Architectures of Fire

Processes, Space and Agency in Pyrotechnologies

edited by

Dragoş Gheorghiu

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Introduction

Dragoş Gheorghiu

This book regroups papers from the session with the same title co-organized by Dragoş Gheorghiu and Derek Pitman at the 2015 Annual Meeting of the European Association of Archaeologists, as well as two new contributions.

In the last few decades fire archaeology has become an increasingly frequent topic of study, examining the indexical presence of fire (at macro or micro levels), as well as of pyro-instruments. But the study of fire is not only focused on the material analysis, but also on the human agency in relation to the phenomenon.

The French School of Anthropology was the first to deal with the body-technology relationship (Mauss 1936; Leroy Gourhan 1943-1945; Leroy Gourhan 1964-1965), and applied structuralism to analyse the technological stages, called *chaînes opératoires* (Cresswell 1976; Lemonnier 1983; Lemonnier 2002; Schlanger 1994). Since pyro-technological studies still neglect the human presence, namely ergonomics and the embodiment of the technology and the corporeality, the purpose of this book is to guide future research toward such a viewpoint.

Entanglement

The book attempts to present the entanglement of the physical phenomenon of fire, the pyro-technological instruments, i. e., its material supports, and the human being. It is a relationship which continues the one proposed by Ian Hodder (2012) between humans and things. In this perspective, the physical process of combustion, the material culture, as well as the development of human action in space, will be addressed together. Such an approach to materiality and performance is specific to the analysis of the architectural space.

The centrality of fire

Fire is located at the centre of any pre-modern architecture. It creates the living or the technological space. It is not surprising then that in Indian mythology the god Agni is a promoter of architecture (see *Agni-purana*, XXXVIII, 1-50, in Nath Dutt 1903: 142-146). In the Mycenaean dwelling the goddess Hestia, symbolized by the round hearth, holds the central place, as stated by the *Homeric Hymns* dedicated to Aphrodite (Richardson 2010).

The orientation of the body

All pyro-instruments that encapsulate fire, as opposed to the round hearths, require from the operator (or operators) a certain working position determined by the air-draught and the internal process of combustion. In order to be able to work with it, the operator is located in front of the pyro-instrument, facing the fire. In this way, pyro-instruments determine a space of activity with an anthropomorphic 'left – right' symbolism. From the sensory perspective, the workspaces around the pyro-instruments are thermal spaces of different intensities in relation to the openings of the respective devices.

Geometry

The circle is the geometric image of the efficiency (maximum surface area with minimum contour) and of the ergonomic use of space, because such a spatial organization creates a minimum surface of use.

Round hearths can still be identified from the Aurignacian, at the Klisoura Cave in Greece (Karkanas *et al.* 2004).

Fire creates architectures since it imposes geometry, from the simple circles of stone or clay, which control its spread (and which are the geometrical figures of the optimal efficiency), to cone trunks, cylinders, half-spheres, half-cylinders or parallelepipeds, circular geometric figures that efficiently control the air-draught process required for combustion. All these forms involving the circle are determined by the control and conservation of the thermal energy.

Architecture

We should not imagine that the term 'architecture' evokes only constructed objects that delimit human action. Architecture means not only the built space, but also the experienced space, in the present case, around the pyro-instruments.

Pyro-instruments involve an ergonomic, kinaesthetic and visual relationship, as well as rhythmic actions of feeding or maintaining fire at a certain technological tempo. The technological agency is structured both by the physics of the combustion phenomenon, and by the type of operation to be performed. 'In accommodating pyrotechnical structures as architecture, we open them up for what, in craft studies, would be novel forms of analysis' (J. Slater, this volume).

This phenomenological perspective of pyro-technologies has imposed the archaeological experiment as an instrument of investigation, with all the limitations of the sensorium and of our modern cognition, the experiment helping us to experience the 'architecture' of pyro-technologies.

Sinopsis of chapters

Silje Evjenth Bentsen and **Sarah Wurz** chapter, 'A Song of Space and Fire: Is There a Pyrotechnical Architecture of the African Middle Stone Age?', addresses a case of pyro-architecture in Middle Stone Age (MSA) Africa, presenting three cases of combustion features, or in the technological perspective 'three different operating chains for fire use'. The research is based on experiments that determine 'the wood mass, fire temperatures and the size of combustion features'.

Comparing the quantities of ash excavated from a cave at the Klasies River main site (KRM), South Africa, as well as the thermal alterations in quartzite stones, the authors present three different hearths, with different levels of energy investment for the humans who built those fires.

