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Fission Track Dating of Obsidian Samples from Lipari Neolithic Settlements

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Abstract: The present work describes the first results of the project "Lipari Obsidian and Neolithic Human Communities in the Aeolian Islands", which aims to study the connection between obsidian sources on the island of Lipari and Neolithic populations on the Aeolian archipelago in Italy. Obsidian is a natural volcanic glass used to produce chipped tools; in the Neolithic period it was the sharpest known material and its trade played an important role in the Mediterranean area. It is thus of particular interest for tracing prehistoric trading patterns. Indeed, Lipari obsidian has a wide distribution and has been found even in southern France, Dalmatia, Sicily and mainland Italy. To reach the project goal, we considered both raw materials from different obsidian geological samples and artefacts from Neolithic settlements on the Aeolian islands, and performed fission-track dating (FT), a radiometric technique that can be used for uranium-bearing minerals and glasses. The preliminary results facilitated the age determination of geological samples, which we could relate to the different eruption phases. Archaeological samples were also dated; their link with the studied volcanic deposits and lava flows made it possible to shed some new light on raw material procurement and on the ability of the Neolithic populations to move from their locations, with particular attention to the consequences of environmental features on the first human settlements on the Aeolian islands.

Keywords: Neolithic settlements; obsidian flows; fission-track dating

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1. Introduction

1.1. The Project

The present work is part of the project "Lipari Obsidian and Neolithic Human Communities in the Aeolian Islands", which concerns the study and analysis of obsidian flows on the island of Lipari in relation to the population of the Aeolian Islands during the Neolithic. The project proposes some scientific aims that concern a synthesis of archaeological and volcanological studies, and at the same time new chronological elements for the temporal reconstruction of the volcanic events that produced obsidian.

The area of interest of the project is the correlation between the first phases of population and the exploitation of this raw material.

The main objectives of the project are:

(1) Analysis of the supply sources (location, dates, sample analysis) of raw material and obsidian artefacts in use in the Aeolian Neolithic settlements, witnessing the volcanic activities of Lipari in prehistory.
(2) Hypotheses on the methods of collecting raw material and the mobility of communities in relation to the Neolithic settlements in the Aeolian Islands.
(3) Environmental characteristics that may have influenced the first population of the islands.

In the present paper we describe how, through the fission-track method, it is possible to determine the age of lava flows and pyroclastic deposits from which the pieces of obsidian used by the Neolithic communities of Lipari were extracted. This will allow us to develop a local chronological framework of the exploitation of the raw material and to compare it with the absolute and cultural chronologies of the prehistory of the Mediterranean.

1.2. The Neolitic of the Aeolian Islands

The archipelago of the Aeolian Islands (Figure 1) includes seven islands, Lipari, Vulcano, Salina, Panarea, Stromboli, Filicudi and Alicudi, and some islets. Except for Vulcano, all the islands and islets have preserved traces of frequentation and settlements starting from the Neolithic [1–5]. The main impetus for the beginning of human settlement in the area was the presence on the island of Lipari of excellent quality obsidian, black, shiny, glassy and perfect for making cutting tools. Control of this raw material allowed for its exchange on a long-distance basis, determining the first form of "trade" in the Mediterranean.

