Reviewed Article:

The Experimental Reconstruction of an Early Neolithic Underground Oven of Portonovo (Italy)

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This contribution presents the experimental reconstruction of an underground oven replicated according to the archaeological evidence unearthed from the Early Neolithic site of Portonovo-Fosso Fontanaccia (Ancona-Italy). A domed structure, measuring 190x180 cm diameter at the base and 50 cm in height, was dug in 15 hours, in a sediment compatible with

the geological formation that features the archaeological site. The experimental protocol presented in this article aims to reconstruct techniques, timing and tools needed to dig the peculiar underground structures of Portonovo used by Neolithic groups and understand key topics regarding the entire technical process such as energy investment for the community, seasonality and lifespan.

> “Creating a fire within ovens like these which lack a vertical draft, is not an easy task, and the fire struggled to start, however, the oven worked well once the gaseous components of the fire found their path throughout the dome. This confirmed that the oven can work efficiently with a vertical draft system allowing the smoke to get out through the entrance of the oven, and suggesting that a vertical hole along the dome is not necessary in these kinds of structures to make them functional.

The Archaeological Context

The Early Neolithic site of Portonovo - Fosso Fontanaccia is located in the Marche region, along the Adriatic side of central Italy (See Figure 1) and is characterised by the exclusive presence of underground ovens and by the absence of dwellings (Conati Barbaro, et al., 2013). The site belongs to the “Middle Adriatic Impressa culture” which developed during the 6th millennium BC along the Adriatic coast of central Italy. Research carried out during the last years unearthed 23 structures of fired earth in an area of 600m^2. The ovens have a circular base, from 1.80 to 2 m in diameter, a height of about 0.50 m, a single central opening faced on a large pit. According to the archaeological investigation, each structure is characterised by a recurring lining, variable in thickness, probably due to the repeated exposure of the sediment to the fire; moreover, the surface of the ovens’ floors suggests a sort of intentional treatment likely by smoothing the superficial sediment at a wet state. This preliminary reconstruction is based on a first analysis of technical features of the archaeological remains and, in particular, of seven of the ovens that were found completely intact (Conati Barbaro, et al., 2019) (See Figure 2).

Archaeological material found inside the structures appears scantly whilst the most of the pottery, lithic industry, and faunal remains were unearthed from the large pits located in front of the ovens. Even a great amount of charred barley caryopses was found inside three of these structures (Conati Barbaro et al., 2019).

According to the radiometric dating the site was occupied from 5900 to 5200 BC, a period during which the ovens were not all in use at the same time. Their spatial distribution does not reflect a chronological order, although the location of each oven was probably well known when a new structure was to be built. Furthermore, some of the ovens were used for funerary purposes, as attested by the burials of three adult individuals dating back to the last centuries of the 6th millennium BC (Conati Barbaro, et al., 2013).

The investigation regarding the function of this archaeological context availed of archaeometric analyses applied to the archaeological structures in order to address the building process and the activities actually performed around of the underground structures. The results of the PXRD analysis applied to the hardened sediment sampled from specific parts of four different ovens (floors, walls, vaults) suggest that temperature reached by the structures did not exceed 500°C (Conati Barbaro, et al., 2013). According to this data and to the great amount of charred barley caryopses found inside three of the ovens, it was hypothesised that these structures were used for activities of food processing including roasting or drying cereals for their storage or consumption. In order to confirm this reconstruction and contribute to the understanding of the function of the site, an experimental replica of the underground ovens of Portonovo was built reaching the actual size of the archaeological items. Very few reconstruction experiments of these types of ovens have been attempted so far (Eiland, Luning & Williams, 2003; Lüning, 2004) and since the main purpose of those experiments was to investigate the function of the structure and its performance, the building procedure was not fully explained. Moreover, most of the building experiments performed so far have been focused on domed ovens or earth ovens (e.g.: Đuričić, 2014; Costa, Cavulli & Pedrotti, 2017; Pfaffinger and Pleyer, 1990; Prévost-Dermarkar, 2003; Werner, 1991). This contribution will present a detailed methodology to build an underground oven inspired by the shape and size of the Neolithic structures unearthed at Portonovo.

The experimental replica

The experimental underground oven was replicated according to shape, measurements, and technical features of the Neolithic structures found at Portonovo-Fosso Fontanaccia. The replica was carried out in three main steps including: (1) the preliminary set up of the experiment, (2) the digging of the structure and (3) the final heating for consolidation.

