
2018-7	Retouched F	Black-green	N	0	N
2018-18	Blade M F	Black	N	4	N
2018-19	F	Dark-grey	N	5	N
2018-20	Angular waste	Black	N	3	N
2018-21	Angular waste	Black	N	3	N
2018-22	Blade P F	Black	Y	3	N
2018-23	F	Black	N	4	N
2018-24	Blade P F	Black	N	4	N
2018-25	Blade M F	Dark-grey	N	5	N
2018-26	Blade M F	Dark-grey	N	4	N
2018-27	Blade M F	Dark-grey	N	3	N
2018-28	Blade P F	Black	Y	4	N
2018-29	Blade M F	Dark-grey	N	3	N
2018-30	F	Black	N	4	N
2018-53	Blade D F	Dark-grey	N	3	N
2018-54	Retouched F	Black	N	2	Y
2018-63	F	Dark-grey	N	3	N
2018-64	Blade D F	Dark-grey	Y	3	N
2018-65	Blade P F	Black	Y	3	N
2018-108	F	Dark-grey	N	3	N
2018-109a	Blade D F	Black	N	3	N
2018-111	Blade P F	Dark-grey	N	5	N
2018-112	Blade M F	Dark-grey	Y	3	N
2018-113	Blade P F	Black	N	4	Y
2018-114	Blade P F	Black	N	4	N
2018-115	F	Dark-grey	Y	4	N
2018-116	F	Dark-grey	Y	4	N

F = fragment; P = proximal; M = mesial; D = distal; Y = yes; N = no.

The occupation of the island during the Neolithic is concentrated so far to the area of PDC and Spalmatore, even if the exploitation of the resources of the whole island was probably very easy due to the reduced area. Ustica is far away from raw material sources, and as such has interesting implications for our understanding of regional patterns of exploitation of obsidian from the Neolithic to the Bronze Ages. Contexts with imported lithic raw materials are potential places to observe technological adaptation and variability/changes, as the uncertainty of access to lithic resources is one main factor that determines the technological production strategy (see e.g. Gaffney & Summerhayes, 2019).

The stratigraphical data for the two items from Pantelleria sources being absent, for the site of PDC we have a 100% provenance from Gabellotto source for the Middle/Late Neolithic phase (Figure 8).

Table 2: Results of pXRF analyses from 41 obsidian items of Piano dei Cardoni

Cat. #	USF Lab #	Fe	Rb	Sr	Y	Zr	Nb	Source	Sub-source
Ustica 2019-1	38522	17318	283	18	47	154	36	Lipari	Gabellotto
Ustica 2019-2	38523	16924	282	16	48	148	37	Lipari	Gabellotto
Ustica 2019-3	38524	21982	341	19	55	168	39	Lipari	Gabellotto
Ustica 2019-4	38525	17273	269	15	49	152	34	Lipari	Gabellotto
Ustica 2019-5	38526	15685	315	14	42	150	33	Lipari	Gabellotto
Ustica 2019-6	38527	15154	306	17	46	158	37	Lipari	Gabellotto
Ustica 2019-7	38528	18944	349	17	44	157	38	Lipari	Gabellotto
Ustica 2019-8	38529	15836	268	18	46	151	36	Lipari	Gabellotto
Ustica 2019-9	38530	16640	275	16	47	152	35	Lipari	Gabellotto
Ustica 2019-10	38531	18211	296	19	51	165	35	Lipari	Gabellotto
Ustica 2019-11	38532	19241	308	19	52	164	39	Lipari	Gabellotto
Ustica 2019-12	38533	12291	280	16	45	150	35	Lipari	Gabellotto
Ustica 2019-13	38534	16550	271	21	50	195	35	Lipari	Gabellotto
Ustica 2018-2	38535	79957	169	9	165	1611	387	Pantelleria	Balata dei Turchi
Ustica 2018-7	38536	83163	174	8	166	1609	410	Pantelleria	Balata dei Turchi
Ustica 2018-18	38537	15800	266	16	47	151	36	Lipari	Gabellotto
Ustica 2018-19	38538	16173	282	17	49	153	34	Lipari	Gabellotto
Ustica 2018-20	38539	19480	272	26	46	147	33	Lipari	Gabellotto
Ustica 2018-21	38540	16657	275	15	47	150	35	Lipari	Gabellotto
Ustica 2018-22	38541	18900	352	21	43	158	37	Lipari	Gabellotto
Ustica 2018-23	38542	17380	303	30	53	168	35	Lipari	Gabellotto
Ustica 2018-24	38543	17063	291	16	44	152	38	Lipari	Gabellotto
Ustica 2018-25	38544	16236	277	15	48	150	35	Lipari	Gabellotto
Ustica 2018-26	38545	17774	309	17	50	160	37	Lipari	Gabellotto
Ustica 2018-27	38546	17580	295	19	63	163	35	Lipari	Gabellotto
Ustica 2018-28	38547	14754	324	19	51	167	37	Lipari	Gabellotto
Ustica 2018-29	38548	16329	297	19	52	162	36	Lipari	Gabellotto
Ustica 2018-30	38549	18845	374	22	55	172	37	Lipari	Gabellotto
Ustica 2018-53	38550	19161	317	19	48	159	37	Lipari	Gabellotto
Ustica 2018-54	38551	15709	322	16	42	150	34	Lipari	Gabellotto
Ustica 2018-63	38552	15597	312	19	49	160	36	Lipari	Gabellotto
Ustica 2018-64	38553	18706	309	17	48	156	36	Lipari	Gabellotto
Ustica 2018-65	38554	20736	327	20	51	164	36	Lipari	Gabellotto
Ustica 2018-108	38555	19181	281	22	47	153	35	Lipari	Gabellotto
Ustica 2018-109°	38556	16769	284	16	46	149	34	Lipari	Gabellotto
Ustica 2018-109b	38557	15620	276	15	45	147	36	Lipari	Gabellotto
Ustica 2018-111	38558	12248	286	16	47	152	34	Lipari	Gabellotto
Ustica 2018-112	38559	15659	267	19	48	153	34	Lipari	Gabellotto
Ustica 2018-114	38560	15682	260	16	48	150	33	Lipari	Gabellotto
Ustica 2018-115	38561	18630	346	18	46	162	36	Lipari	Gabellotto
Ustica 2018-116	38562	18565	292	18	49	158	35	Lipari	Gabellotto