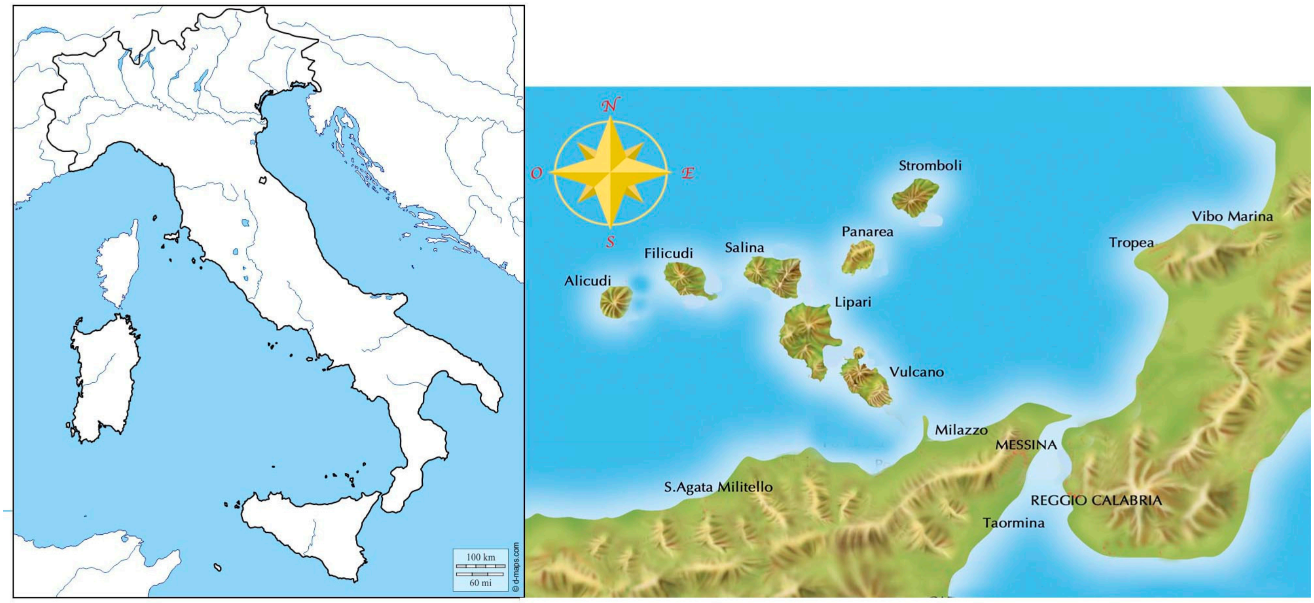

Figure 1. The Aeolian Islands archipelago.

The subaerial eruptive history of Lipari [6] developed between about 267,000 years ago and the Late Middle Ages. There were several eruptions that produced obsidian. The oldest is Monte Guardia (27–24,000 years ago) which seems to have never been used, followed by Canneto Dentro and Vallone del Gabellotto (about 8700–8400 years before present) which were exploited during prehistory. Finally, the formation of the Monte Pilato and Forgia Vecchia volcanoes probably occurred in two phases at the end of the 8th century [6,7] and in the 13th century [8,9].

The actual territory in the north-eastern part of the island is the result of the most recent eruptions and natural erosion that have modified the environment frequented during prehistory. Detailed analyses of the geological sources have allowed us to identify two sources where obsidian was collected in the Neolithic: Vallone del Gabellotto and Canneto Dentro [10], and probably a third source in Vallone Fiume Bianco [11]. Due to the changes in this part of the territory, the areas for collecting raw materials frequented during the Neolithic are no longer visible, but two supply and processing areas have been discovered. The first, Canneto–Lami, relating to the early Neolithic, has been dated through carbon-14 dating at 6290 $\pm$ 30 BP (calibrated 5320–5217 BC) in [11]; the second, Canneto–Acquacalda, relating to the late Neolithic, has returned a fragment of red monochrome pottery from the Diana culture [12]. The exploitation of Lipari obsidian began in the Neolithic around the middle of the 6th millennium BC and continued until the Middle Bronze Age (1500–1300 BC), but then disappeared completely. The large quantity of processing chips, blades and exploited cores found in the settlements of the Aeolian Islands, from the Neolithic to the Early Bronze Age, demonstrates that the working of this material took place as a domestic craft within the villages [2]. In the most ancient phase of the population of the Aeolian Islands (Stentinello culture), dated around 5300 BC, two main settlements are known: one in Lipari at the Castellaro site [12] and the other in Salina at the Rinicedda site [13]. Both are characterized by their position in flat areas where subsistence agriculture is possible. Archaeological traces speak of small agricultural communities who lived in huts made of reeds and clay. Their main activity was the exploitation and collection of obsidian. The ceramics that characterize the Stentinello culture are decorated with impressions made by hand or molds. This pottery is associated with the production of fine purified ceramics painted with red or brown banded motifs [14]. The rapid coastal advance of the Neolithic settlers led to the establishment of exchange networks that determined an early circulation of obsidian for hundreds of kilometers, and consequently the Aeolian Neolithic community manifested the need to control the primary source of raw material. In fact, during the periods of painted vases, first trichrome pottery then Serra d'Alto pottery, the settlement stabilized only in Lipari on the coastal cliff, today called a castle, naturally fortified by rocky crags that due to these characteristics have been inhabited continuously over the centuries. During the late Neolithic, the Diana culture emerged, characterized by a red monochrome pottery, widespread in Sicily and the Italian peninsula between 4500 and 4000 BC. Its name derives from the large settlement located on a large coastal plain that was discovered in the middle of the last century in Lipari in the Diana district [15]. During the period of the Diana culture the obsidian chipping technique became highly specialized [16]. All the islands, except Vulcano, were inhabited with settlements; the diffusion of Lipari obsidian reached the entire Mediterranean area and beyond [17].

