DOI 10.13131/UNIPI/4VQT-8Y76

Simone Sani*/§, Niccolò Mazzucco*, Davide Mengoli**, Elisabetta Starnini*

* Dipartimento di Civiltà e Forme del Sapere, Università di Pisa.
** Istituto Italiano di Paleontologia Umana (IIPU) / Lares s.r.l.
§ Corresponding author (simone.sani@cfs.unipi.it).

THE OBSIDIAN MANAGEMENT IN THE CENTRAL MEDITERRANEAN: A CASE STUDY FROM FORNACE CAPPUCCINI (NORTHERN ITALY, EARLY NEOLITHIC)

Abstract: Obsidian played a central role in the socioeconomic changes that took place in the central Mediterranean during the early stages of Neolithization, marked by an increased circulation of exogenous materials and the rise of specializations that often led to unequal access to distant resources. Through the case study of Fornace Cappuccini (Faenza, RA, Early Neolithic), this work investigates the variability in obsidian management and exchange practices within the interaction networks of early farmers. Technological data suggest that obsidian was at least partially knapped locally, despite the site's location at the northern margins of raw material distribution. Functional analysis of macroscopic use-wear traces indicates that part of the complex was used for working soft materials. These results suggest that this exogenous raw material had distinct management and use, partially overlapping with flint industries.

Keywords: Obsidian, stone tools, neolithic exchange, technological analysis, functional analysis.

1. Introduction

Obsidian appears in archaeological contexts of the central Mediterranean beginning in the late 7th millennium BC, marking one of the most significant innovations among Neolithic populations. It quickly became one of the most widely circulating materials, reaching sites hundreds of kilometres far from its outcrops (Tykot, 2017). Given that obsidian deposits in central Mediterranean are exclusively located on the islands of Lipari, Palmarola, Sardinia (Monte Arci), and Pantelleria, the circulation of this volcanic glass is closely linked to navigation practices, which seem to have intensified during the Neolithic, facilitating long-distance interactions (Farr, 2006).

Obsidian assemblages from sites of the Italian peninsula have been primarily studied with a typological approach. Only a few sites provide sufficiently detailed technological data, and even fewer have been examined from a functional perspective (Ammerman et al., 1988; Iovino, 1997, 2000, 2001; Iovino & Martinelli, 2008; Lemorini, 2007; Setzer, 2004; Starnini & Voytek, 1997; Tykot et al., 2006). Yet, these aspects are crucial for understanding the patterns of circulation and management of this exogenous material.

The integration of chronological, technological, use-wear and provenance data remains partially incomplete. For these reasons, the circulation of obsidian in the central Mediterranean continue to represent one of the most challenging topics in the study of early agricultural societies.

2. Materials and methods

2.1 The archaeological site of Fornace Cappuccini

Fornace Cappuccini is located in Emilia-Romagna (northern Italy) in the city of Faenza (RA), which lies approximately 25 km from the Adriatic Sea at the mouth of the Lamone River Valley and close to the Senio River Valley. This location serves as a transition zone between the Tuscan-Romagna Apennines and the southeastern Po Valley (**fig.** 1, a, b).

Archaeological investigations began in 1978 as part of a rescue archaeology project (**fig.** 1, c). An approximately 680-meter-long circular ditch was uncovered in the eastern sector, which may have been associated with an embankment (Antoniazzi et al., 1990). The deeper fill layers of the ditch yielded fragments of Impressed Ware, suggesting that the construction of the ditch can be attributed to the site's initial occupation (Antoniazzi et al., 1987, 1990; Bermond Montanari & Massi Pasi, 1998). Negative features were found both inside and outside the perimeter of the ditch, mainly concentrated in the western sector. The structures are primarily small, circular pits, but some complex-shaped features have also been detected. For the majority, a residential function seems unlikely, except perhaps for structure 30/83, which has been preliminarily interpreted as a combustion feature, although its interpretation remains controversial (Mengoli, 2011). Most negative structures may have ultimately served as waste or garbage pits after initially being used for productive activities, as proposed for some sites in the Po Valley (Biagi et al., 2020; Pearce, 2008; Starnini et al., 2018). Due to damage of the upper layers, which may have contained occupational floors, and the limitations of the excavation's documentation, a more complex interpretation of the site's structures is not possible. Concerning their chronology, eighteen out of twenty-three structures can be confidently attributed to the Impressed Ware phase, based on the pottery assemblage recovered (Mengoli, 2011). Later structures, attributed to the Eneolithic phases, have been excluded from this study.

Three radiocarbon dates have been obtained from features associated with Impressed Ware pottery:

- Structure 1 (Bln-3372): 6320 ± 60 uncal. BP (charcoal)[1];
- US 443 (R-2314): 6280 ± 80 uncal. BP (unknown sample)[2];
- US 435/E (R-2313): 6100 ± 170 uncal. BP (unknown sample)[3].

---

1 Antoniazzi et al., 1990; Bagolini & Biagi, 1987.

2 Bermond Montanari, 2000.

3 Bermond Montanari, 2000.

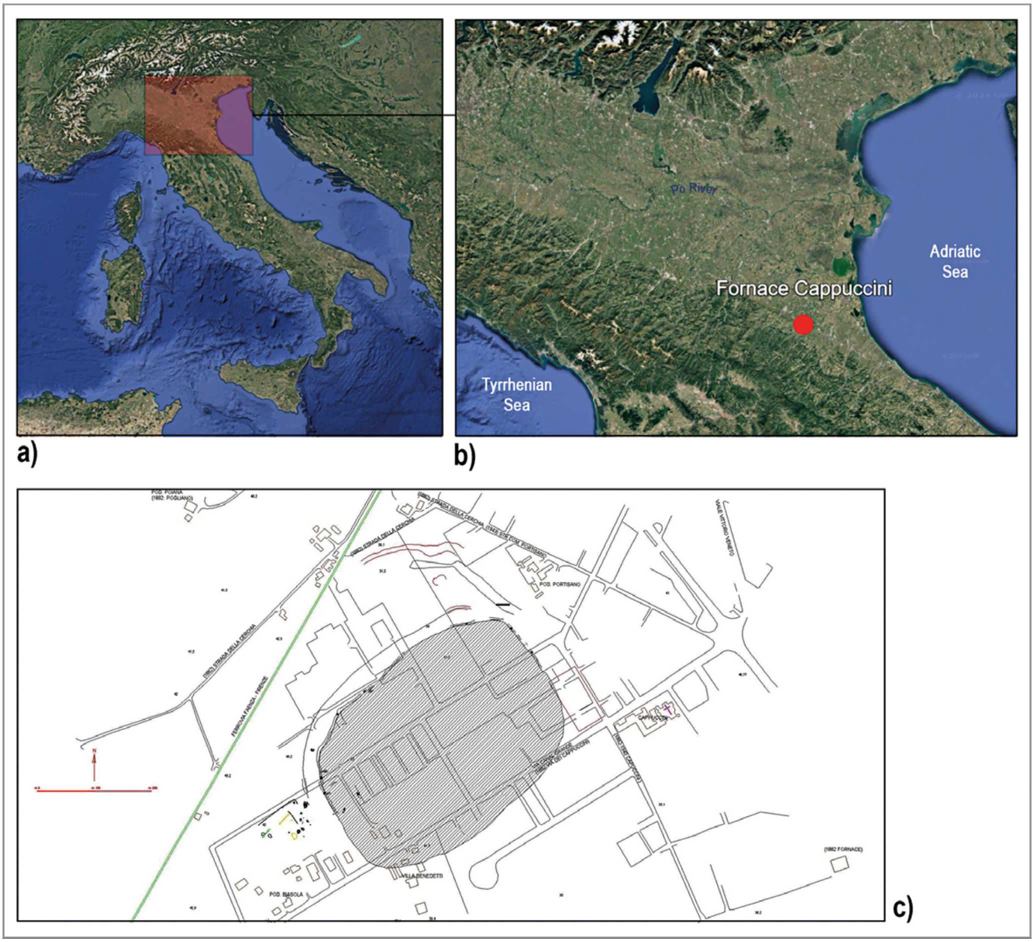

fig. 1. Location of the site and archaeological survey projections. a) East-central Po Plain (in red) within the central Mediterranean context; b) Site location; c) Area included in the preventive archaeology project. Grey hatching indicates the positioning of excavations and survey projections.