Obsidian in Ustica for all chronological phases comes from Pantelleria and Lipari, with a single exception from Palmarola (Foresta Martin et al., 2016).

Obsidian from the unexcavated area of Pirozza-Spalmatore, the Neolithic/Copper Age site on the western part of the island, records an origin from Lipari-Gabellotto (89%) and Pantelleria-Balata dei Turchi and Lago di Venere (11%) (Foresta Martin & Tykot 2019). Considering the origin of obsidian on the island during the Bronze Age, artifacts from the I Faraglioni Village (Middle Bronze Age) were analysed; also, during this late phase, obsidian on the island was imported from Lipari and Pantelleria (Tykot et al., 2013; Tykot, 1995; Tykot & Foresta Martin, 2020, this Special Issue).

Analysing the lithic assemblage as a whole, the high incidence of obsidian tools in the lithic complex of PDC (92% of the assemblage, 8% of chert tools) is quite high for the average of the obsidian assemblages of

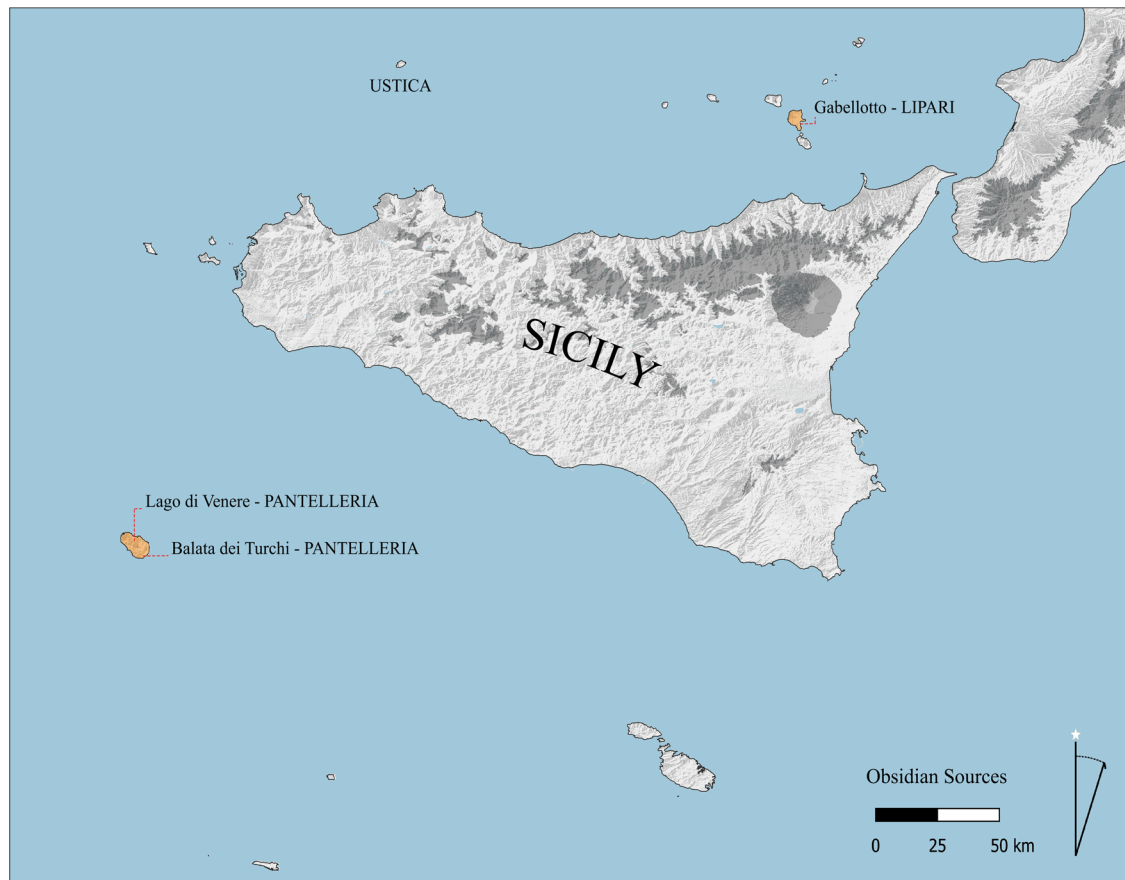


Figure 8: Position of the obsidian sources in Southern Tyrrhenian.

the same phase (6th–5th millennium BC) from sites distant to the sources (Freund, 2018). One must consider, nevertheless, that Ustica is far also from chert quarries, as it was probably imported from north-western Sicily; so Ustica is a key site for the interpretation of lithic assemblages because both main lithic raw resources were required to be moved from other territories beyond the sea. It is also possible to take into account a preferential channel of exchange and communication with the Aeolian archipelago during these first phases of the occupation of the island. Finally, it is likely that obsidian was imported as a raw material to the island, as testified by the outstanding number of big, medium, and small fragments (sometimes detected only by the 0.5 mm mesh) that testify to knapping on the site. Analysis of chert technology is still ongoing, but the presence of debris of medium and small size is detected as for obsidian.