The end of the Neolithic dates back to the beginning of the 4th millennium BC (Diana–Spatarella culture) and coincided with a period of economic and demographic crisis caused by the introduction of metalworking techniques, which reduced the demand for obsidian, and by the volcanic activities of Stromboli and Vulcano which directly and indirectly influenced the population of Lipari with consequences throughout the archipelago [18].

1.3. Provenance Studies for Obsidian Samples

As part of the present project, fission-track (FT) dating of obsidian is utilized as a tool for provenance determination. This approach is widely practiced in the field of archaeometry and has been applied in various contexts, as obsidian holds paramount importance for archaeological studies predating the advent of ceramics [19–22].

Several chemical analyses have demonstrated their effectiveness in distinguishing sources of obsidian since the initial studies conducted in the 1960s [19,23–26]. Early methods included emission spectrometry [27] and proton inelastic scattering [28]. Over time, more advanced techniques were introduced, such as laser ablation–inductively coupled plasma mass spectrometry (LA-ICP-MS) [29], particle-induced X-ray emission (PIXE) [30,31] and energy-dispersive spectroscopy with a scanning electron microscope (SEM-EDS) [32].

One of the most commonly used methods remains neutron activation analysis (NAA) [33], a nuclear technique occasionally paired with particle-induced gamma emission (PIGE) [26] or X-ray fluorescence (XRF) [32]. This unique analytical method offers high precision and detects a wide range of elements; however, it requires irradiating samples with a neutron flux. Over the years, Raman micro-spectroscopy [21,31], Mössbauer spectroscopy [15] and optical emission spectroscopy (OES) [27] have also been employed for similar purposes.

Among the techniques applied to obsidian provenance studies, energy-dispersive X-ray fluorescence (ED-XRF) has emerged as a leading method [16,17,34–38]. It enables the quantification of elements in a non-destructive manner, offering relatively low detection limits for samples of any size. Furthermore, both portable and laboratory-based equipment are available for this purpose. Despite this, the suboptimal detection of low atomic number (Z) elements necessitates specialized calculation and calibration software, requiring customized data processing [39]. This limitation is often addressed by focusing on element ratios rather than absolute elemental concentrations for geographic origin discrimination [16,32,38]. Using this approach, studies on obsidian samples consistently demonstrate the capability of XRF—whether performed with tabletop or portable devices—to reliably identify sample provenance [40,41].

Starting from this premise, it is worth emphasizing the practical advantages of FT dating, particularly its ability to provide absolute age constraints. This capability not only supports provenance determination but also enhances broader archaeological chronologies. While the method necessitates specialized laboratory facilities and a minimum uranium content in the analyzed glass, it serves as a valuable complement to geochemical techniques, especially in complex volcanic settings.

2. Materials and Methods

In 2019, a research agreement was signed between the Archaeological Park of the Aeolian Islands—Luigi Bernabò Brea Museum and the University of Milan—Department of Physics, which implemented some of the aims proposed by the previously mentioned project. The sampling of obsidian flows and tephra layers accessible on the island of Lipari was carried out and, at the same time, samples of obsidian artefacts of the chipping products (debitage) from archaeological excavation contexts in the main Neolithic settlements of the Aeolian archipelago were selected [11].

2.1. Obsidian Samples

Samples from both geological sources and archaeological sites were selected for this study. The geological samples are from dated volcanic phases and comprehend obsidian blocks from pyroclastic deposits and lava flows, or from secondary beds near known or supposed ancient obsidian sources. The archaeological materials, mainly splinters and blades, were from both Salina and Lipari Islands.

2.1.1. Geological Samples

In the present work, 11 geological samples (see Figure 2 for the location of the sampling and Figure 3 for a selection of fragments) have been analyzed; Table 1 summarizes their provenance and eruption age, while further details are given below.

Figure 2. Map of the island of Lipari: the locations where geological samples and Lipari archaeological site samples have been collected are marked in red.

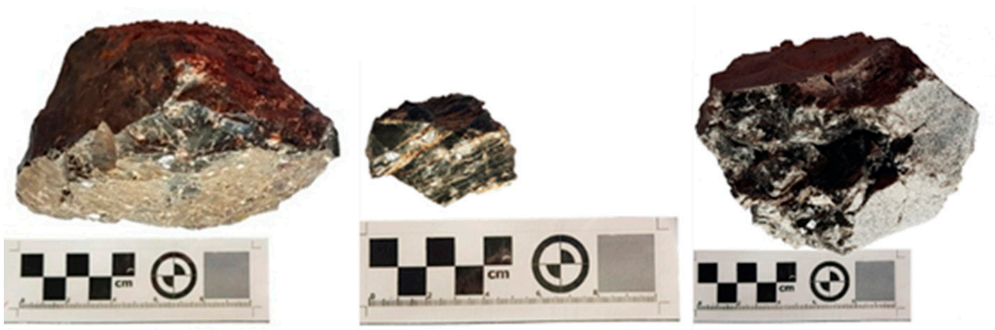

Figure 3. From left to right, obsidian fragments from geological samples 12, 12B and 13A, respectively.