Using the OxCal v.4.4 calibration program (Bronk Ramsey & Lee, 2013) with the IntCal20 calibration curve (Reimer et al., 2020), the following calibrated BC dates (2σ) were obtained:

- Bln-3372: 5472-5079 cal. BC
- R-2314: 5471-5031 cal. BC
- R-2313: 5469-4613 cal. BC

The calibrated dates indicate that the settlement was primarily occupied during the second half of the 6th millennium BC, which is consistent with the few ^{14}C dates available from the area (Bagolini & Biagi, 1990) and the material culture of the northern Adriatic Impressed Ware sites (Bagolini & Ghirotti, 1980; Bagolini & von Eles, 1978; Bagolini et al., 1991). Although the available ^{14}C measurements are limited and based on unidentified wood charcoal samples (Bermond Montanari, 2000), the general chronological attribution of the site appears accurate and coherent with the available chrono-cultural framework for the Upper Adriatic region.

Recovered materials are abundant and include lithic and ceramic industries, concentrations of charcoal, and daub fragments, while polished stone objects were only sporadically present, and bone industry was absent (Antoniazzi et al., 1987; Bermond Montanari et al., 1991).

The entire lithic assemblage consists of 7608 artefacts (Mazzucco et al., 2018, **tab.** 1). Lithic production primarily utilised *Scaglia Rossa*, sourced from areas about 80-100 km from the site. Local flint is also present, found as siliceous pebbles in the *Sabbie Gialle* deposits. Exceptional exogenous finds include Lessinian flint, Apennine flint and jasper and ftanite from Liguria (Antoniazzi et al., 1987, p. 559; Bagolini & Biagi, 1987, 1987b; Bermond Montanari et al., 1991; Mengoli, 2011).

The initial block shaping likely did not occur on-site. The products were mainly extracted from unidirectional prismatic cores with single debitage surfaces, which were abandoned when exhausted. The production sequences are primarily oriented towards laminar production, utilizing both pressure flaking and indirect percussion techniques. A secondary, less organised sequence for producing flakes has also been identified (Mengoli, 2011). Retouched tools are mainly blades, with laterally retouched blades and notched blades prevailing, along with burins, geometrics, and truncations. The micro-burin technique is also widely attested (Mengoli, 2011). Thirty-eight sickle blades were identified, some of which showed traces of adhesive substances (Finocchiaro, 2023; Mazzucco et al., 2018, 2020).

Obsidian, found in exceptional quantities for such a northern site, will be discussed later.

2.2 Analysis methodology

The obsidian assemblage, which had already been preliminarily studied as part of the chipped stone industry of Fornace Cappuccini (Mengoli, 2011), was subject to a revision and a dedicated study, separate from the analysis of artifacts made from other raw materials. The materials were initially categorised by technology and typometry to identify recurring patterns and possible refittings. A dataset (FC_obs_Technology) was created, and the following analysis methodology is outlined:

- Artifact identification. The site name, the identifying number and layer of the piece are recorded.
- Raw material description. Preliminary classification of the lithic raw materials has been carried out relying on macroscopic aspects. Each piece is analysed using a stereoscopic microscope (OPTIKA SZ-T, 5x-40x), by observing the properties and characteristics of the surfaces and matrix. Translucency is defined, and the matrix is qualitatively described by assessing its uniformity and discontinuities, as well as the presence and distribution of inclusions (phenocrysts) and fractures potentially originating from them. The surfaces are examined for characteristics such as sheen and reflection. Based on these observations, the raw material is classified into a variant.

- Technological characterization. The technological analysis follows the methodologies proposed by Inizian et al. (1999) and Tixier (1984), aiming to recognise the different production sequences (Leroi Gourhan, 1964) and the knapping management. For each element, the degree of integrity and the type of product is recorded, which is assigned, when possible, to a corresponding flaking phase. The three largest dimensions of each element were measured, except for debris or small fragments under 7 mm, which are not diagnostically significant. Special attention was given to the laminar elements and their maximum dimensions, which were considered only for intact pieces, where dimensional ratios may be indicative of the different flaking modules. For dimensional analysis of blades, a "k-means" clustering method was applied using *RStudio* (packages: ggplot2 and dplyr) to identify the main modules among the intact pieces based on thickness and width. From a morphological point of view, the shapes, sections, profiles, butts, bulbs, and overhangs were described as diagnostic characteristics of preparation, flaking methods, applied force, and type of hammer. If present, cortex morphology and its extension was recorded, with the aim of determining the original nature of the raw material exploited.
- Alterations description. This refers to natural alterations caused by post-depositional processes, such as patina formation or by potential anthropogenic factors, like contact with fire.
- Typological description. Retouched elements are listed and briefly described according to Laplace's typological classification method (1964).
- Notes. Observations regarding all the previously analysed aspects, any recurring patterns, refitting possibilities, and detailed technological descriptions are noted.

The entire assemblage was subjected to an initial analysis focusing on macroscopic use-wear traces, representing the first stage of a more in-depth study that will be carried out on the Fornace Cappuccini assemblage. This study will include high-power (reflected light microscopy) and quantitative approaches (confocal microscopy).

We aim to provide a preliminary classification of the material according to macro-wear patterns. Specifically, we aim to: 1) identify possibly used areas; 2) characterise the macro-damage; 3) propose a functional classification of the materials based on kinematics (transversal / longitudinal / rotational / percussive motions) and the hardness of worked materials (soft / medium-abrasive / hard materials).

All the items were examined under a stereoscopic microscope (OPTIKA SZ-T, 5x-40x), with magnifications ranging from 10x to 40x. Areas that retained macroscopic use-wear traces were photographed using a microscope adapter and the OPTIKA Lite View software. A Dino Lite Edge 3.0 digital microscope, equipped with Dino Capture 2.0 software, was also used to record some of the use-wear traces. Observations were recorded in a dedicated dataset (FC_obs_Traceology) for the identified use-wear traces, following the methodology outlined below.

- Preservation. Post-depositional alterations on the surfaces were identified, which may affect the accurate interpretation of use-wear traces (Clemente Conte et al., 2015, pp. 73-75; Hurcombe, 1992a, pp. 71-78).

- Identification and description of traces from a macroscopic perspective. The number of areas potentially affected by use was recorded, along with their position relative to the face and edges. The type, pattern, distribution, localization, and direction of the traces were described at a macroscopic level using a low-power approach (Odell, 1987, 2001; Odell & Odell-Vereecken, 1980; Tringham et al., 1974; see Grace, 1996, for a review) and following methodologies published in previous works on obsidian assemblages (Brito-Abrante & Rodríguez-Rodríguez, 2024; Clemente-Conte et al., 2015; Gibaja & Mazzucco, 2023; Hurcombe, 1992a, 1992b; Kononenko, 2011; Mengoli & Mazzucco, 2018; Setzer, 2004, 2012; Walton, 2019).
- The presence of edge rounding was noted, and its intensity classified into general categories (low / high) based on intra-tool comparisons. Striations were recorded, along with their direction relative to the edges, distribution type, and groove depth. Finally, any association between traces and edge retouching, as well as the presence of gloss, was also registered.
- Reliability of the wear patterns. Objects were classified based on the readability of the use-wear traces into two categories (possibly used / used).
- Residues. Traces of residues on the surfaces, potentially organic substances or adhesives, were described in terms of colour and distribution. If sufficiently abundant, they were sampled using a surgical scalpel and sterile gloves and prepared for gas chromatography analysis.
- Kinetic interpretation and hardness of the worked material. Based on the observed traces, possible actions performed by the artefact edges have been inferred, as well as the hardness estimation of the worked materials.