4.2 Archaeological Interpretation of the Data (Figure 9)

Ustica is not close to the obsidian sources (about 150 km far away from Lipari – but only 120 km from Alicudi – and about 250 km from Pantelleria). It is possible that its link through maritime connections was direct to Aeolian sources. The route through the Sicilian coast (about 30 km from Lipari to Capo d’Orlando, 160 km from there to Capo Gallo/Palermo, and then 60 km to Ustica) seems unlikely in terms of effort, but not to exclude at this phase of the investigation.

Furthermore, prevalent currents of the Mediterranean show a predominance of dynamics from west to east (El-Geziry & Bryden, 2010; Millot & Taupier-Letage, 2005), making the sailing routes from Ustica to the Aeolian Islands easier, which are also more clearly visible due to their altitude (up to 987 m a.s.l. of Salina), at the opposite of Ustica that is more rarely visible from the coast or the archipelago. No data on sailing are

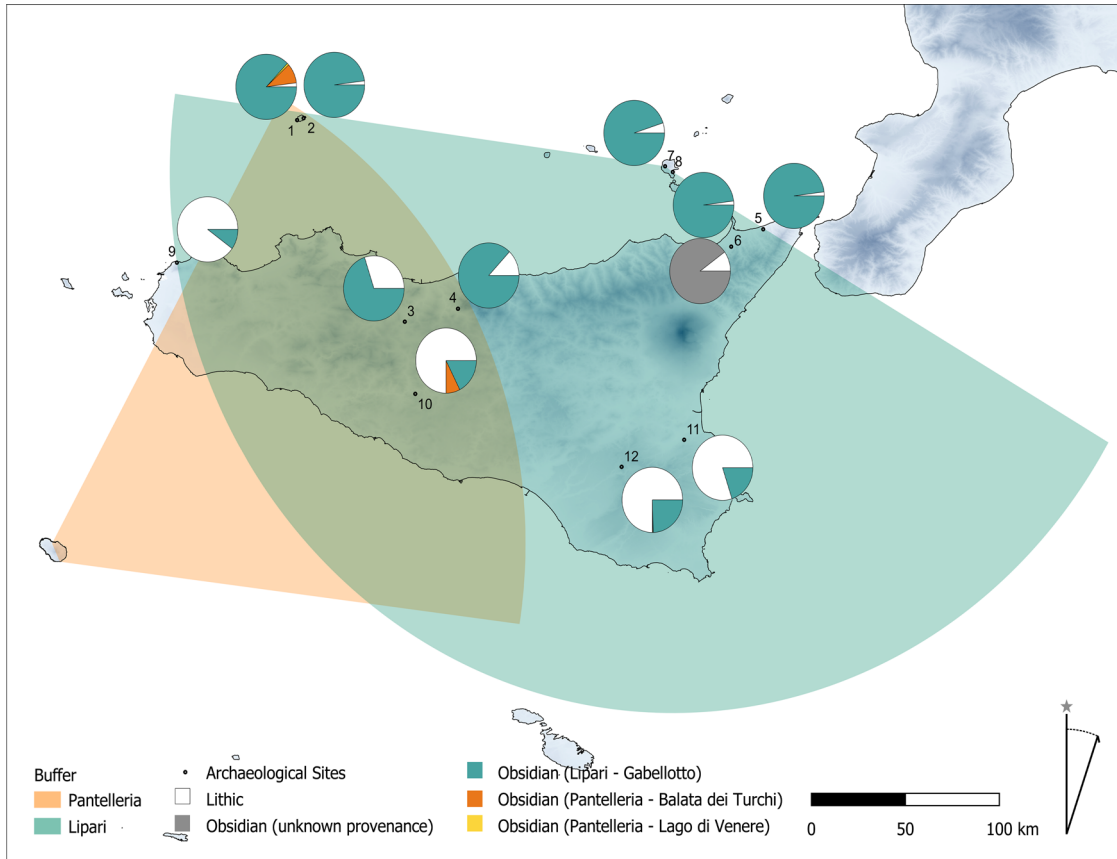


Figure 9: The figure is related to Table 3. 1 – Piano dei Cardoni, Ustica; 2 – Spalmatore, Ustica; 3 – Roccapalumba; 4 – Vallone Inferno, Scillato; 5 – San Martino, Spadafora; 6 – Contrada Limina, Barcellona P. G.; 7 – Castellaro, Lipari; 8 – Diana, Lipari; 9 – Grotta Bonagia, Crocefissello; 10 – Serra del Palco, Milena; 11 – Colle Tirone, Lentini; 12 – Via Capuana, Licodia Eubea.

available for the Neolithic of the Mediterranean (nor archaeological data from shipwrecks or representation of sailing means), despite the fact that obsidian collection in the broader Mediterranean is documented since the 11th millennium (Broodbank, 2006). A sailing route from Ustica to Palermo is possible within 2 days of favourable weather conditions, assuming that a paddle-propelled craft was used (Broodbank, 2013). Longer and harder was the sailing from Ustica to the Aeolian islands (or even worse the opposite), considering a full day of at least 12–13 h during the good season (searoutes.com). Ustica-Pantelleria is not a sea route to consider without at least a stop, and getting to Pantelleria, given the distance from Sicily, was probably as hard as getting from Alicudi to Ustica, more or less being the same distance. More experimental data would be necessary for detailed estimations.