During the first step, we identified a sediment highly compatible with the ancient geological formation chosen by the Neolithic groups that dig the prehistoric underground structures (See Figure 3); we proceeded with the removal of the vegetation followed by the preparation of the excavation wall and a pit in front of it about 1.80 x 1.50 m wide. The set up step included also the collection of tools necessary to dig the oven; the selection was made according to wood species attested in this area during the Neolithic period, and animal bones. The selection of these kinds of tools was made according to the raw materials commonly used in well preserved Neolithic archaeological sites, such as La Draga, in Spain, (López et al., 2012, Palomo et al., 2011) and La Marmotta in Italy (Fugazzola Delpino, D'eugenio & Pessina, 1993). These findings testify the large production and use of wood and bone tools by Neolithic communities. Conversely, the selection of wood tools with long handles currently lacks of direct archaeological evidence in particular in the archaeological

site of Portonovo; nevertheless, the possibility to reach easily the deepest areas of the underground oven, working from the outside, led us to test their efficacy.

We collected tools made of oak (*Quercus robur L.*) exhibiting a thin utilized edge and a long handle (1.67m) along with other two implements, of different dimensions, made of acacia (*Robinia pseudoacacia Mill.*) characterized by a curved working edge and a long handle (65cm); we also tested several wood wedges and a wood mallet (*Ligustrum vulgare L.*, *Castanea sativa L.*, *Populus nigra L.*). Furthermore, a tool made of a bovid bone (*Bos taurus L.*) was utilized as well, featuring a sharp edge and a wooden haft, which was lined with leather to favour its gripping (See Table 1; See Figure 7).

tool	shape and size	material	use activity	technical step	efficacy
stick	thin edge and a long handle (1,6 7 m)	wood (*Quercus robur* L.)	dig (direct percussion)	during the whole process	high
stick	short curved edge and long handle (65 cm)	wood (*Robinia pseudoacacia* Mill.)	dig (direct percussion)	during the initial process	low
stick	curved edge and long handle (80 cm)	wood (*Robinia pseudoacacia* Mill.)	pull out the sediment resulting from digging	during the whole process	high
wedge	sharp edge (30 cm)	wood (*Ligustrum vulgare* L.)	dig (direct percussion)	during the initial process	high
wedge	sharp edge (30 cm)	wood (*Castanea sativa* L.)	dig (direct percussion)	during the initial process	medium
mallet	hammer shaped (40 cm)	wood (*Populus nigra* L.)	direct percussion on mallet	just at the biginning of digging high	high
scraper	sharp edge and a wooden haft	bone (*Bos taurus* L.)	remove irregularities of the internal surface following the digging process	after the dig of the oven	medium

TABLE 1. TOOLS SELECTED AND USED DURING THE EXPERIMENT. EACH TOOL IS DESCRIBED IN SHAPE, SIZE, TASK AND EFFICACY OF ITS USE IN EACH SPECIFIC STEP.

During the second step of the experiment that coincides with the digging of the structure, we proceeded engraving the limits of the entrance along the main wall (See Figure 4). We started this phase using a wooden mallet (See Table 1). Once reaching a 10 cm ca. deep entrance we started to dig the structure, shaping the oven within the sediment until we created a dome measuring 190x180 cm in diameter at the base and 50 cm in height. A total amount of the sediment corresponding to 0.786 m^3 was extracted utilizing wood wedges and a wood mallet throughout direct and indirect percussion (See Table 2; See Figures 4 and 6). The sediment

detached through the percussion gesture was pulled out of the structure through a wooden tool with a flat functional edge and a long handle in order to reach the deeper areas of the oven and clean the floor from sediment residues (See Figure 6c). This gesture was performed at each step in order to avoid an accumulation of the sediment inside the structure that usually made difficult the working. During this phase the experimenter, a young man working on his own, performed the entire technical sequence in a supine position (See Figure 6 d); the use of long tools made it easier for the experimenter to work from inside and reduce the risk in case of a collapse of the structure. The pit found as a recurrent structure developing in front of the ovens favour these operations.

hours	oven measures				
	depth	width	frontal height	central height	rear height
1°	40/42 cm	57 cm	36 cm	–	28 cm
2°	64 cm	81 cm	33 cm	–	25 cm
3°	80 cm	86 cm	29 cm	27 cm	20 cm
4°	85 cm	96 cm	–	32 cm	–
5°	97 cm	97 cm	–	36 cm	–
6°	106 cm	113 cm	–	–	–
15°	180 cm	190 cm	50 cm	50 cm	20 cm

TABLE 2. MEASUREMENTS AND TIMING NECESSARY TO BUILD A REPLICA OF THE NEOLITHIC OVEN OF PORTONOVO.