3. Results

3.1 Raw material

Qualitative observations on the raw material enabled a preliminary macroscopic classification into three main obsidian variants:

- Group 1. Characterised by a mostly uniform and semi-translucent matrix, with some non-translucent elements. The surfaces are glossy, often with patches of discontinuities. This is the largest group, comprising 169 items, of which 47 display phenocrystals.
- Group 2. Characterised by a generally less uniform and semi-translucent matrix, with more non-translucent elements than Group 1 and more items with phenocrystals (43). The surfaces are frequently opaquer, often showing parallel bands, sometimes with yellowish tones. This is the intermediate group in terms of quantity, comprising 110 items.
- Group 3. Characterised by a uniform matrix that is completely or nearly translucent. Occasionally, bubble-like discontinuities appear in the matrix, with a dotted or longitudinal distribution. Inclusions are rarer, only 9 items display phenocrystal and impurities. This is the smallest group, with 70 artifacts.

Analysis of the assemblage revealed a clear link between translucency and the presence or absence of patina. Fresh breaks in some artifacts show glossy surfaces hidden beneath post-depositional alteration patinas that had rendered them opaque. Thus, the proposed classification is inevitably affected by alterations produced by post-depositional processes. Additionally, it should be noted that the translucency of the surfaces is partly influenced by the thickness of the artifacts. Inclusions have a significant impact on the quality of the raw material; in 25 pieces, fractures, reflections, surface irregularities, or notch formations were noted due to the presence of phenocrystals within the glassy matrix.

Provenance analyses, using the fission track method on a limited sample of artifacts (18 out of 349), identified the islands of Palmarola (10 samples) and Lipari (8 samples) as sources of supply (Bigazzi & Radi, 2003). New non-destructive provenance studies are currently underway on the entire collection using pXRF at the Laboratory of Archaeometry and Diagnostics of the University of Pisa.

3.2 Technological and morphometric data

The obsidian assemblage consists of 349 items. Artefacts are not evenly distributed across the site, forming three main concentration clusters (**fig.** 2). Furthermore, Structure 1 stands out, having yielded 118 items, approximately one-third of the entire assemblage (Antoniazzi et al., 1987, p. 559). The degree of fragmentation is high, with only 79 pieces (approximately 23%) remaining intact. A single conjoint has been found, consisting of a cortical bladelet from two different structures (31/40 and 30/83).

One core was recovered, whose characteristics will be described later. Among the products, blades are predominant, making up almost half of the entire complex (48%).

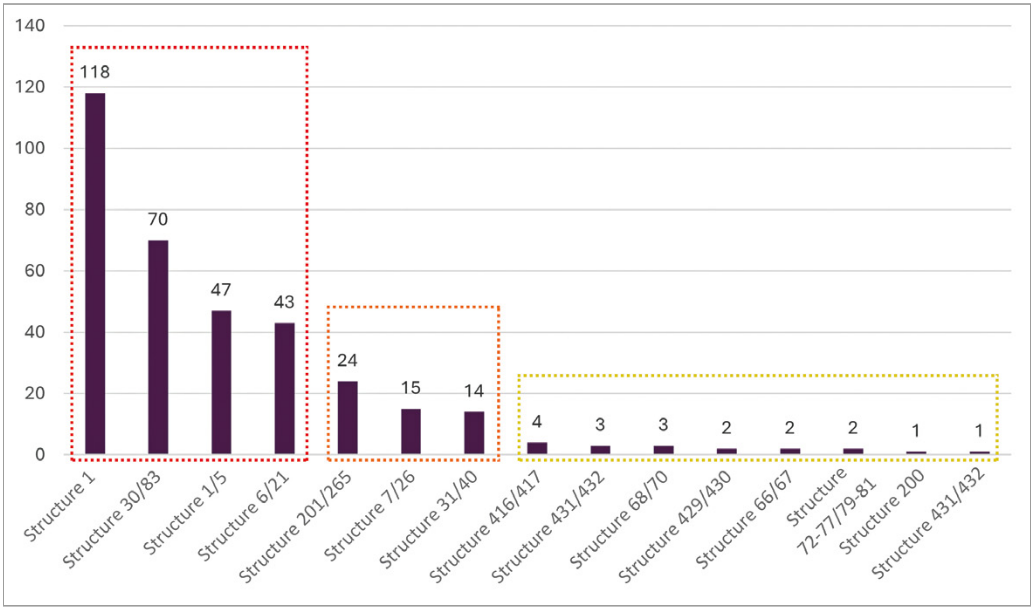

fig. 2. Intra-site distribution of obsidian. X-axis: structures; Y-axis: quantities. The dataset is grouped into three clusters based on quantity: red (higher quantities), orange (intermediate quantities), and yellow (lower quantities).

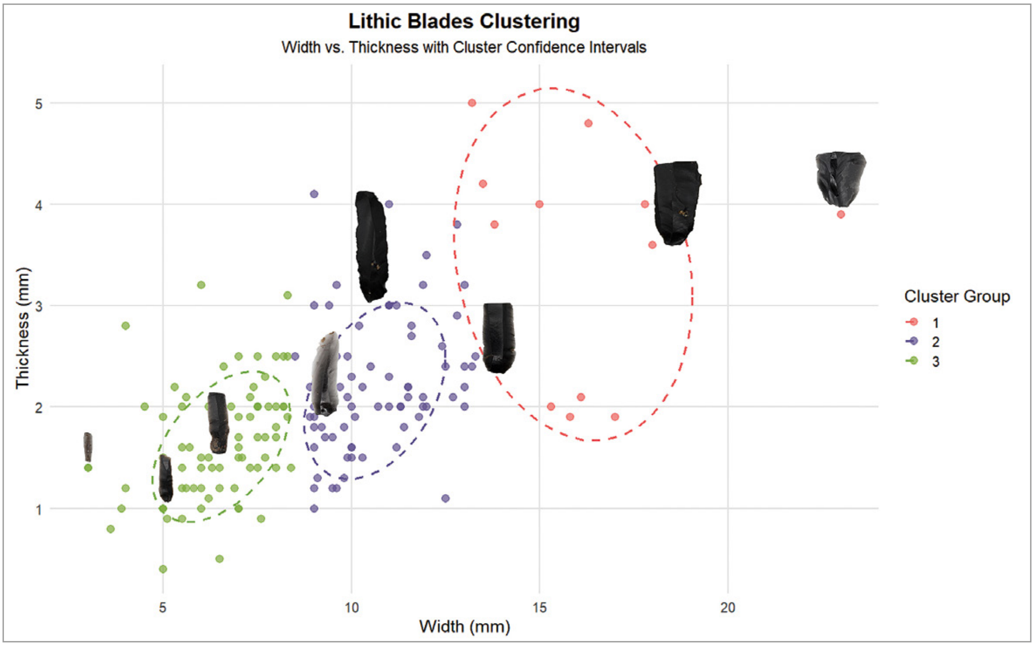

fig. 3. Scatter plot based on width (x-axis) and thickness (y-axis) of blades. Cluster 1 is shown in red, cluster 2 in blue, and cluster 3 in green. Archaeological examples are plotted on the Cartesian plane.

Maximum blade width and thickness are the main parameters employed to identify blade-knapping modules. Plotting the measures, three main clusters, corresponding to three potential different blade-knapping modules, were identified (**fig.** 3). However, only one knapping module was significantly distinct enough to be clearly separated from the others.

- Cluster 1 includes 12 blades with maximum widths between 13.2 and 23 mm and maximum thicknesses between 1.9 and 5 mm.
- Cluster 2 consists of a larger number of blades and bladelets (74), with maximum widths ranging from 8.5 to 13.3 mm and thicknesses between 1 and 4.1 mm.
- Cluster 3, also large, is composed of 76 bladelets and micro-bladelets with maximum widths from 3 to 8.4 mm and thicknesses from 0.4 to 3.2 mm.