Obsidian assemblages and their typology, together with pottery typologies, testify that the Neolithic “package” arrived at Ustica for the first time through contact with the Aeolian islands. It is to pay particular attention to the quality (and the sources) of obsidian raw materials and to the potential tasks for which it was designed. While the existence of itinerant specialists is possible, the current data suggest that the initial procurement and subsequent redistribution of Lipari obsidian were undertaken by a select number of communities who had the capacity to organize and crew long-distance voyages to the quarry sites (Freund, 2018).

The site was compared with some selected excavated sites of the end of 6th and 5th-millennium in Sicily where data about lithic assemblage were available, as shown in Figure 9. The sites are open-air and caves. It is quite evident that chert is the favourite material for south-eastern, central, and western Sicily.

Gabellotto in Lipari is undoubtedly the main source of obsidian in Sicily and southern Italy during the 5th millennium BC. It is almost the only source of obsidian from the Neolithic site of Contrada Diana in

Table 3: Lithic assemblages from the 2nd half of 6th–5th millennium Sicilian sites

No.	Name	Chronology	Obsidian (%)	Lithic (chert) (%)	Gabelotto (%)	Lago Venere (%)	Bal. Turchi (%)	Distance from Pantelleria (km)	Distance from Lipari (km)	No. obsidian analyzed	References
1	Spalmatore – Ustica	Mid 5th mill.?	—	—	89	<1	10	250	160	28	Foresta Martin & Tykot, 2019
2	Cardoni – Ustica	Second half 5th mill.	98	2	100	0	0	250	160	40	This paper
3	Roccapalumba	Mid 5th mill.	70	30	100	0	0	180	140	34	Italiano <i>et al.</i> , 2018;
4	Vallone Inferno – Scillato	Second half 6th mill.	87	13	100?	—	—	200	110	7	F. Ianni <i>pers. Comm.</i>
5	San Martino – Spadafora	5th mill.	98	2	100?	0?	0?	330	55	None	Forgia, 2019; Vianello & Tykot, 2016
6	Contrada Limina – B. P. di Gotto	First half 5th mill.	>90	<10	—	—	—	315	50	None	Quero <i>et al.</i> , 2019
7	Castellaro – Lipari	First half 5th mill.	>95	<5	100	0	0	320	4	(150)	Genovese, 1978
8	Diana – Lipari	End 5th mill.	>98	<2	100	0	0	320	3	(150)	Bernabò Brea & Cavalier, 1957;
9	Grotta Bonagia – Crocefissello, TP	End 5th mill.	10	90	100?	0?	0?	145	215	None	Martinelli <i>et al.</i> , 2019;
10	Serra del Palco – Milena	5th mill. to beginning 4th mill.	20–30	70–80	70?	0?	30?	170	160	15	Nomi & Speciale, 2017
11	Colle Tirone – Lentini	First half 5th mill.	20	80	100?	0?	0?	270	140	None	Martinelli <i>et al.</i> , 2019
12	Via Capuana, Licodia Eubea	End 5th mill.	25	75	98?	1?	1?	240	150	691	Moscoloni & Ruggini, 2012

By “lithic” is listed the percentage of lithic artifacts such as chert; “distance” is the linear distance between two places; when number of obsidian samples is in bracket, it is an approximate number.

Lipari (Martinelli et al., 2019). Comparing the data of provenance in the sites of mainland Sicily, according to scanning electron microscopy (SEM-EDX) and inductively coupled plasma mass spectrometry (LA-ICP-MS) analyses, obsidian from Roccapalumba (in central Sicily, around 40 km south of Palermo) has a unique origin from Gabelotto, Lipari (Italiano et al., 2018); in Roccapalumba, besides the tools, many cores are present (Mannino, 2012), differently from PDC. For other sites of mountainous northern Sicily, Lipari represents the main source (Forgia, 2019). At the present moment, there are very few Neolithic sites in western Sicily with obsidian (i.e. Grotta dell'Uzzo, Francaviglia & Piperno, 1987, where a high percentage of Pantellerian obsidian is recorded). In general, in western Sicily there is a mix of provenance from Balata dei Turchi and Lipari sources, while in eastern Sicily Lipari obsidian is nearly exclusive (Freund et al., 2017; Pappalardo et al., 2013; Quero, Martinelli, & Giordano, 2019). It is possible that Ustica was a centre of import and production of obsidian tools and its percentage, quite similar to the sites close to the sources like Lipari and northern Sicily, makes it an unusual far-from-the-quarry site, identifying it as a hybrid site, with very close contacts to Aeolian Islands; basically, a direct destination of Aeolian obsidian exploitation before distributing it to other sites in Western Sicily and/or Central Sicily.