The ash is presented as an index of the magnitude and function of the fire, and the presence of stones with fire-cracks intended to retain as much heat as possible, is an indication of a longer and more intense use. Differences in intensity between the three hearths are seen as indices of short and long-term activities, the latter involving the collection of a large fuel mass. Although the authors do not consider the ash features to be the product of built pyro-objects, they state that 'the combustion features do represent pyrotechnical architecture in that they have fixed points in space that people moved by and around when the fires were active,' demonstrating that the human relationship with fire in MSA has a degree of complexity and dynamism.

The oven is a clay capsule for fire control with multiple functions, as demonstrated by the chapter of **Cecilia Conati Barbaro, Chiara La Marca, Vanessa Forte, Giacomo Eramo, Italo M. Muntoni,** and **Alberto Rossi**, 'Firing the Earth. The Early Neolithic Ovens of Portonovo (Marche, Italy)'. Their analysis covers a series of underground ovens dating from the Early Neolithic, at the Portonovo site, Italy. Due to the insulation provided by the soil, this type of pyro-instrument presents the advantage of conserving more thermal energy, while the pit in front of it sometimes allows the operator access to two ovens. The grouping of ovens that existed for half a millennium, positioned outside houses or domestic structures, indicates a cyclical, joint activity that attracted scattered communities of the area. During the harvest period, the pyro-instruments created a space allowing intense activity, lasting for several days, as the different temperatures reached allowed the performance of different operations. Over time, the workspace saw its function change, becoming a funeral area, which infers a degree of sacredness of the ovens and the place.

The complex relationship with fire of the inhabitants of the *tell* settlements of the Chalcolithic Lower Danube area, is analysed by **Dragoş Gheorghiu** in the chapter 'Architecture and Fire: The Pyro-proximities of the Chalcolithic Dwelling', from the perspective of the combustion process both in pyro-instruments and in dwellings and settlements. In these cases one can discern a relationship between fire and geometry, from the shape of the objects to the spatial organization of the *tell* settlement. The proximal relationships with fire are analysed both inside the house and in the space of the settlement, both during daily activities and in times of arson. In the case of the interior architecture, the spatial organization and the ergonomic and ritual use of the different fixed or mobile pyro-instruments, such as ovens, fireplaces, fire-starters, and heaters, are presented in their daily and nocturnal use.

In the chapter 'Italian Pottery Kilns and Production Areas from the Bronze Age to the Archaic Period (2200-500 BC). A Typological Approach', **Agostino Sotgia** proposes a model for the organization of craft contexts from the Bronze Age to the Archaic period, offering a chrono-typological classification, which, not only reflects the technical developments in the kilns' technology, but can provide data on the organization of the production of ceramics. The production areas research was based on both the archaeological evidence and ethno-archaeological research and experimental reconstructions. One finding concerned the use of simple archaic technologies alongside more technically advanced ones. The production areas revealed complex workspaces, with sets of kilns, water tanks, workshops with drying rooms, and pits for extracting clay.

Jessica L. Slater's chapter, 'Shifting Focus: Expanding the Potential of Experimental Metallurgical Reconstructions' advocates for expanding the concept of 'architecture', which should also include the 'technological architecture' of the pyro-instruments that structure the human action, and that would offer 'a novel form of analysis' in craft studies. Such a perspective would shift the focus of research from *processes* toward the study of the *practice* and *experience*. In the experimental study on metallurgical practice Slater used time-slice photographs to record the actions in space. The analysis method used highlights the 'timing and rhythm of metallurgical activities', proximities to the pyro-instruments, and the way 'the loci of production are organized'. The space is 'an essential aspect of craft', as well as the place, being revealed by the *practice*, through routinised behaviours. As a result, the craft creates a spatial relationship between the furnace and the cumulative structured deposition of residues that can be approached through a time / geography approach.

Michał Wojenka and **Małgorzata Kot**'s chapter 'Ergonomics as a Tool for Fire Structures Reconstruction. Case Study of a Kiln Located in the Garncarskie Rockshelter in Polish Jura Chain' is a demonstration of the use of ergonomics for archaeological inferences, applied when determining the shape of a Post-Medieval kiln for pottery built under a rock shelter. Using ethnographic data combined with ergonomic measurements of the space between the pyro-instrument and the rock wall, the authors propose different configurations of the kiln and of the ceramic production operations. We are here in front of a case of natural architecture, in which the advantages of a rock shelter for the use of the pyro-instrument, such as air-draught due to a natural flue, or low moisture, were exploited through the development of a context-oriented design. In this case the normal space of the kiln was adapted to the constraints of a natural space.

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A Song of Space and Fire: Is There a Pyrotechnical Architecture of the African Middle Stone Age?