The complex also contains a substantial number of flakes (32%), including a notable number of laminar flakes and debitage flakes. Among the core rejuvenation elements, platform rejuvenation flakes are the most common, along with some overhang rejuvenations and a partial tablette, suggesting the management of percussion platforms. Flakes rarely show preparation on the percussion platform; smooth butts are more common.

The presence of debris and various phases of the production sequence suggests that, at least partially, obsidian knapping took place on-site. However, only 23 pieces of production waste were found, suggesting the reduction of prepared cores. Obsidian likely reached the site in form of partially decorticated blocks, as indicated by the low number of cortical elements, which make up just over 13% of the total. The cortex characteristics, mostly smooth and lacking roughness, indicate a sourcing of the blocks from secondary deposits.

Artifacts were mainly produced following three operational sequences aimed at creating both blade and flake supports:

Operational sequence 1 (CO1). It represents an incomplete production sequence. Only finished products are represented, consisting of blades extracted from larger modules than those most common in the complex, corresponding to Cluster 1 (**fig.** 4, a). No preparation or core rejuvenation elements, or production waste, were found. The fragmentary state of these products prevents a definitive determination of the minimum core length; however, blades approximately 10 cm long were likely produced. These blades typically show trapezoidal cross-sections, convex profiles, and faceted butts, when conserved. This operational sequence therefore required an accurate preparation of the striking platforms. Considering the absence of knapping management and waste elements, blades from larger CO1 cores were likely introduced into the site as finished products. Notably, there was some variability in the quality of raw materials used for these blanks, with some pieces being inclusion-free and highly translucent, while others were opaque and rich in phenocrystals.

Operational sequence 2 (CO2). Almost the entire operational sequence is represented (**fig.** 4, b). Bladelets and microbladelets with variable morphology were produced (**fig.** 4, b, 1). The presence of many complete bladelets, some with similar morphologies, allows a more precise estimation of original core lengths. Products exhibit similar widths, mainly around 10 mm, and at least 5 complete bladelets, quite similar to each other, suggest extraction from cores approximately 5 cm in length. These bladelets show knapping angles close to 90°, trapezoidal sections, and curved distal ends. Blades are mostly fragmented, with proximal fragments predominating, and several elements show fractures in the mesial areas, including at least five pieces with bending fractures caused by notches or retouching. In some cases, the presence of these elements, along with the high frequency of fractures on similar sections of typometrically comparable pieces, suggest breaking intentionality. This sequence also includes several proxies of on-site knapping, such as debitage flakes (**fig.** 4, b, 2) and rare core preparation elements. Overhang rejuvenations, rejuvenations flakes, and partial core tablettes indicate stages of knapping management (**fig.** 4, b, 3). With nearly all stages of the production process represented, numerous debris elements can likely be linked to this operational sequence.

A single core is present: an intact, sub-pyramidal *tournant* core (**fig.** 4, b, 5), from which microbladelets were extracted. These microbladelets are morphometrically comparable to some found in the assemblage. This core was likely abandoned due to exhaustion and hinged extractions, with one occurrence related to the presence of a large inclusion. Detachments are unidirectional, with the last two extractions made after platform rejuvenation. Two artifacts are identifiable as rejuvenation byproducts of pyramidal or sub-pyramidal core-tips. They show unidirectional detachments (**fig.** 4, b, 4), with one clearly displaying microblade morphometry, probably produced by pressure flaking. Thus, cores were likely rejuvenated and used until exhausted.

Operational sequence 3 (CO3). Flakes of varying sizes (**fig.** 4, c) are detached using multidirectional exploitation patterns, indicating a more unstructured knapping

fig. 4. Technological composition of the Fornace Cappuccini complex. a) Technological composition of CO1; b) Technological composition of CO2. 1. Blades; 2. Débitage flakes; 3. Platform rejuvenation flakes; 4. Rejuvenations of sub-pyramidal core bases; 5. Core. c) Technological composition of CO3. 1. Fully cortical flake; 2. Flakes; Flake extracted using bipolar on anvil technique. Scale: 3 cm.

management. The presence of direct percussion is evident, given the morphology of the impact points, the widespread occurrence of prominent bulbs, and the discontinuous ventral surfaces on some specimens. Some artifacts also appear to have been produced by bipolar-on-anvil technique (**fig.** 4, c, 3), as showed by scars on the distal and proximal edges. This operational sequence may be linked to local, occasional production by non-specialised knappers.

3.3 Functional data

Although much of the assemblage shows some taphonomic alteration, it is generally well-preserved, which has made it possible to identify a significant number of artifacts suitable for more detailed analysis. Several flakes showed unmodified, sharp, and intact edges, indicating that the assemblage has not suffered from strong mechanical alterations. Moreover, strong rounding at the dorsal ridges was not detected during macroscopic observation, further confirming that the assemblage is generally well-preserved. Only a few items (2%) are characterised by strong patinas and chemical alterations, and these implements have not been considered for use-wear analysis.

As result of the analysis, a total of 87 pieces exhibited potential use-wear traces, within which a subgroup of 23 items showed more evident and diagnostic traces, primarily on blades. Unifacial use predominates, with 67 items, compared to bifacial one, represented by 20 pieces (**tab.** 1).

Given the frequent use of multiple edges on the same tool, a total of possibly 130 used areas were identified across 87 tools, with most of them located on the edges of bladelets, microbladelets, or laminar flakes. In contrast, none of the flake show use on more than one edge, except for a single tool (**fig.** 5, b, 129), which, heavily modified by retouching (A2, *sensu* Laplace, 1964), showed potential wear traces on three edges (right, left, and transverse).

	USE-WEAR						MOVEMENT			INTERPRETATION		
	Possible	Definite	Tot	Used areas	On retouch	Opposite to retouch	Transversal	Longitudinal	Mixed	Working of soft/low-resistance material	Working of hard/abrasive material	Hafting/ handling
Blades/Laminar flakes	**48**	**20**	**68**	**108**	**28**	**17**	**65**	**34**	**1**	**80**	**11**	**17**
Unretouched blades	17	4	21	26	0	0	16	9	1	23	1	2
Laterally retouched blades	12	8	20	33	6	5	26	7	0	21	8	4
Backed blades	5	4	9	19	9	7	11	8	0	11	1	7
Truncations	7	0	7	10	4	0	7	3	0	9	0	1
Notched blades	5	2	7	12	4	4	10	2	0	10	1	1
Composite tools	2	2	4	8	5	1	3	5	0	6	0	2
Flakes	**12**	**2**	**14**	**16**	**3**	**1**	**14**	**2**	**0**	**13**	**2**	**1**
Unretouched flakes	5	1	6	6	0	0	5	1	0	6	0	0
Laterally retouched flakes	1	1	2	2	2	0	2	0	0	2	0	0
Rejuvenation flakes	6	0	6	8	1	1	7	1	0	5	2	1
Composite tools	0	0	0	0	0	0	0	0	0	0	0	0
Ind	**3**	**0**	**3**	**3**	**1**	**0**	**3**	**0**	**0**	**3**	**0**	**0**
Notched ind	1	0	1	1	1	0	1	0	0	1	0	0
Spalls	**0**	**1**	**1**	**2**	**1**	**0**	**0**	**1**	**0**	**1**	**1**	**0**
Waste	**1**	**0**	**1**	**1**	**1**	**0**	**1**	**0**	**0**	**1**	**0**	**0**
Total	**64**	**23**	**87**	**130**	**34**	**18**	**83**	**36**	**1**	**98**	**14**	**18**

tab. 1. Functional data on macro-wear traces: counts of "possible," "definite," and "total" related to product type. Additional counts correspond to all identified used areas associated with each product type.

Most of the tools showing wear are associated with retouching (53 pieces), 47 of which are blades, especially laterally retouched bladelets, backed bladelets and truncations. Retouched blades, in particular blades with lateral retouching (L, *sensu* Laplace, 1964) appear to have been preferred for use over other technological categories. Among the retouched items, two main groups can be distinguished: one exhibits abrasions and notches on the opposite edge to the retouched one, while the other shows wear traces on the retouched edge, which forms the larger group. (**fig.** 5, a).