Observing the distribution of the percentages, Ustica could be a node of the “down-the-line” system for the spread of raw materials towards western Sicily (see, i.e. Sardinian obsidian towards Southern France, Freund & Batist, 2014). It is so far difficult to find direct contacts between Ustica and central Sicily which could justify some dynamics in the spread of the obsidian raw sources and it is more likely to separate the two lines, one directly through the bridge of Aeolian islands to Ustica and one from Lipari through northern Sicily towards central Sicily. Less easy to identify is the route through which Pantelleria obsidian could have been brought to Ustica – if the 2 pantescan samples collected from the surface belong to the Neolithic phase – although a route through western Sicily is probable. Occupation of Pantelleria island for the exploitation of obsidian sources is still quite unexplored (Cattani & Tusa, 2012), despite a change in the coastal level that could hide a very early occupation of the island since the Early Neolithic, maybe for the exploitation of obsidian (Abelli et al., 2016).

Obsidian in PDC is the main exotic good recorded on the site. Production of pottery with local materials is recorded and exploitation of local volcanic rocks for grinding tools is clear in the settlement (Speciale et al., 2020b). Of course, it is not possible to establish at this stage of the investigation if obsidian was the primary and/or only material or if it was a complement to other exchanged goods. At the same time, Ustica resources, such as volcanic millstones or pottery, could be traded to north-western Sicily and exchanged for chert resources or other goods. Moreover, compared to the rest of the lithic assemblage, obsidian prevails in northern Sicily, while in south-eastern Sicily, where obsidian sources are less reachable and chert sources are quite available, the ratio is the opposite.

5 Conclusion

The new data from the site of PDC confirm that the island was widely occupied since the end of the Middle Neolithic period. Ustica operated within a network of exchange of different raw materials and objects, and obsidian was undoubtedly one of the most important ones. Despite the wide use of local volcanic rocks for millstones and axes, easily collectible near PDC or on the northern side of the island, the conspicuous and heterogeneous lithic assemblage shows a fundamental reliance on lithic resources from Lipari. The volcanic origin of Ustica and the absence both of chert and obsidian make it a hybrid place, far from the access to all of these lithic sources that were imported through the sea from Lipari and, maybe in minor part, from Pantelleria, but probably also from the area of Palermo for the chert. Nevertheless, the prevalence of obsidian in the lithic assemblage (more than 92%) makes PDC's percentage similar to the close-to-the-source sites. Further investigations and a more detailed typological investigation are required to understand the role of Ustica in the network distribution of the raw material towards northwestern Sicily.

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References

- Abelli, L., Agosto, M. V., Casalbore, D., Romagnoli, C., Bosman, A., Antonioli, F., ... Chiocci, F. L. (2016). Marine geological and archaeological evidence of a possible pre-Neolithic site in Pantelleria Island, Central Mediterranean Sea. In J. Harff, G. Bailey, & F. Lüth (Eds.), *Geology and Archaeology: Submerged Landscapes of the Continental Shelf* (Special Publications, Vol. 411, pp. 97–110). London: Geological Society. doi: 10.1144/SP411.6.
- Barberi, F., Borsi, S., Ferrara, G., & Innocenti, F. (1969). Strontium isotopic composition of some recent basic volcanites from southern Tyrrhenian sea and Sicily Channel. *Contributions to Mineralogy and Petrology*, 23, 157–172.