Table 1. Obsidian geological samples used to characterize possible recruitment sites for Neolithic people.

Sample	Sampling Area	Coordinates
LIP2	Canneto Dentro (at a desalination plant) agricultural soil with obsidian in secondary deposit)	38°28′56″ N; 14°57′22″ E
LIP3	Canneto Dentro (thepra layer)	38°29′1″ N; 14°57′37″ E
LIP3A	Canneto Dentro (thepra layer)	38°29′1″ N; 14°57′37″ E
LIP4	Vallone Fiume Bianco (thepra layer)	38°29′44″ N; 14°56′ 2″ E
LIP5	Vallone Fiume Bianco (in the river bed)	38°29′44″ N; 14°56′2″ E
LIP6	Vallone Fiume Bianco (at a modern pumice quarry—thepra layer)	38°29′58″ N; 14°55′49″ E
LIP7	Vallone Gabellotto (Pomiciazzo lava flow)	38°29′42″ N; 14°57′24″ E
LIP12	Monte Guardia (by surface collection)	38°27′42″ N; 14°56′51″ E
LIP12A	Monte Guardia (by surface collection)	38°27′37″ N; 14°56′41″ E
LIP12B	Monte Guardia (by surface collection)	38°27′37″ N; 14°56′41″ E
LIP13A	Vallone Gabellotto (thepra layer from the right slope of the river)	38°29′37″ N; 14°57′29″ E

LIP2, LIP3 and LIP3A are all from the Canneto Dentro area, and have never been directly dated before. LIP2 was extracted in agricultural land within a secondary deposit formed after a landslide. This obsidian sample appears black and shiny despite being immersed in soil material. LIP3 was taken from a pyroclastic deposit formed during the Canneto Dentro dome emplacement and appears black in color with a shiny and compact surface. LIP3A has the same origin as LIP3, and it is characterized by a black color, an opaque appearance and a rough surface, as well as by the presence of bubbles and inclusions. These samples should belong to the same eruptive phase as Vallone del Gabellotto–M. Pilato, Epoch 9a of the geological map [6].

LIP4 and LIP5 are both attributed to the Vallone del Gabellotto Formation. The former is composed of four separate fragments collected from the pumice tephra layer and looks greyish and rough, with many bubbles present in the obsidian itself. LIP5 was collected from the bed of a stream at Vallone Fiume Bianco; the sample has a black color and a shiny surface which presents, in some areas, residues of rocky material. LIP6 was collected from a layer of a pumice quarry in the Vallone Fiume Bianco area, and it is characterized by a black color, a shiny and compact appearance and a smooth surface; inside, it has a large number of bubbles and inclusions. LIP7, from the Pomiciazzo lava flow (on the right bank of the Gabellotto gorge), is black, shiny and relatively opaque, with some inclusion visible under the microscope, and surrounded by a different rocky material. LIP13A is a black and shiny obsidian block, with many inclusions, in a pumice tephra layer from the left bank side of the Gabellotto gorge.

LIP12, LIP12A and LIP12B appear to be opaque, black to gray in color and with a very large number of inclusions. These samples come from the Monte Guardia and Monte Giardina flows and have an expected age of 27–24,000 years BP [6].

2.1.2. Archaeological Samples

Nine archaeological samples (see Table 2 for details and Figure 4 for a selection of fragments) were selected among obsidian artefacts from the Neolithic sites of Lipari and Salina [4], held among Lipari Museum materials, such as splinters and blades of different shapes and sizes, used for various types of daily activities. Details of the samples are given in the following.

Table 2. Obsidian archaeological samples from Neolithic archaeological sites.

Sample	Sampling Area	Excavation Year
MU2	Lipari, Contrada Diana, Trench XVII, Square E, Cut 4	1953
MU4	Lipari Castellaro	1957
MU6	Salina, Rinicedda, Area A, Cuts 2–6	1989
MU7	Salina, Rinicedda, Square L-M 42–44 US 6, Cut 1	2008
MU9	Salina, Rinicedda, Square N43 US 6, Cut 3	2008
MU10	Salina, Rinicedda, Square N44 US 6, Cut 2	2008
MU12	Salina, Rinicedda, Square O44 US 7, Cut 1	2008
MU13	Salina, Rinicedda, Square M45 US 7, Cut 3	2008
MU14	Lipari, Canneto–Acquacalda, neolithic quarry	1977