Some flakes also show potential use-wear patterns like those observed on blades (**fig.** 5, b). These include both unifacial and bifacial abrasions and fractures, sometimes associated with retouched edges (**fig.** 5, b, 5085 and 129).

Transversal actions are the most frequently observed within the assemblage (**tab.** 1). The directionality of chippings, fractures, and striations on the analysed tools indicate extensive use of the edges through transverse or oblique movements relative to the tool's axis. This evidence is found across all technological categories. Among these, at least three pieces seem to be associated with a multiple use and rejuvenation phase, as indicated by the retouching of rounded edges (**fig.** 5, c).

Item no. 5099 (**fig.** 5, c) has very rounded edges, and it was likely used for working abrasive materials, possibly through transverse actions, as indicated by the distribution of striations. In this case too, a retouch overlaps the rounded edge, indicating a rejuvenation of the previously used edge. A broken burin spall (no. 5093) seems to represent the rejuvenation of a tool extensively used on hard, abrasive materials. Wear traces following spall extraction suggest the item was possibly reused in a later phase, extending its functional lifespan.

Longitudinal use-wear traces are less frequent and almost entirely related to the processing of soft or non-abrasive materials. In several cases, these traces are found on both faces, showing bifacial or alternating pattern.

Despite the predominance of use on retouched edges, wear is frequently observed on the opposite edge, particularly on blades and laminar flakes. Additionally, some tools exhibit bilateral retouches or abrasions on both lateral proximal edges, as observed in obsidian tools from La Marmotta (Mineo et al., 2023, fig. 9.1.3.). In some cases, these patterns may be linked to hafting or handling systems, although further investigations at higher magnifications are required.

Four bladelets showed residues with a resinous-pitchy appearance and a brown-yellowish colour (**fig.** 5, d), linked to use-damage on the opposite edge, as observed in artifacts no. 255 and no. 5179 (**fig.** 5, d). The presence of such residues is rare in the site assemblage, leading us to exclude a post-depositional origin. However, in the absence of chemical characterization, the nature of these residues cannot be confirmed. Nevertheless, it is noteworthy to highlight the presence of such spots of viscous substances on potentially used tools.

In conclusion, the preliminary analysis of the obsidian assemblage from Fornace Cappuccini confirms that this material had a specific functional role and utilitarian value, rather than serving solely as a status-related material. Based on the macro-wear patterns, it appears that obsidian was primarily used for processing soft or non-abrasive materials. Only a few items, mostly laterally retouched blades, show heavily rounded or chipped edges, along with deep striations, indicating their use for processing harder, more abrasive materials.

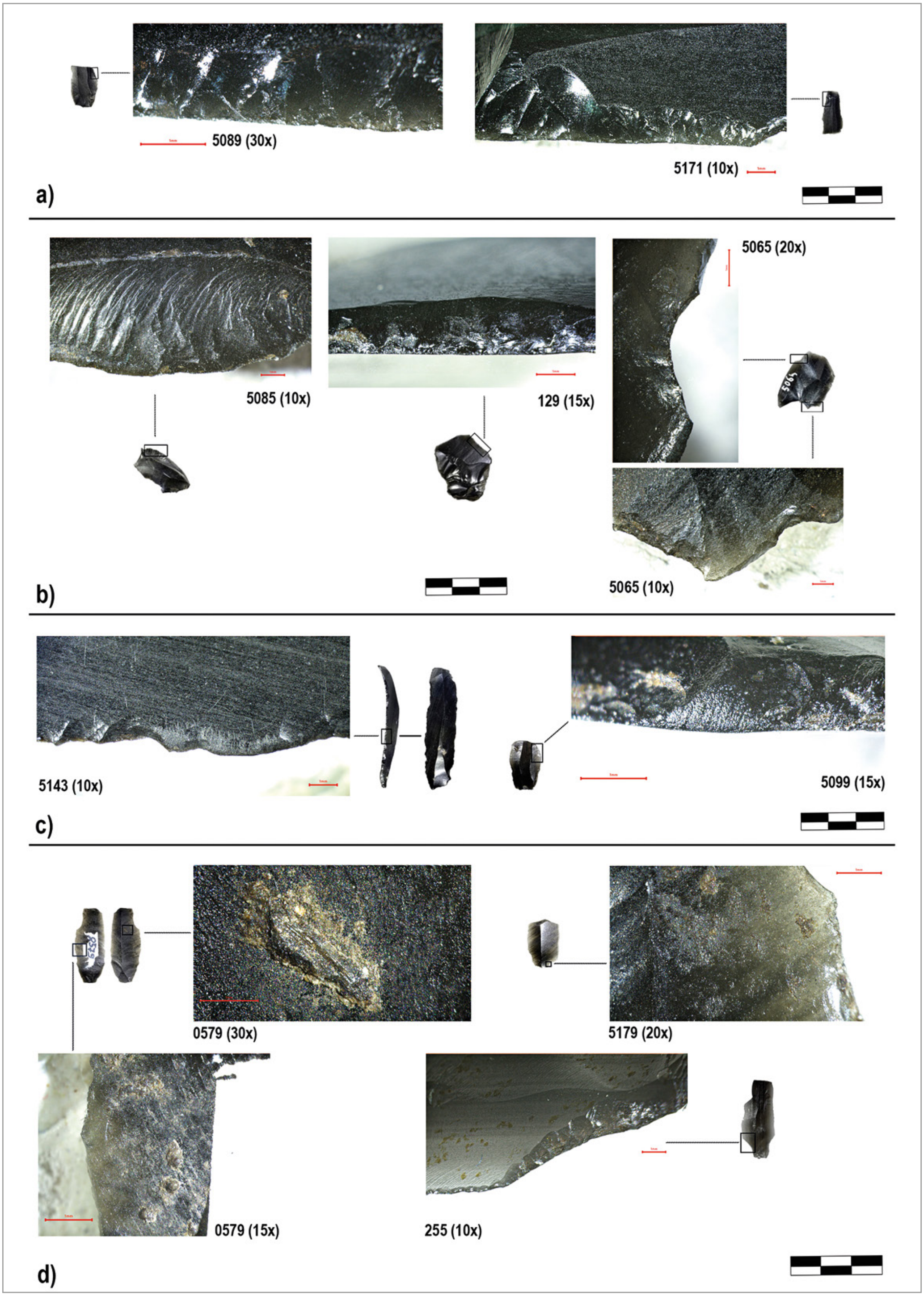

fig. 5. Functional data. a) Abrasions on retouched edges; b) Use-wear on flakes; c) Multiple phases of use and edge rejuvenation; d) Use-wear associated with hafting, with residues on the surfaces. Scale: 3 cm. Microscope images scale (in red): 1 mm.

3.4 Typology

A total of 70 pieces shows evidence of retouching, with the majority being blades (54). Among these, laterally retouched blades are the most common, accounting for 31 items, most of which display marginal (L1) and inframarginal (L1-0, Starnini & Voytek, 1997, p. 351) retouching. There is also a notable presence of backed blades (9 pieces) and oblique truncations (T3) with 6 items. Additionally, significant is the presence of notches and denticulated bladelets, with 11 pieces, mainly represented by type D1. A single burin on a blade (B1) is present, while end scrapers are entirely absent. Scrapers (R1-0, R1, R3) are also represented with six pieces.

4. Discussion

4.1 Fornace Cappuccini in the context of the neolithization of the Po Valley

Fornace Cappuccini was occupied during the second half of the 6th millennium BC, within the context of the northward expansion of groups associated with Impressed Ware from the central Adriatic regions, a process that largely came to a halt in Romagna (southeastern Po Valley) with its late aspects. This same chronological period also marks the formative phase of the Neolithic groups of the Po Valley (Biagi et al., 2020; Starnini et al., 2018), among which Fiorano (Labate, 2006). The northward expansion of Impressed Ware populations may have been halted upon encountering other Neolithic communities (Improta & Pessina, 1998). However, it is important to consider that the distribution of sites in the lower Po Valley could also reflect alterations in sedimentary processes that have taken place since the Holocene (Bruno et al., 2017). Many sites may now lie buried under meters of sediment (Biagi et al., 2020).