Once the dig ended, we used a bone tool with a sharp working edge in order to regularise the inner surface and the outer wall and remove the irregularities due to the shaping step (See Figure 7). Nevertheless, given the regular and smooth surface of the bases in the archaeological ovens, we decided to adopt two different surface treatments in order to investigate possible different refining techniques of the surfaces and test more than one reaction of the sediment to fire contact. For this reason, half of the structure was left unmodified, without any other treatment on the surface; the other half was instead smoothed through the application of water in order to spread the sediment on this area of the floor. In the latter case a homogeneous coating was produced (See Figure 8).

The final step of the experiment coincided with an intentional heating of the oven in order to expose the sediment to high temperature and ensure a consolidation of the entire structure (See Figure 9 a). After the first firing the structure showed a light-yellow colour and a solid consistence in particular along the areas refined with water (the floor close to the entrance) (See Figures 9, b-c).

After a sampling of the sediment in order to apply archaeometric analyses, we observed that the first consolidation process was probably not enough to obtain a fired clay having a thick layer compatible with the one observed during the dig of the archaeological structures.

Creating a fire within ovens like these which lack a vertical draft, is not an easy task, and the fire struggled to start, however, the oven worked well once the gaseous components of the fire found their path throughout the dome (See Figure 9d). This confirmed that the oven can work efficiently with a vertical draft system allowing the smoke to get out through the entrance of the oven, and suggesting that a vertical hole along the dome is not necessary in these kinds of structures to make them functional.

Conclusions

This contribution presented the technical sequence necessary to build an experimental replica compatible for shape, measurements, and functioning with the archaeological ovens found in the Neolithic site of Portonovo-Fosso Fontanaccia (Italy). The experimentation provided new data regarding resources, digging techniques and physical efforts that allowed us to address the function of such a peculiar archaeological site and the Neolithic communities that lived in this area. According to the experimental results a dome underground oven measuring 190x180 cm in diameter at the base and 50 cm in height can be dug in 15 hours of work by a single person as suggested by the performance of the young man that carried out the experiment. An almost 2 m wide structure can be shaped using wood and bone tools to remove the sediment, shape the dome and refine the surface. According to the shape of the oven, its position and the recurrence of wide pits in front of the archaeological items, it is a possible hypothesis that the predominant working position of the performer is supine, taking advantage by the space in front of the oven, and this can be favoured by using tools with long handle to reduce the working time spent within the oven. Nevertheless, we cannot exclude that people would never enter the structure for carrying out the construction.

Tools used were enough resistant to be hypothetically reused for digging other structures and some of them worked with major efficacy compared to others (See Table 1). Moreover, a high compatibility was ascertained between the traces left by the wooden tools with long handles along the internal surface of the experimental oven and the traces visible along the internal dome of the archaeological structures (See Figure 10).

The results show that it is possible to excavate an underground structure starting from a proper exposed sediment section, and then enlarge it in width and in height.

We also observed that the first attempt to consolidate the structure by firing was not sufficient to reach the thickness of the inner coating of fired clay that features the archaeological ovens. Probably this result follows several heating or phases of use during time. The traces left after the firing on the inner walls of the oven confirmed a possible finishing phase of the internal walls throughout the smoothing of the more superficial sediment by the addition of water.

Another important aspect was considered at the end of the experimental protocol. Indeed, the possibility to carry out the building of such a peculiar oven allowed who worked on this research to take part directly to an experiential activity developing a deeper perception of what actually required an activity like this in terms of physical efforts and timing necessary to build an underground structure. Although at a very first moment the experiment was scheduled in order to understand the technical sequence of production of the Neolithic ovens of Portonovo, at the end of the experiment new questions and preliminary hypotheses arose. Indeed, it emerged how this activity does not necessarily require a collaboration of many people and building a new structure could not be considered a particularly heavy task. This does not exclude any form of collaboration in the oven building but at the same time, on the basis of the experimental and experiential activity, we can affirm that the building on an underground oven was possibly accomplished by a single person in more than one step (15 hours in total according to the experiment). Moreover, the strength and resilience of the sediment could suggest that each oven was enough resistant to be used also multiple times before its dismiss. Future research will be focused on the use of the experimental oven in order to address the activities actually performed in such a peculiar archaeological context.