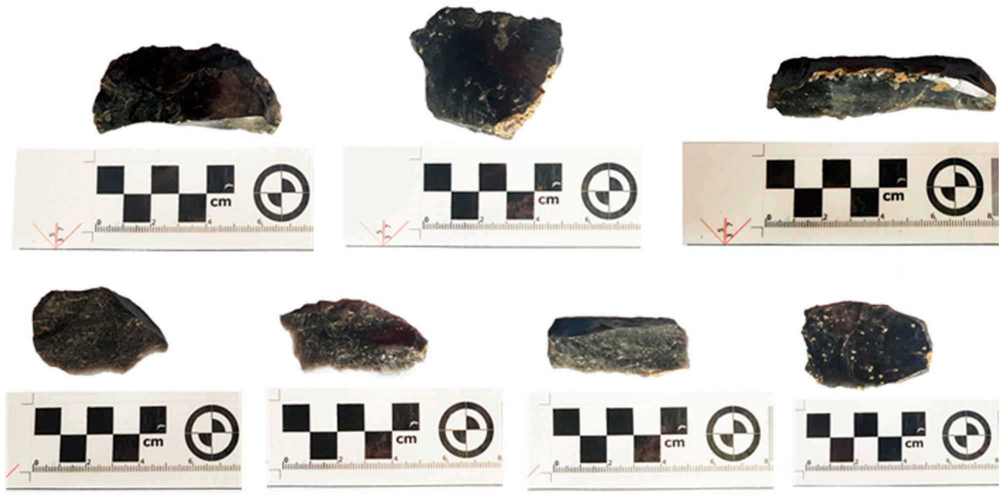

Figure 4. From left to right, top to bottom: obsidian fragments from archaeological samples MU2, MU4, MU9, MU10, MU12, MU13 and MU14, respectively.

Sample MU2 consists of eight pieces found in 1953 in Lipari in the Contrada Diana district. All samples have an opaque appearance and a black color with gray areas. They present, depending on the fragment under analysis, a variable bubble and inclusion presence, which made fission-track dating a delicate task.

Sample MU4 consists of two blocks excavated in 1957 in Lipari at the Castellaro site. They appear slightly different from each other: one is opaque and with a black color tending towards grey, while the other is blacker and shiny. Under the microscope, the fragments under analysis have bubbles and inclusions inside them.

Samples MU6 (two fragments), MU7 (four fragments), MU9 (three fragments), MU10 (three fragments), MU12 (five fragments) and MU13 (two fragments) are from the Rinicedda archaeological site on Salina Island excavated in 1989 and 2008. They are all opaque and black, with bubbles and inclusions. Sample MU7 shows the presence, in some areas, of rocky material; MU13 is grayish.

Sample MU14 (three fragments) was recovered from a Neolithic quarry on the Canneto–Acquacalda road. The fragments are black and characterized internally by the presence of bubbles and inclusions.

2.2. Fission-Track Dating

Obsidian, a naturally occurring volcanic glass formed when lava extruded from a volcano cools rapidly with minimal crystal growth, can be dated by means of the fission-track method, which has already proved to be useful for source identification [42,43] and provenance studies [44,45]. In Neolithic times, obsidian was the sharpest known material, and it is thus considered one of the earliest pieces of evidence for commerce conducted over a long distance.

Fission-track dating (FTD) [46–48] is based on the detection of the fission products of uranium that create damage trails (fission tracks) within minerals [49,50]. It is a radiometric technique used for both very old materials, such as meteorites, and younger objects, including artifacts from archaeological sites, providing a versatile tool for dating a wide range of samples. In fission-track dating, the fission products are identified as microscopic damage trails or tracks in the crystal lattice rather than as daughter isotopes. ^{238}U undergoes spontaneous fission decay, and it is the only isotope with a decay rate relevant to the significant production of natural fission tracks. As detailed in Section 2.1.1, the density of spontaneous fission tracks in a material increases over time as events accumulate, making it directly proportional to the age of the sample. In general, obsidian is datable by FTD [49,51–53], and thus this technique is a tool for reconstructing the chronological framework of Lipari obsidian flows. As collecting and processing obsidian was the main economic resource for the Neolithic population of Lipari, FTD on archaeological findings allows us to correlate obsidian artifacts with natural sources.

The physical bases of FTD rely on the fact that the spontaneous nuclear fission of uranium 238 within minerals creates damage trails, the so-called fission tracks, that can be etched and observed with an optical microscope [54–56]: the surface density of fission tracks on a thin chip of material thus represents a measure of the time over which tracks accumulate. Both spontaneous and induced fission tracks are uniformly distributed throughout the entire volume of the material under study, as the uranium that generates them is uniformly distributed. However, the counting is performed on an internal surface obtained by sectioning the material. For this reason, we refer to surface density.