Silje Evjenth Bentsen and Sarah Wurz

Abstract

Is there a pyrotechnical architecture of the African Middle Stone Age? We examine this question through ash features and potentially heated rocks from three contexts at Klasies River main site (KRM), South Africa. We compare these to actualistic fire experiments showing that a wood mass of 1.5-3 kg produces hearth areas of 300-440 cm^2 and heat for 3-5 hours. We identify three different *chaînes opératoires* of fire-related behaviour showing differences in the investment required for using fire in the Middle Stone Age (MSA). We argue that ash features, although not associated with stone linings, can be regarded as a form of pyrotechnical architecture.

Keywords: Middle Stone Age, Early modern humans, Klasies River, combustion features

Introduction

The word 'architecture' can lead the mind to inner pictures of solid structures, sometimes connected to political units and social relationships. The stone walls of Great Zimbabwe, for example, marks both physical boundaries and positions of power (e.g., Pikirayi 2013) and the site contains clear evidence of pyrotechnical architecture, such as fireplaces and furnaces (e.g., Bandama *et al.* 2016; Chirikure and Pikirayi 2008). Massive, built structures are not associated with the African Middle Stone Age (MSA), dating to 300,000 to 25,000 years ago (see e.g., Wadley 2015), although MSA sites contain impressive evidence of the life of early modern humans. For example, repeated visits to the Klasies River main site (e.g., Deacon and Geleijnse 1988; Singer and Wymer 1982; Wurz *et al.* 2018), South Africa, during the MSA can be examined through the 21 m archaeologically significant deposits left at the site. These deposits include results of fire-related behaviour, such as burnt bone and ash patches (e.g., Henderson 1992). But to what extent is it possible to discern and discuss a pyrotechnical architecture at KRM or during the MSA?

Hunter-gatherers and pyrotechnical architecture

Pyrotechnical architecture here refers to features and structures formed through fire-related behaviour. Combustion features such as hearths or ash dumps are examples of pyrotechnical architecture found amongst hunter-gatherers. The appearance of such features can, however, vary (see discussion in Mentzer 2012). MSA hearths are generally not restricted by a stone lining, but consist of a small area of ash and sometimes contain other remains of the fire such as charcoal (Bentsen 2014b). The heat of a fire can affect the sediments under it and produce a hearth with internal strata, although actualistic experiments have shown that the colours and presence of these strata depend on factors such as the temperatures of the fire and the properties of the topsoil (e.g., Bentsen 2012; Bentsen 2013; Mallol *et al.* 2013; Mallol *et al.* 2007). A hearth can be made for a range of activities, such as cooking or tool production, used repeatedly, once, and over long or short periods, and be affected by various post-depositional processes (e.g., Mallol *et al.* 2007; Mentzer 2012). The term 'ash patches' may sometimes refer to less intact hearths, while 'ash dumps' or 'ash heaps' refers to secondarily deposited remains (see also Mentzer 2012). Scattering or dumping of ashes and the formation of middens may, additionally, be a result of cooking processes where ashes and fire residues have to be removed to retrieve the cooked food (Aldeias *et al.* 2019).

Various perspectives on pyrotechnical architecture and site formation among hunter-gatherer groups have been offered through time. Combustion features are, for example, part of what Binford (e.g., 1978) named 'site furniture', or facilities available for use at a site. Group size and expected duration of the stay can affect the kind of facilities present (Binford 1978), and little site furniture, such as at MSA sites, suggests little investment in the sites and high level of mobility (Roebroeks and Soressi 2016). Binford (e.g., 1978) furthermore coined the terms 'drop zone' and 'toss zone' to characterise general behaviour around a hearth, based on his observations among Nunamiut groups in Alaska, USA. Small fragments detached from bone, stone, or other material are left *in situ* to form a drop zone by the hearth, while larger items are tossed and consequently form a separate toss zone about 1-3 m from the fire, depending on the material tossed (Binford 1978). Another perspective on pyrotechnical architecture is offered by Leroi-Gourhan (e.g., Leroi-Gourhan and Brézillon 1972), who focussed on what he named 'evident' and 'latent' features at a site. Evident features are clearly recognizable features during excavation, such as stone-lined hearths, while latent features are artefact distributions that might only be recognised during post-excavation analysis. In terms of fire use, for example, the distribution of thermally altered rocks might reveal relations between areas and activities that can only be recognised through refitting of thermally altered rocks, spatial analyses, and other post-excavation research (Petraglia 2002).

From the perspective of agency and structuration, humans use rules and resources to produce and reproduce social action (Giddens 1984). Pyrotechnical architecture can be regarded as physical resources or even boundaries that humans use and work around, similar to the concept of 'site furniture' (Binford 1978). Combustion features can also manifest a set of rules. A hearth can, for example, represent a social unit and different social units might be placed at a certain distance from each other (e.g., Yellen 1977). A social group can, furthermore, produce different fires and hearths in different contexts; for example, communal cooking hearths in a camp and off-camp fires to roast food during hunting or gathering (Mallol *et al.* 2007). Pyrotechnical architecture can thus provide important insights on a social group and agency. We approach the topic through the *chaîne opératoire* of the hearth (Bentsen 2007) (Figure 1), to examine how humans interweave actions and social practices to work with and around the fire and produce and reproduce social practice.