However, sites with Fiorano-type pottery show a significant presence of Alpine flint, in contrast to areas beyond the direct influence of Fiorano groups, such as Impressed Ware sites, where it is either absent or found only sporadically (Mengoli, 2011). Likewise, Fiorano sites are notably excluded from the obsidian circulation networks, which appear only episodically and in and in minimal quantities north of Fornace Cappuccini during the Early Neolithic (Pessina, 1998, 2000).

Within this broader framework of raw material circulation, Fornace Cappuccini represents the northernmost "frontier" of the Adriatic in the diffusion of obsidian. The distribution routes of obsidian thus seem to have been linked to a complex network of relations, which did not uniformly involve all communities and territories.

4.2 Obsidian in the Early Neolithic: Technological and Functional Aspects

The lithic assemblage from Fornace Cappuccini belongs to a broader tradition shared by many *Ceramica Impressa* (Impressed Ware) sites. Pressure flaking, documented across the peninsula and applied to all types of long-distance raw materials, offers a more efficient use of resources compared to percussion (Perlès, 1990). This technique may have been especially preferred for processing exogenous raw materials. However, the pressure technique requires 1) a very vitreous and homogeneous cryptocrystalline rock, and 2) a considerable investment in terms of skill and learning, implying the need for some degree of artisanal specialization. Specialists in raw materials and flintknapping might have played a key role in the circulation of obsidian, likely acting as primary agents through itinerant mobility (Perlès, 1990, 2004), and they may have spread larger pressure-flaked products. Locally, obsidian may have been exploited in a less specialised manner, using smaller cores, sometimes already nearly exhausted, to produce bladelets, microbladelets, and flakes. Cores are rarely abandoned in earlier knapping phases; more often, they are found in residual and exhausted state, often with hinged removals on the surfaces. Furthermore, the size of the products may, in some cases, have been influenced by the characteristics of the raw material deposition, which, as observed at Palmarola, tends to consist of relatively small blocks (Ceruleo, 1982; Guilbeau, 2022; Radmilli, 1954).

The presence of flakes produced through direct or bipolar-on-anvil percussion suggests that some non-specialised knappers were involved in working raw materials locally. We can therefore hypothesize that not only different production sequences existed, but also different social actors involved in the circulation and knapping of obsidian.

However, larger blades could have been distributed alongside small cores without necessarily implying the presence of itinerant knappers, but rather as part of broader exchange networks that also included other exogenous materials. In fact, the distribution of obsidian may have been managed alongside other non-local materials.

The data suggest that Fornace Cappuccini served more as an "intermediate" site, where obsidian was primarily used and consumed locally, but where small quantities of flakes and blades could also have been redistributed to nearby sites, given the considerable amount of material present. The presence of both blade and flake production sequences, along with their similarity in technological management, flaking techniques, and typology to the flint assemblage, suggests a local management of part of the obsidian tool production.

From a functional perspective, the preliminary macro-wear analysis indicates that part of the assemblage was indeed used, confirming its utilitarian value. The macroscopic evidence of edge damage on several tools provides an initial, albeit partial, interpretation of the functional domains in which obsidian was used within the settlement. The evidence suggests that obsidian was mainly employed for processing soft and fragile materials, primarily using blade tools, although some flakes also show signs of use. In general, harder and more abrasive substances appear to have been worked with other raw materials, such as flint, which was likely more effective for such tasks, for example, cereal harvesting, where more durable materials are more effective (Astruc et al., 2012). Agricultural practices and hunting activities are exclusively associated with flint tools. At Fornace Cappuccini, geometric-backed tools bearing impact traces are present (Mengoli, 2011) and flint sickle inserts are widely attested (Mazzucco et al., 2018).

The functionality of obsidian tools remains an interesting and open topic of research. Data is still scarce, and further analysis is needed. However, some studies seem to suggest that specific behaviours were employed depending on the context. A combined study of experimental and archaeological samples from Sardinia indicates that the physical properties of different obsidian deposits might have been chosen for processing different materials. SC variant was used for working harder inorganic materials and a wider variety of materials compared to the SA sub-source (Setzer, 2004; Setzer & Tykot, 2010). At Contrada Diana in Lipari, there is evidence of the processing of hard materials such as bone and antler, sometimes using formal tools like end scrapers. This evidence should be linked to the fact that obsidian at Lipari was the primary lithic resource (Iovino & Martinelli, 2008). A more specialised use is hypothesised for Grotta dell'Uzzo (TP), where volcanic glass seems to be used for skinning and butchering fish (Iovino, 1997, 2001).

5. Conclusions and perspectives

One of the key differences between the first farming communities and the last hunter-gatherer societies lies in the circulation of exotic and non-local materials, which saw an exponential increase starting in the Neolithic (Barfield, 2000). This shift is tied to other important processes, such as the rise of specialization, which allowed consumers to no longer be directly involved in the production of the goods they used, enabling them to access and utilize raw materials from distant sources just as they would local ones (Perlès, 2012). The selection of high-quality materials becomes increasingly common and new supply strategies are introduced, such as the opening of maritime routes or the extraction of raw materials from mines (Galiberti, 2005). The management of obsidian is thus part of a clear shift in the relationship with landscapes and resources, which is entangled in a network of circuits that do not form part of a unified process.

The circulation of obsidian, as a complex phenomenon, cannot be understood by assuming it was solely intended for special uses, nor by analysing it without distinguishing it from flint industries. The meanings and values that obsidian could assume have been mutable both spatially and diachronically, and it is each society that determines whether a raw material has utilitarian value, serves as a means of social interaction, or is considered a prestige good (Perlès, 2012). Furthermore, objects have biographies and statuses that can change even within the same generation. In fact, a singular model is unable to account for the complexity and variability present in obsidian assemblages. One of the most widely circulated exogenous materials during the Early Neolithic requires further study. One of the main goals of the research will be to standardise data of various types, coming from different research methodologies, to allow both qualitative and quantitative comparisons. It will also be essential to connect provenance data with technological supports to understand the origin and circulation of materials, and how such dynamics evolved over time, refining chronologies with new dating programs. Finally, expanding the availability of traceological data will be crucial to highlight similarities and differences at various analytical scales[4].

[4] The review study of the obsidian materials from Fornace Cappuccini was carried out as part of the PRIN 2022 project "CHRONOS – The obsidian route in the central Mediterranean: DiaCHRONic pathways and cultural connectiONS" (Project code 2022JLC8SF CUP I53D23000080006), funded by the European Union-Next GenerationEU coordinated by the University of Pisa and in cooperation with the University of Cagliari. The project's aim is to investigate the circulation patterns of obsidian in the Mediterranean during the Neolithic, modelling data of different types from various chrono-cultural contexts.

References

Ammerman, A. J., Shaffer, G. D., & Hartmann, N. (1988). A Neolithic Household at Piana di Curinga, Italy. *Journal of Field Archaeology*, *15(2),* 121-140.

Antoniazzi, A., Bagolini, B., Bermond Montanari, G., Massi Pasi, M., & Prati, L. (1987). Il Neolitico di Fornace Cappuccini a Faenza e la Ceramica Impressa in Romagna. In *Atti della XXVI riunione scientifica*, Vol. II (pp. 553-564). Istituto Italiano di Preistoria e Protostoria.

Antoniazzi, A., Bermond Montanari, G., Giusberti, G., Massi Pasi, M., Mengoli, D., Morico, G., & Prati, L. (1990). Lo scavo preistorico a Fornace Cappuccini. In M. Maioli, M. Massi Pasi, & S. Gelichi (eds.), *Archeologia a Faenza: Ricerche e scavi dal Neolitico al Rinascimento. Catalogo della mostra*. Nuova Alfa Editoriale.