Keywords furnace, kiln or oven
fire

Country Italy

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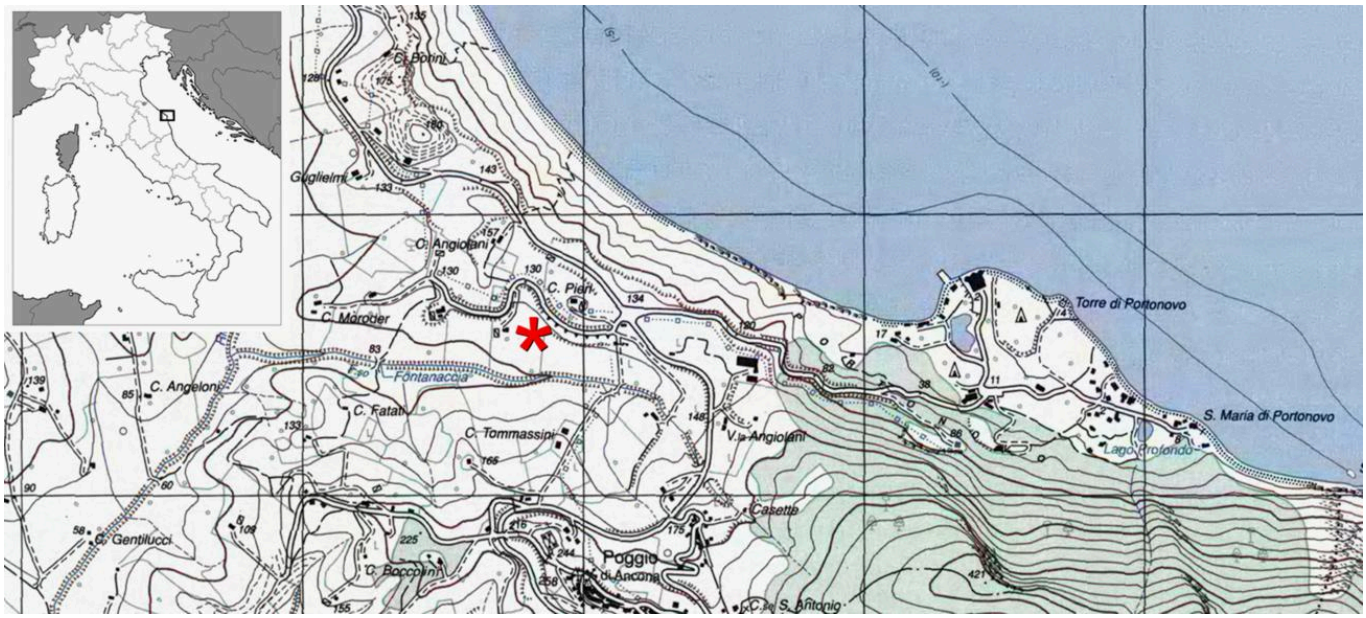

FIG 1. LOCALISATION OF THE ARCHAEOLOGICAL SITE OF PORTONOVO. MODIFIED AFTER IGM MAP.

FIG 2. THE UNDERGROUND OVENS OF PORTONOVO: A. AERIAL VIEW OF SOME OVENS; B. OVEN 23; C. CROSS SECTION OF OVEN 23 AND ITS ACCESS PIT.

FIG 3. IDENTIFICATION OF A SEDIMENT COMPATIBLE WITH THE ANCIENT GEOLOGICAL FORMATION CHOSEN BY THE NEOLITHIC GROUPS TO BUILD THE OVENS.

FIG 4. IDENTIFICATION OF ENTRANCE LIMIT ALONG THE MAIN WALL FOR DIGGING OF THE STRUCTURE.

FIG 5. ENTRANCE OF THE STRUCTURE DURING THE FIRST STEPS OF DIGGING.

FIG 6. A. EXPERIMENTAL ITEMS FROM WHICH WERE SELECTED THE TOOLS USED TO PERFORM THE OVEN REPLICA; B. DIRECT PERCUSSION TO DIG THE OVEN; C. TOOLS USED TO DETACH THE SEDIMENT; D. EFFICACY POSITION AND TECHNIQUE TESTED TO DIG THE OVEN.

FIG 7. REFINING STEP WITH A BONE SCRAPER TO PULL AWAY IRREGULARITIES ALONG THE SURFACE.

FIG 8. THE TWO MAIN SURFACE TREATMENTS ADOPTED TO UNDERSTAND THE REFINING PROCESS OF THE OVEN.

FIG 9. A. HEATING STEP; B. RESULT OF THE OVEN HEATING; C. DETAIL OF THE FIRED SEDIMENT; D. EXAMPLE OF THE VERTICAL DRAFT SYSTEM ACTIVATING DURING THE USE OF THE STRUCTURE.

FIG 10. A. TOOL MARKS ARE VISIBLE ON A FRAGMENT OF THE INTERNAL WALL OF OVEN 10; B, TOOL MARKS OF A LONG-HANDLED WOODEN TOOL USED FOR THE EXCAVATION OF THE EXPERIMENTAL OVEN.