- Barberi, F., & Innocenti, F. (1980). Volcanisme Neogène et Quaternaire. Guide a l'excursion 122-A. *Società Italiana di Mineralogia e Petrologia*, 99–104.
- Bernabò Brea, L., & Cavalier, M. (1957). Stazioni preistoriche delle isole Eolie I. La stazione stentinelliana di Castellaro Vecchio presso Quattropani (Lipari); II. Stazioni preistoriche di Piano Conte sull'altipiano di Lipari. *Bullettino di Paleontologia Italiana*, 66, 97–151.
- Bevan, A., & Conolly, J. (2013). *Mediterranean Islands, Fragile Communities and Persistent Landscapes: Antikythera in Long-Term Perspective*. Cambridge: Cambridge University Press.
- Boscaino, A., D'Amora, A., Nicoletti, F., Trifuoggi, M., & Tusa, S. (2012). Indagini sulla caratterizzazione e la provenienza delle ossidiane di Serra del Palco (CL). In *Atti della XLI riunione scientifica: Dai ciclopi agli ecisti: società e territorio nella Sicilia preistorica e protostorica, San Cipirello (PA), 16–19 novembre 2006* (pp. 569–578). Firenze: Società e territorio nella Sicilia preistorica e protostorica.
- Broodbank, C. (2006). The origins and early development of Mediterranean maritime activity. *Journal of Mediterranean Archaeology*, 19(2), 199–230. doi: 10.1558/jmea.2006.v19i2.199.
- Broodbank, C. (2013). *The Making of the Middle Sea*. London: Thames and Hudson.
- Cattani, M., & Tusa, S. (2012). Paesaggio agro-pastorale e spazio rituale nell'età del Bronzo a Pantelleria. In *Atti della XLI riunione scientifica: Dai ciclopi agli ecisti: società e territorio nella Sicilia preistorica e protostorica, San Cipirello (PA), 16–19 novembre 2006* (pp. 803–816). Firenze: Società e territorio nella Sicilia preistorica e protostorica.
- Cavalier, M. (1979). Ricerche preistoriche nell'arcipelago eoliano. *Rivista di Scienze preistoriche*, 34(1–2), 45–136.
- Cinque, A., Civetta, L., Orsi, G., & Peccerillo, A. (1988). Geology and geochemistry of the island of Ustica (Southern Tyrrhenian sea). *Rendiconti della Società italiana di Mineralogia e Petrografia*, 43, 987–1002.
- Dawson, H. (2020). Network science and island archeology: Advancing the debate. *The Journal of Island and Coastal Archaeology*. doi: 10.1080/15564894.2019.1705439.
- de Vita, S. (1993). *Assetto geologico-strutturale ed evoluzione vulcanologica dell'isola di Ustica (stratigrafia, tettonica e meccanismi eruttivi)* (PhD Thesis). Napoli: Università degli Studi di Napoli "Federico II".
- de Vita, S., & Foresta Martin, F. (2017). The palaeogeographic setting and the local environmental impact of the 130 ka Falconiera tuff-cone eruption (Ustica island, Italy). *Annals of Geophysics*, 60(2), S0224.
- de Vita, S., Guzzetta, G., & Orsi, G. (1995). Deformational features of the Ustica volcanic area in the Southern Tyrrhenian Sea (Italy). *Terra Nova*, 7, 623–629.
- de Vita, S., Laurenzi, M. A., Orsi, G., & Voltaggio, M. (1998). Application of $^{40}\text{Ar}/^{39}\text{Ar}$ and ^{230}Th dating methods to the chronostratigraphy of Quaternary basaltic volcanic areas: The Ustica island case history. *Quaternary International*, 47/48, 117–127.
- de Vita, S., & Orsi, G. (1994). I terrazzi marini dell'isola di Ustica (Mar Tirreno Meridionale, Italia). *Memorie Descrittive della Carta Geologica D'italia*, 52, 405–406.
- El-Geziry, T. M., & Bryden, I. G. (2010). The circulation pattern in the Mediterranean Sea: Issues for modeller consideration. *Journal of Operational Oceanography*, 3(2), 39–46.
- Foresta Martin, F., Di Piazza, A., D'oriano, C., Carapezza, M. L., Paonita A., Rotolo S. G., & Sagnotti, L. (2016). New insights into the provenance of the obsidian fragments of the island of Ustica (Palermo, Sicily). *Archaeometry*, 59(3), 435–454.
- Foresta Martin, F., & La Monica, M. (2019). The Black Gold that came from the sea. A review of obsidian studies at the island of Ustica, Italy. *Annals of Geophysics*, 62(1), VO14.