Astruc, L., Ben Tkaya, M., Torchy, L., Altinbilek, C., Balcı, S., Bontemps, C., Gassin, B., Ducret, S., Kayacan, N., Kayan, K., Kurt, N., Oral, O., Özbaşaran, M., Pelegrin, J., Rodriguez Rodriguez, A., & Toprak, Ö. (2012). De l'efficacité des faucilles néolithiques au Proche-Orient: approche expérimentale. *Bulletin de la Société préhistorique française*, 109(4), 671-687. https://doi.org/10.3406/bspf.2012.14202

Bagolini, B., & von Eles, P. (1978). L'insediamento neolitico di Imola e la corrente culturale della ceramica Impressa nel medio e alto Adriatico. *Preistoria Alpina* 14, 33-63.

Bagolini B., & Ghirotti, L. (1980). La Cultura della Ceramica Impressa a Misano Adriatico (Forli): aspetti del Neolitico della Romagna. *Preistoria Alpina* 16: 31-43.

Bagolini, B., & Biagi, P. (1987a). Il Neolitico dell'Emilia-Romagna. In *Atti della XXVI riunione scientifica*, Vol. II (pp. 217-227). Istituto Italiano di Preistoria e Protostoria.

Bagolini, B., & Biagi, P. (1987b). The first Neolithic chipped stone assemblages of Northern Italy. In J.K. Kozlowski & S.K. Kozlowski (eds.), *Archeologia Interregionalis. Papers delivered at the International "Chipped stone industries of the Early Farming Cultures in Europe.* Varia, Vol. CCXL, 423-448.

Bagolini, B., & Biagi, P. (1990). The radiocarbon chronology of the Neolithic and Copper age of northern Italy. *Oxford Journal Of Archaeology* 9(1), 1-23.

Bagolini, B., DeLucca, O., Ferrari, A., Pessina, A., & Wilkens, B. (1991). Insediamenti neolitici ed eneolitici di Miramare (Rimini). *Preistoria Alpina*, 25, 53-120.

Barfield, L. (2000). Commercio e scambio nel Neolitico dell'Italia settentrionale. In A. Pessina & G. Muscio (eds.), *La Neolitizzazione tra oriente e occidente. Atti del Convegno di Studi, Udine 23-24 aprile 1999* (pp. 55-66). Edizioni del Museo Friulano di Storia Naturale.

Bermond Montanari, G., & Massi Pasi, M. (1998). New data on the Neolithic Age in Romagna. *Preistoria Alpina*, *34*, 263-269.

Bermond Montanari, G. (2000). Datazioni radiometriche della stazione di Fornace Cappuccini (Faenza, Ravenna). In P. Biagi (ed.), *Studi sul Paleolitico, Mesolitico e Neolitico del bacino dell'Adriatico in ricordo di Antonio M. Radmilli*. Società per la Preistoria e Protostoria della Regione Friuli-Venezia Giulia, Quaderno 8, 21-26.

Biagi, P., Starnini, E., Boric´, D., & Mazzucco, N. (2020). Early Neolithic settlement of the Po Plain (northern Italy): Vhò and related sites. *Documenta Praehistorica*, *XLVII*, 192-221.

Bigazzi, G., & Radi, G. (2003). L'ossidiana in Abruzzo durante il Neolitico. In *Atti della XXXVI Riunione Scientifica: Preistoria e Protostoria dell'Abruzzo, Chieti-Celano 27-30 settembre 2001* (pp. 619-624). Istituto Italiano di Preistoria e Protostoria.

Brito-Abrante, I., & Rodríguez-Rodríguez, A. (2024). Use-Wear Analysis of Obsidian and Other Volcanic Rocks: An Experimental Approach to Working Plant Resources. *Journal of Archaeological Method and Theory*, *31*(4), 1873-1916.

Bronk Ramsey, C., & Lee, S. (2013). Recent and Planned Developments of the Program OxCal. *Radiocarbon*, *55*, 720-730.

Bruno, L., Bohacs, K. M., Campo, B., Drexler, T. M., Rossi, V., Sammartino, I., Scarponi, D., Hong, W., & Amorosi, A. (2017). Early Holocene transgressive palaeogeography in the Po coastal plain (northern Italy). *Sedimentology*, *64*, 1792-1816.

Ceruleo, P. (1982). La stazione litica di Setteville di Guidonia (Roma). *Studi per l'ecologia del Quaternario, 4*, 67-70.

Farr, H. (2006). Seafaring as social action. *Journal of Maritime Archaeology*, *1*, 85-99.

Clemente Conte, I., Lazuén Fernández, T., Astruc, L., & Rodríguez Rodríguez, A. C. (2014). Use-wear analysis of nonflint lithic raw materials: The cases of quartz/quartzite and obsidian. In *Use-wear and residue analysis in archaeology* (pp. 59-81). Cham: Springer International Publishing.

Finocchiaro, C. (2023). Approccio chimico analitico allo studio delle sostanze adesive sui falcetti neolitici. Master degree diss. University of Pisa.

Galiberti, A. (ed.). (2005). *Defensola. Una miniera di selce di 7000 anni fa*. Protagon Editori Toscani.

Gibaja, J. F., & Mazzucco, N. (2023). Lithic implements used to work cereal and other non-ligneous plants from Sarakenos Cave, Boeotia, Greece. In A. Sampson & T. Tsourouni (eds.), *The Sarakenos Cave at Akraephnion, Boeotia, Greece: From the Middle Palaeolithic to the end of the Bronze Age* (Vol. IV, pp. 249-264).

Grace, R. (1996). Review Article Use-Wear Analysis: The State of the Art. *Archaeometry*, *38*(2), 209-229.

Guilbeau, D. (2022). Analyse du matériel lithique de la Marmotta – études 2019, 2021 et 2022. Unpublished.

Hurcombe, L. M. (1992a). *Use wear analysis and obsidian: Theory, experiments and results* (4th ed.). Sheffield Archaeological Monographs, University of Sheffield Department of Archaeology and Prehistory.

Hurcombe, L. (1992b). New contributions to the study of the function of Sardinian obsidian artifacts. *Sardinia in the Mediterranean: a footprint in the sea. Sheffield Academic, Sheffield*, 83-97.

Kononenko, N. (2011). Experimental and archaeological studies of use-wear and residues on obsidian artefacts from Papua New Guinea. *Technical Reports of the Australian Museum, Online*, *21*(February), 1-244.

Improta, S., & Pessina, A. (1998). La neolitizzazione dell'Italia settentrionale. Il nuovo quadro cronologico. In A. Pessina & G. Muscio (eds.), *Settemila anni fa il primo pane. Ambienti e culture delle società neolitiche.* Catalogo della mostra (pp. 107-116). Comune di Udine, Museo friulano di Storia naturale.

Inizian, M. L., Reduron, M., Roche, H., & Tixier, J. (1999). *Technology and terminology of knapped stone*. Cercle de Recherches et d'Étude Préhistoriques.

Iovino, M.R. (1997). La funzione dell'ossidiana: Un approccio sperimentale al problema, *Origini, XX*, 71-107.

Iovino, M.R. (2000). Attività agricole nei siti neolitici della Sicilia orientale. In A. Pessina & G. Muscio (eds.), *La Neolitizzazione tra oriente e occidente*. Atti del Convegno di Studi, Udine 23-24 aprile 1999 (pp. 513-522). Edizioni del Museo Friulano di Storia Naturale.

Iovino, M.R. (2001). Il contributo degli studi funzionali sulle industrie litiche in ossidiana nell'analisi dello sfruttamento preistorico delle risorse marine: Grotta dell'Uzzo (TP), *Rivista di Scienze Preistoriche LI, 2000-2001*, 423-431.