To calculate the fission-track age, it is necessary to measure the amount of uranium present by irradiating the sample with thermal neutrons in a nuclear reactor. This procedure artificially induces fission on uranium 235; the ratio between uranium 238 and uranium 235 fission-track density is used to calculate the age.

2.2.1. Fission-Track Age Equation

The fission-track method is based on the natural radioactive decay of the unstable parent nucleus, uranium 238, into a stable daughter nucleus, the fission fragments. The age equation in its most complete form is given by:

$$T = \frac{1}{\lambda_\alpha} ln\left(1 + \frac{\lambda_\alpha}{\lambda_f}\frac{\sigma\phi}{\eta}\frac{N_s}{N_i}\right), \tag{1}$$

where:

λ_α is the decay constant of uranium 238 for alpha decay;

N_s/N_i is the ratio between the number of uranium 238 nuclei per unit volume that decay by means of spontaneous fission and the number of uranium 235 nuclei per unit volume that decay by means of induced fission after neutron irradiation. The ratio can be determined through the ratio of surface densities of fission tracks determined in the non-irradiated and irradiated samples.

For samples younger than 100 million years (Ma), that is, for the vast majority of the studied materials, the approximate form of the age equation is used:

$$T = \frac{\phi\sigma}{\lambda_f \eta} \cdot \frac{\rho_s}{\rho_i}, \tag{2}$$

where:

T is the age in years,
ρ_s is the surface density of fossil tracks,
and ρ_i is the surface density of induced tracks.

From Equation (2), it can be clearly seen that T is proportional to the surface density of fossil and induced tracks, and thus to the uranium content in the sample, as well as to the thermal neutron dose and a series of constants, namely [57]:

- Φ is the thermal neutron dose (neutrons/cm^2), which can take different values depending on the dosimeter used and the characteristics of the nuclear reactor;
- σ is the neutron cross-section for the fission of uranium 235; this is not a true constant but is an average associated with the spectrum of thermal neutrons produced in nuclear reactors under standard conditions;
- λ_f is the decay constant for the spontaneous fission of uranium 238; this value includes some uncertainty due to the low probability of the event;
- η is the isotopic ratio of uranium 238 to uranium 235.

The values of the above-described parameters used in the present research are reported in Table 3.

Table 3. Numerical values of the parameters to be used in the age equation.

Φ	1.48×10^{15} n/cm^2
σ	580.2 barn
λ_f	7.03×10^{-17} y^{-1}
η	137.88

The age Equation (2) is valid if several important assumptions are met [58], i.e., if it is assumed that every single fission event leaves a latent track in the material and that this track remains stable over time; that the system is considered "closed", meaning there have been no variations in the uranium content of the sample; if the uranium content is assumed to be uniformly distributed throughout the material; and if the fission tracks from the spontaneous fission of uranium 238 and the induced fission tracks of uranium 235 are considered equivalent, as they have a negligible difference in energy.

The total error value in the age equation is given by the sum of the errors encountered in the calculation of the individual variables, namely those related to the dose Φ and the ratio ρ_s/ρ_i, assuming λ, σ and η as constants.

2.2.2. Experimental Procedure

Samples for FTD require long and laborious preparation, consisting of a series of steps that can be summarized as follows. Firstly, the obsidian block is broken into thin chips, divided into two batches, one of which is irradiated with thermal neutrons. The neutron irradiation took place using the TRIGA MARK II research reactor at the L.E.N.A. laboratory at the University of Pavia. The reactor is fueled with low-enriched 235U and moderated with light demineralized water, with a steady-state power of 250 kW. For the irradiation facility, the rotating sample holder, LS (Lazy Susan), was selected in order to achieve a thermal flux around 1×10^{12} n cm^{-2} s^{-1} [59].

After irradiating part of the samples, the chips from both batches are embedded into epoxy resin, so as to obtain resin cylinders that serve as support for the processing. For this purpose, a two-component epoxy resin (Buehler), which polymerizes at room temperature, was used. Grinding and polishing are the last two stages of sample preparation before etching; the chemical treatment, employed to selectively etch the obsidian surface, enlarges the fission tracks and allows a clearer detection through optical microscope observation.

The standard conditions for the chemical treatment of obsidian are HF in a 20% aqueous solution at a temperature of 40 °C for 120 s.

At the end of this procedure, it is possible to count the fossil and induced traces and to perform the calculations for age determinations.