- Foresta Martin, F., & Tykot, R. H. (2019). Characterization and provenance of archaeological obsidian from Pirozza-Spalmatore, a site of Neolithic colonization on the island of Ustica (Sicily). *Open Archaeology*, 5(1), 4–17. doi: 10.1515/opar-2019-0002.
- Foresta Martin, F., Larocca, F., Micheletti, F., Pallara, M., & Acquafredda, P. (2020a). Archaeometric characterization of obsidian artifacts at Casa dei Francesi (Ustica Island, Italy) and clues of a hidden prehistoric settlement. *Open Archaeology*, 6(1), 236–247. doi: 10.1515/opar-2020-0111.
- Foresta Martin, F., Barca, D., & Posedi, I. (2020b). Evidencing human occupation of a small island through ancient glass: The case of Ustica (Palermo, Italy). *Open Archaeology*, 6(1), 124–150. doi: 10.1515/opar-2020-0108.
- Forgia, V. (2019). *Archaeology of Uplands on a Mediterranean Island. The Madonie Mountain Range in Sicily*. Palermo: UNIPA Springer Series.
- Francaviglia, V., & Piperno, M. (1987). La répartition et la provenance de l'obsidienne archéologique de la Grotta dell'Uzzo et de Monte Cofano (Sicile). *ArchéoSciences, revue d'Archéométrie*, 11, 31–39.
- Francovich, R., Patterson, H., & Barker, G. (2000). *The Archaeology of Mediterranean Landscapes 5: Extracting Meaning from Ploughsoil Assemblages*. Oxford: Oxbow Books.
- Freund, K. P. (2018). A long-term perspective on the exploitation of Lipari obsidian in central Mediterranean prehistory. *Quaternary International*, 468, 109–120. doi: 10.1016/j.quaint.2017.10.014.
- Freund, K. P., & Batist, Z. (2014). Sardinian obsidian circulation and early maritime navigation in the Neolithic as shown through social network analysis. *The Journal of Island and Coastal Archaeology*, 9(3), 364–380.
- Freund, K. P., Tykot, R. H., & Vianello, A. (2015). Blade production and the consumption of obsidian in Stentinello period Neolithic Sicily. *Comptes Rendus Palevol*, 14, 207–217.
- Freund, K. P., Tykot, R. H., & Vianello, A. (2017). Contextualizing the role of obsidian in Chalcolithic Sicily (c. 3500–2500 BC). *Lithic Technology*, 41(1), 35–48.
- Furlani, S., Antoniolli, F., Cavallaro, D., Chirco, P., Caldarelli, F., Foresta Martin, F., ... Agate, M. (2017). Tidal notches, coastal landforms and relative sea-level changes during the Late Quaternary at Ustica Island (Tyrrhenian Sea, Italy). *Geomorphology*, 299, 94–106. doi: 10.1016/j.geomorph.2017.10.004.
- Gaffney, D., & Summerhayes, G. R. (2019). Coastal mobility and lithic supply lines in northeast New Guinea. *Archaeological and Anthropological Sciences*, 11, 2849–2878. doi: 10.1007/s12520-018-0713-8.
- Genovese, P. (1978). Tracce di un insediamento neolitico stentinelliano a Barcellona. *Sicilia Archeologica*, 38, 84–91.
- Guzzardi, L. (2012). Insediamenti preistorici nei territori di Leontinoi e Megara: Scavi e nuove scoperte nell'ultimo biennio. In *Atti della XLI riunione scientifica: Dai ciclopi agli ecisti: società e territorio nella Sicilia preistorica e protostorica, San Cipirello (PA), 16-19 novembre 2006* (pp. 729–739). Firenze: Società e territorio nella Sicilia preistorica e protostorica.
- Holloway, R. R., & Lukesh, S. S., (1995). *Ustica I: Excavations of 1990 and 1991*. Brown University, Center for Old World Archaeology and Art.
- Holloway, R. R., & Lukesh, S. S., (2001). *Ustica II. Excavations of 1994 and 1999*. Brown University: Providence.
- Italiano, F., Correale, A., Di Bella, M., Foresta Martin, F., Martinelli, M. C., Sabatino, G., & Spatafora, F. (2018). The Neolithic obsidian artifacts from Roccapalumba (Palermo, Italy): First characterization and provenance determination. *Mediterranean Archaeology and Archaeometry*, 18(3), 151–167. doi: 10.5281/zenodo.1476967.
- Knodel, A. R., Athanasoulis, D., Tankosić, Z., Cherry, J. F., Garonis, T. K., Levine, E. I., ... Öztürk, H. C. (2020). An island archaeology of uninhabited landscapes: Offshore islets near Paros, Greece (the Small Cycladic Islands Project). *The Journal of Island and Coastal Archaeology*. doi: 10.1080/15564894.2020.1807426.
- La Monica, M., Rotolo, S. G., & Foresta Martin, F. (2019). Petrographic and spectroscopic (Ft-Ir) study of Western Mediterranean obsidians geological sources and of a lithic collection from Ustica Island (Sicily). *Annals of Geophysics (Spec. Issue: Explosive Eruptions and the Mediterranean Civilization through Prehistory and History)*, 62(1), 13.
- Mannino, G. (1979). Ustica. Risultati di esplorazioni archeologiche. *Sicilia Archeologica*, 41, 7–40.
- Mannino, G., (1982). Il villaggio dei Faraglioni di Ustica. Note preliminari. In R. Vonwiller, F. Studi in onore di Ferrante Rittatore Vonwiller (pp. 279–297). Como: Società archeologica comense.
- Mannino, G. (1998). Il neolitico nel palermitano e la nuova scoperta nell'isola di Ustica. *Quaderni del Museo Salinas*, IV, 45–80.
- Mannino, G. (2012). Lo “scarico” neolitico di Castellaccio di Fiaccati Roccapalumba (PA). In *Atti della XLI riunione scientifica: Dai ciclopi agli ecisti: società e territorio nella Sicilia preistorica e protostorica, San Cipirello (PA), 16-19 novembre 2006* (pp. 1099–1100). Firenze: Società e territorio nella Sicilia preistorica e protostorica.
- Mannino, G., & Ailara, V. (2014). *Le Grotte di Ustica*. Palermo: Edizioni del Centro Studi e Documentazione Isola di Ustica.
- Mannino, G., & Ailara, V. (2016). *Carta Archeologica di Ustica*. Palermo: Edizioni del Centro Studi e Documentazione Isola di Ustica.
- Martinelli, M. C. (2000). Analisi dell'industria in selce e in pietra dal villaggio neolitico della contrada Diana a Lipari. In U. Spigo & M. C. Martinelli (Eds.), *Quaderni del Museo Archeologico Regionale Eoliano*, 3, *Nuovi studi di Archeologia Eoliana* (pp. 9–29). Messina: Effegieffe Arti Grafiche.
- Martinelli, M. C., & Quero, T. (2013). Cultural and trade networks in Western Mediterranean, during the Neolithic period: A testimony from Northern Sicily. The S. Martino-Spadafora (ME) Site. In L. Bombardieri, A. D'Agostino, G. Guarducci, V. Orsi, & S. Valentini (Eds.), *SOMA 2012: Identity and connectivity; proceedings of the 16th Symposium on Mediterranean Archaeology, Florence, Italy, 1-3 March 2012* (BAR International Series 2581, Vol. 2, pp. 813–822). Oxford: Archaeopress.