Iovino, M.R., Martinelli, M.C. (2008). Production and function(s) of obsidian tools at the Neolithic site of Contrada Diana (Aeolian Islands, Sicily). In L. Longo & N. Skakun (eds.),'*Prehistoric Technology' 40 years later: Functional Studies and the Russian Legacy*. Proceedings of the International Congress, Verona (Italy), 20-23 April 2005 (pp. 439-443). BAR International Series 1783.

Labate D., ed. (2006). Fiorano e la Valle del torrente Spezzano. Archeologia di un territorio. Quaderni di archeologia dell'Emilia Romagna 14.

Laplace, G. (1964). *Essai de typologie systématique.* Annali Univ. Ferrara, sez. 15, suppl. al vol. I.

Lemorini, C. (2007). Il sito di Sant'Anna di Oria (Brindisi): risultati dell'analisi funzionale dell'industria litica scheggiata. In I. Tiberi (ed.), *Sant'Anna (Oria-Br). Un sito specializzato del VI millennio a.C.* (pp. 118-123). Congedo Editore.

Leroi-Gourhan, A. (1964). *Le Geste et la Parole. I, Technique et Langage*. Michel, coll. Sciences d'aujourd'hui.

Martinelli, M. C., Tykot, R. H., & Vianello, A. (2019). Lipari (Aeolian Islands) Obsidian in the Late Neolithic. Artifacts, Supply and Function. *Open Archaeology, 5*, 46-64.

Mazzucco, N., Capuzzo, G., Pannocchia, C. P., Ibáñez, J. J., & Gibaja, J. F. (2018). Harvesting tools and the spread of the Neolithic into the Central-Western Mediterranean area. *Quaternary International*, *470*, 511-528.

Mazzucco, N., Ibáñez, J. J., Capuzzo, G., Gassin, B., Mineo, M., & Gibaja, J. F. (2020). Migration, adaptation, innovation: The spread of Neolithic harvesting technologies in the Mediterranean. *PloS one*, *15*(4), e0232455.

Mengoli, D. (2011). *Fornace Cappuccini (Faenza): Un complesso litico della Ceramica Impressa Medio Adriatica*. Tesi di dottorato. Università degli Studi di Siena.

Mengoli D, Mazzucco N. (2019) – Mursia (Pantelleria): industria litica scheggiata della struttura B14, Rivista di Scienze Preistoriche LXVIII: 425-458.

Mineo, M., Mazzucco, N., & Gibaja, J. (2023). The submerged site of La Marmotta (Rome, Italy).

Odell, G. H. (1987). Analyse fonctionnelle des traces d'usure effectuée à une échelle régionale: l'Illinois. *L'Anthropologie*, 91(2), 381-398.

Odell, G. H. (2001). Stone tool research at the end of the millennium: classification, function, and behavior. *Journal of Archaeological Research*, 9, 45-100.

Odell, G. H., & Odell-Vereecken, F. (1980). Verifying the reliability of lithic use-wear assessments by 'blind tests': the low-power approach. *Journal of field Archaeology*, *7*(1), 87-120.

Pearce, M. (2008). Structured Deposition in Early Neolithic Northern Italy. *Journal of Mediterranean Archaeology*, *21(1)*, 19-33. https://doi.org/10.1558/jmea.v21i1.19

Perlès, C. (1990). L'outillage de pierre taillée néolithique en Grèce: approvisionnement et exploitation des matières premières. *Bulletin de correspondance hellénique, 114(1)*, 1-42.

Perlès, C. (2004). *The early Neolithic in Greece: The first farming communities in Europe*. Cambridge University Press.

Perlès, C. (2012). Le statut des échanges au néolithique. In Congrés Internacional Xarxes al Neolític – Neolithic Networks. *Rubricatum. Revista del Museu de Gavà*, *5*, 539-546.

Pessina, A. (1998). Aspetti culturali e problematiche del primo Neolitico dell'Italia settentrionale. In A. Pessina & G. Muscio (eds.), *Settemila anni fa il primo pane. Ambienti e culture delle società neolitiche*. Catalogo della mostra (pp. 95-106). Comune di Udine, Museo friulano di Storia naturale.

Pessina, A. (2000). Il primo Neolitico dell'Italia settentrionale: problemi generali. In A. Pessina & G. Muscio (eds.), *La Neolitizzazione tra oriente e occidente*. Atti del Convegno di Studi, Udine 23-24 aprile 1999 (pp. 81-90). Edizioni del Museo Friulano di Storia Naturale.

Radmilli A. M. (1954). Le Isole Pontine e il commercio dell'ossidiana nel continente durante il neo-eneolitico, in Origines, Raccolta di scritti in onore di Mons. Giovanni Baserga, Tipografia Editrice Antonio Noseda, Como, 115-129.

Reimer, P. J., Austin, W. E. N., Bard, E., Bayliss, A., Blackwell, P. G., Bronk Ramsey, C., Butzin, M., Cheng, H., Edwards, R. L., Friedrich, M., Grootes, P. M., Guilderson, T. P., Hajdas, I., Heaton, T. J., Hogg, A. G., Hughen, K. A., Kromer, B., Manning, S. W., Muscheler, R. et al.

(2020). The IntCal20 Northern Hemisphere Radiocarbon Age Calibration Curve (0-55 cal kBP). *Radiocarbon, 62*(4), 725-757. https://doi.org/10.1017/RDC.2020.41

Setzer, T. J. (2004). *Use-wear experiments with Sardinian obsidian: Determining its function in the Neolithic*. Graduate thesis. University of South Florida.

Setzer, T. (2012). Use-wear Experiments with Obsidian. *Lithic Technology*, *37*(1), 35-46.

Setzer, T. J., & Tykot, R. H. (2010). Considering the source: The importance of raw material characterization and provenance in obsidian use-wear studies. In C. Lugliè (ed.), *L'ossidiana del Monte Arci nel Mediterraneo. Nuovi apporti sulla diffusione, sui sistemi di produzione e sulla loro cronologia*. Atti del 5° Convegno internazionale, Pau, Italia, 27-29 Giugno 2008 (pp. 71-84). NUR.

Starnini, E., & Voytek, B. (1997). The Neolithic chipped stone artefacts from the Bernabò Brea-Cardini excavations. In R. Maggi, E. Starnini, B.A. Voytek (eds.), *Arene Candide: A functional and environmental assessment of the Holocene sequence excavated by L. Bernabò Brea (1940-50)* (pp. 349-426). Memorie dell'Istituto Italiano di Paleontologia Umana 5. Il Calamo.

Starnini, E., Biagi, P., & Mazzucco, N. (2018). The beginning of the Neolithic in the Po Plain (northern Italy): Problems and perspectives. *Quaternary International, 470*, 301-317.

Terradas, X., Gratuze, B., Bosch, J., Enrich, R., Esteve, X., Oms, F. X., & Ribé, G. (2014). Neolithic diffusion of obsidian in the western Mediterranean: New data from Iberia. *Journal of Archaeological Science, 41*, 69-78.

Tixier, J. (ed.). (1984). *Préhistoire de la pierre taillée 2: économie du debitage laminaire: technologie et expérimentation*. III table ronde de technologie lithique, Meudon-Bellevue octobre 1982. Cercle de Recherches et d'Étude Préhistoriques.

Tringham, R., Cooper, G., Odell, G., Voytek, B., & Whitman, A. (1974). Experimentation in the formation of edge damage: a new approach to lithic analysis. *Journal of field archaeology, 1(1-2)*, 171-196.

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*, 264-278.

Tykot, R. H., Iovino, M.R., Martinelli, M.C. & Beyer, L. (2006) – Ossidiana da Lipari: Le fonti, la distribuzione, la tipologia e le tracce d'usura. In *Atti della XXXIX Riunione Scientifica: Materie prime e scambi nella preistoria Italiana*, Firenze, 25-27 novembre 2004 (pp. 595-596). Istituto Italiano di Preistoria e Protostoria.

Walton, D. P. (2019). An experimental program for obsidian use-wear analysis in central Mexican archaeology. *Journal of Archaeological Method and Theory*, *26*(3), 895-942.