3. Results

The results obtained are summarized in Figure 5, which shows the comparison between the dates obtained for the geological samples and the archaeological samples. More details and the discussion of the results are provided in Sections 3.1 and 3.2.

Table 4. FTD ages obtained for obsidian geological samples used to characterize possible recruitment sites for Neolithic people.

Sample	Sampling Area	Stratigraphy Age (y)	FTD Age (y)
LIP2	Canneto Dentro	9000–8000 *	9714 ± 5610
LIP3	Canneto Dentro	9000–8000	10,587 ± 3747
LIP3A	Canneto Dentro	9000–8000	9265 ± 6557
LIP4	Vallone Fiume Bianco	9000–8000	9491 ± 1885
LIP5	Vallone Fiume Bianco	9000–8000	10,473 ± 6049
LIP6	Vallone Fiume Bianco	9000–8000	10,019 ± 4101
LIP7	Vallone Gabellotto	8700–8400	10,183 ± 2739
LIP12	Monte Guardia	27,000–24,000	21,306 ± 4778
LIP12A	Monte Guardia	27,000–24,000	25,117 ± 5977
LIP12B	Monte Guardia	27,000–24,000	28,969 ± 8086
LIP13A	Vallone Gabellotto	8700–8400	11,922 ± 3208

* The age of Canneto Dentro has been assumed from geological studies, but never directly dated until the present work.

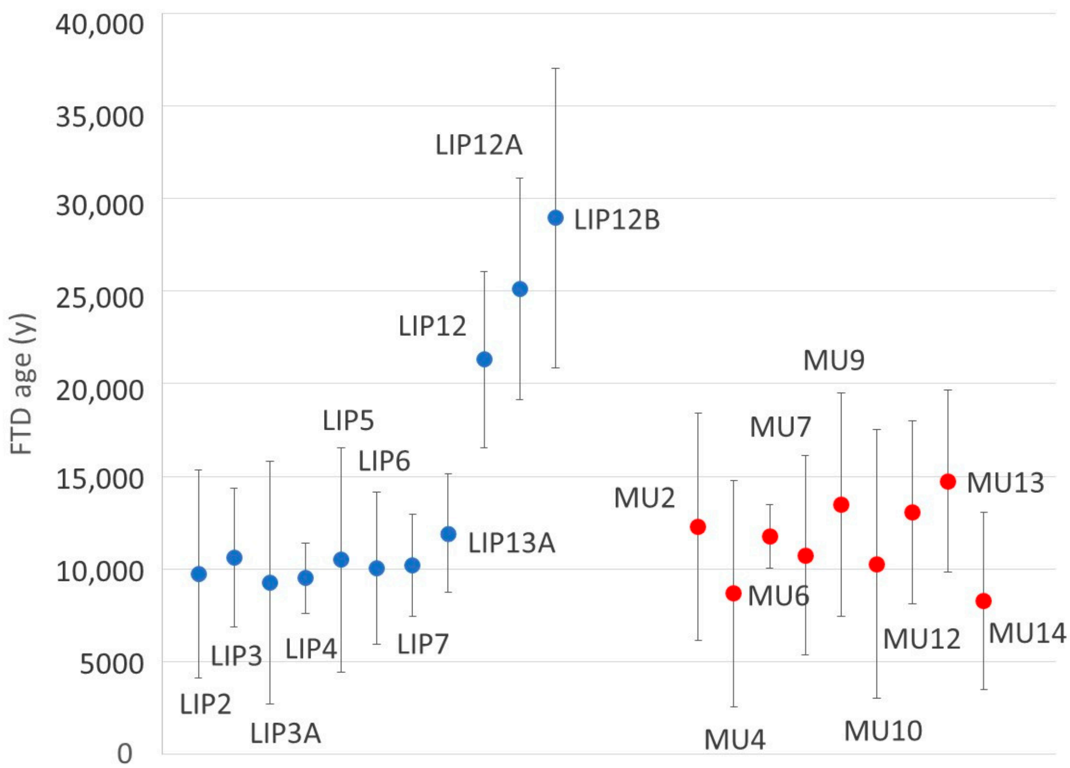

Figure 5. Graphical summary of the results outlined in Tables 3 and 4, highlighting the relationship between the ages of obsidian geological samples (blue dots) and archaeological findings (red dots).

3.1. Geological Samples

The results obtained for the geological samples analyzed in this work are reported in Table 4.