- Martinelli, M. C., Tykot, R. H., & Vianello, A. (2019). Lipari (Aeolian Islands) Obsidian in the Late Neolithic. Artifacts, supply and function. *Open Archaeology*, 5(1), 46–64. doi: 10.1515/opar-2019-0005.
- Millot, C., & Taupier-Letage, I. (2005). Circulation in the Mediterranean Sea: Updated description and schemas of the circulation of the water masses in the whole Mediterranean Sea, in A. Saliot (Ed.), *The Mediterranean Sea*. The Mediterranean Sea (5-K), Handbook of Environmental Chemistry (pp. 29–66). Berlin: Springer. 9783540314929.
- Moscoloni, M., & Ruggini, C. (2012). Le indagini archeologiche a Grotta Bonagia (TP) nel quadro delle modalità di occupazione della Sicilia occidentale durante il Neolitico tardo. In *Atti della XLI riunione scientifica: Dai ciclopi agli ecisti: società e territorio nella Sicilia preistorica e protostorica, San Cipirello (PA), 16-19 novembre 2006* (pp. 513–521). Firenze: Società e territorio nella Sicilia preistorica e protostorica.
- Nomi, F., & Speciale, C. (2017). Castellaro (Lipari, Messina). *Notiziario Istituto Italiano di Preistoria e Protostoria*, 4(3), 87–90.
- Palio, O. (2012). Il villaggio tardo-neolitico di Via Capuana a Licodia Eubea (Catania). In *Atti della XLI riunione scientifica: Dai ciclopi agli ecisti: società e territorio nella Sicilia preistorica e protostorica, San Cipirello (PA), 16-19 novembre 2006*. (pp. 535–542). Firenze: Società e territorio nella Sicilia preistorica e protostorica.
- Pappalardo, L., Romano, F. P., Bracchitta, D., Massimino, A., Palio, O., & Rizzo, F. (2013). Obsidian provenance determination using the beam stability controlled BSC-XRF and the PIXE-alpha portable spectrometers of the LANDIS laboratory: The case of the Via Capuana settlement in Licodia Eubea (Sicily). *Journal of Geophysics and Engineering*, 10(6), 064004.
- Quero, T., Martinelli, M. C., & Giordano, L. (2019). The Neolithic site of San Martino – Sicily: Working and circulation of Obsidian from Lipari. *Open Archaeology*, 5(1), 65–82. doi: 10.1515/opar-2019-0006.
- Romano, R., & Sturiale, C. (1971). L'isola di Ustica. Studio geo-vulcanologico e magmatologico. *Rivista Mineraria Siciliana*, 22, 127–129.
- Shackleton, N. J., & Opdyke, N. D. (1973). Oxygen isotope and paleomagnetic stratigraphy of equatorial pacific core V28–238: Oxygen isotope temperature and ice volumes on a 105 year scale. *Quaternary Research*, 3, 39–55.
- Spatafora, F., & Mannino, G. (2008). *Ustica. Brief Guide*. Palermo: Assessorato Regionale dei Beni Culturali Ambientali e della Pubblica Istruzione.
- Spatafora, F. (2009). Ustica tra il Tirreno e la Sicilia, Storia del popolamento dell'isola dalla Preistoria all'età tardo-romana. In C. Ampolo (Ed.), *Immagine e immagini della Sicilia e di altre isole del Mediterraneo antico* (pp. 507–529). Pisa: Edizioni della Normale.
- Spatafora, F. (2016). Tra mare e terra: La preistoria di Ustica e il villaggio dei Faraglioni. *Scienze dell'Antichità*, 22(2), 315–326.
- Speciale, C., Larosa, N., Battaglia, G., & Vassallo S. (2020a). Ustica – Piano dei Cardoni. *Notiziario di Preistoria e Protostoria*, 6(2), 62–64.
- Speciale, C., de Vita, S., Iovino, M. R., Mantia, F., Montesana, R., Montana, G., ... Vassallo, S. (2020b). Materials and tools across volcanoes: Exploitation of obsidian and other volcanic rocks in Ustica (Italy) during prehistory. *Miscellanea INGV*, 52, 297–298.
- Tinè, V., & Tusa, S. (2012). Il Neolitico in Sicilia. In *Atti della XLI riunione scientifica: Dai ciclopi agli ecisti: società e territorio nella Sicilia preistorica e protostorica, San Cipirello (PA), 16-19 novembre 2006* (pp. 49–80). Firenze: Società e territorio nella Sicilia preistorica e protostorica.
- Traverso, A. (2012). La *facies* del Kronio. Elementi crono-tipologici dagli scavi nell'Antro Fazello al Monte Kronio (Sciaccia, Agrigento). In *Atti della XLI riunione scientifica: Dai ciclopi agli ecisti: società e territorio nella Sicilia preistorica e protostorica, San Cipirello (PA), 16-19 novembre 2006* (pp. 493–504). Firenze: Società e territorio nella Sicilia preistorica e protostorica.
- Tykot, R. H. (1995). Appendix I: Obsidian provenance, in Ustica. I: The results of the excavations of the Regione Siciliana, Soprintendenza ai Beni Culturali ed Ambientali Provincia di Palermo in collaboration with Brown University in 1990 and 1991. *Archaeologia transatlantica* (Vol. 14, pp. 87–90). Providence, Louvain-la-Neuve, Belgium: Center for Old World Archaeology and Art, Brown University.
- Tykot, R. H. (2017). Obsidian studies in the Prehistoric Central Mediterranean: After 50 years, what have we learned and what still needs to be done? *Open Archaeology*, 3(1), 264–278. doi: 10.1515/opar-2017-0018.
- Tykot, R. H. (2019). Geological sources of obsidian on Lipari and artifact production and distribution in the Neolithic and Bronze Age central Mediterranean. *Open Archaeology*, 5(1), 83–105. doi: 10.1515/opar-2019-0007.
- Tykot, R. H., & Foresta Martin, F. (2020). Analysis by pXRF of prehistoric obsidian artifacts from several sites on Ustica (Italy): Long-distance open-water distribution from multiple island sources during the Neolithic and Bronze ages. *Open Archaeology*, 6(1), 348–392. doi: 10.1515/opar-2020-0118.
- Tykot, R. H., Freund, K. P., & Vianello, A. (2013). Source analysis of prehistoric obsidian artifacts in Sicily (Italy) using pXRF. In R. Armitage (Ed.), *Archaeological Chemistry VIII*, (ACS Symposium Series, pp. 195–210). Washington, DC: American Chemical Society.
- Vianello, A., & Tykot, R. (2016). Exchange networks from close-up: The case of Lipari obsidian. *Journal of Lithic Studies*, 3(2), 725–740. doi: 10.2218/jls.v3i2.1410.