The most ancient geological samples (LIP12, LIP12A and LIP12B) are in agreement with the volcanism activity in southern Lipari—Epoch 8a dated 27–24,000 years before present [6]. The other samples belong to the Vallone del Gabellotto Formation, whose stratigraphic interval age is still uncertain. The Canneto Dentro tephra, associated with the obsidian dome, is placed in Epoch 8b, recognized as occurring between the older layers of the Upper Brown Tuffs (24–20 ka) and the Vallone del Gabellotto (8.7–8.4 ka) [6,60]. In recent literature, the date 8.6 ka is assumed as the most probable age of the Vallone del Gabellotto Formation that included the Pomiciazzo obsidian lava flow; however, another date was obtained with the fission-track method, 11,400 ± 1800 BP [44], on obsidian samples from Vallone del Gabellotto. The samples LIP4, LIP5 and LIP6 belong to a long period of volcanic activity but concern an area distant from the primary source of the Vallone del Gabellotto, located where the Fiume Bianco torrent digs the tephra layers of pumice belonging to the Vallone del Gabellotto Formation, uncovering the obsidian blocks present in that deposit dating up to 7170 years BP [61].

3.2. Archaeological Samples

Table 5 shows the fission-track datings obtained for the archaeological samples that are clearly related to the obsidian taken from the Vallone del Gabellotto formation. In the most ancient settlements, Castellaro (Lipari) and Rinicedda (Salina), the obsidian was probably collected from two main sources: (1) the bed of the near river Fiume Bianco and (2) the first Vallone del Gabellotto quarry [11]. In the more recent Neolithic settlement, Contrada Diana, the obsidian was collected primarily in the Vallone del Gabellotto area that included the Canneto Dentro source [10,17]. The most ancient dates are reported from samples of the Rinicedda site (MU6, MU12, MU13). We could suppose that this obsidian belongs to a more ancient eruption which is no longer visible. It is possible that the Neolithic community first inhabited Salina Island and then Lipari Island. This hypothesis could agree with the observations made by Buchner in 1949 [62] in the Papesca locality (actually Capo Rosso) where he observed the presence of older lava at the base of the stratigraphy [63].

Table 5. FTD ages obtained for obsidian archaeological samples from the Lipari and Salina sites.

Sample	Archaeological Site	Excavation Context	FTD Age (y)
MU2	Lipari, Contrada Diana	Trench XVII, E (1953)	12,276 ± 6148
MU4	Lipari Castellaro	(1957)	8660 ± 6129
MU6	Salina, Rinicedda	Square A (1989)	11,749 ± 1707
MU7	Salina, Rinicedda	Square L-M 42–44 US 6 (2008)	10,726 ± 5371
MU9	Salina, Rinicedda	Square N43 US6 (2008)	13,461 ± 6031
MU10	Salina, Rinicedda	Square N44 US6 (2008)	10,261 ± 7261
MU12	Salina, Rinicedda	Square O44 US7 (2008)	13,063 ± 4951
MU13	Salina, Rinicedda	Square M45 US7 (2008)	14,740 ± 4935
MU14	Lipari, Canneto–Acquacalda	Second quarry (1977)	8256 ± 4772

The MU14 sample was collected in the Neolithic second quarry, discovered by Buchner near the Canneto–Acquacalda road, used during the Diana culture phase. This is the youngest sample among the archaeological ones dated in this work. The fission-track date accorded with the chronology of the Vallone del Gabellotto formation but the sample MU2 from Contrada Diana has a different and older date.

Considering that the C14 dating carried out in the archaeological sites indicates the beginning of the population of the Aeolian Islands in the middle of the VI millennium BC, it is assumed that the period of quiescence of the volcanoes of Lipari had begun. In the Middle Ages, the volcanic activity resumed, modifying the territory of the north-eastern part of the island.

Comparing the dates of geological and archaeological samples, a higher incidence is observed around 10,000 years ago, suggesting the presence of an eruptive phase of the Vallone del Gabellotto formation older than the one dated at 8700–8400 years but not yet identified.

4. Conclusions

After the first outcome of this project, which focuses on the dating of geological and archaeological samples using the fission-track method and is the first of its kind to be proposed, we can summarize our conclusive remarks as follows:

These findings may support the hypothesis that obsidian from Lipari was collected and used in early Neolithic (impressed ware) or even Mesolithic settlements outside Lipari, even before the stable occupation of the Aeolian Islands.

The preliminary results presented in the present paper clearly show the potential of the fission-track dating method for provenance studies, particularly in cases where geochemically similar obsidian sources cannot be distinguished using traditional methods. Moreover, its ability to provide absolute age constraints contributes not only to provenance determination but also to broader archaeological chronologies.

The project "Lipari Obsidian and Neolithic Human Communities in the Aeolian Islands" is currently ongoing, aiming to further investigate and deepen our understanding of these aspects.

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