It is, nevertheless, important to remember that a range of chemical and other processes can affect archaeological combustion features and their context during and after formation and abandonment (e.g., Mentzer 2012). It is, furthermore, problematic to impose Western concepts or behaviour observed in modern times on prehistoric groups and systems (e.g., Chirikure and Pikirayi 2008; Fagan 2017). This is not to say that it is impossible to examine fire-related behaviour in the MSA based on modern observations, but that one must do so with caution. It is on this background we here examine potential pyrotechnical architecture in the MSA through a case study of Klasies River main site (KRM) and an example of actualistic experiments.

Klasies River main site

KRM (Figure 2) is situated in the Eastern Cape region, South Africa, approximately 120 km from Port Elizabeth. A National Heritage Monument stretching 2 km along the Tsitsikamma coastline encompasses Caves 3, 4, and 5 in addition to KRM

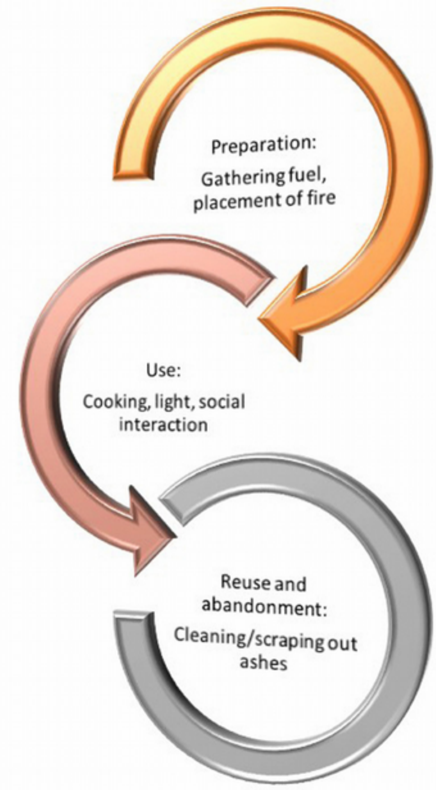

Figure 1: Simplified example of chaîne opératoire *of fire use*

Figure 2: Overview of Klasies River main site and the surrounding lnscape. Inset: location of Klasies River main site and Pinnacle Point.

(Caves 1, 1A, 1B, and 2). KRM is at the edge of a 13 km coastal platform along the Tsitsikamma mountain range and faces the Indian Ocean. The lowest point of the site is currently 6 masl. Although the sea level would have fluctuated through time, the site was never far from coastal resources (Cawthra *et al.* 2014).

KRM has been excavated in three phases: 1967 to 1968 (e.g., Singer and Wymer 1982), 1984 to 1995 (e.g., Deacon and Geleijnse 1988) and the current ongoing phase from 2015 (e.g., Wurz *et al.* 2018). Deacon modernised the excavation protocols at KRM, which includes carefully removing deposits to expose archaeological remains, removing and bagging each artefact individually and routinely taking soil samples and other samples. Deacon also started a classification system of deposits into lithological members (see e.g., Deacon and Geleijnse 1988). The current excavation follows the same system and general protocols, updated to reflect developments in field techniques the last 20 years. For example, the Wurz team uses a Nikon Nivo total station to capture the coordinates of artefacts >2 cm and regularly take photographs of the excavation surface for digital reconstruction (Wurz *et al.* 2018).

Repeated visits to KRM through various phases of the MSA deposited what is now a well-preserved archive of hunter-gatherer-fisher lifestyle. Early modern humans at KRM exploited many resources and consumed shellfish, plants, fish, and both marine and terrestrial mammals (e.g., Henderson 1992; Klein 1976; Langejans *et al.* 2012; Thackeray 1988; Van Pletzen-Vos 2000; Wurz *et al.* 2018). The lithic variability at the site reflects fluctuations in technological traditions through time with an increased proportion of non-quartzite raw material in the Howiesons Poort assemblage (Wurz 2002). Fire-related behaviour at the site is evidenced through intact combustion features and heat-affected artefacts such as bone and quartzite (e.g., Bentsen and Wurz 2017; Henderson 1990; Henderson 1992; Wurz *et al.* 2018). We provide a brief overview of relevant information on artefacts, stratigraphy and dating below, concentrating on Cave 1, 1A and 1B (Figure 3).

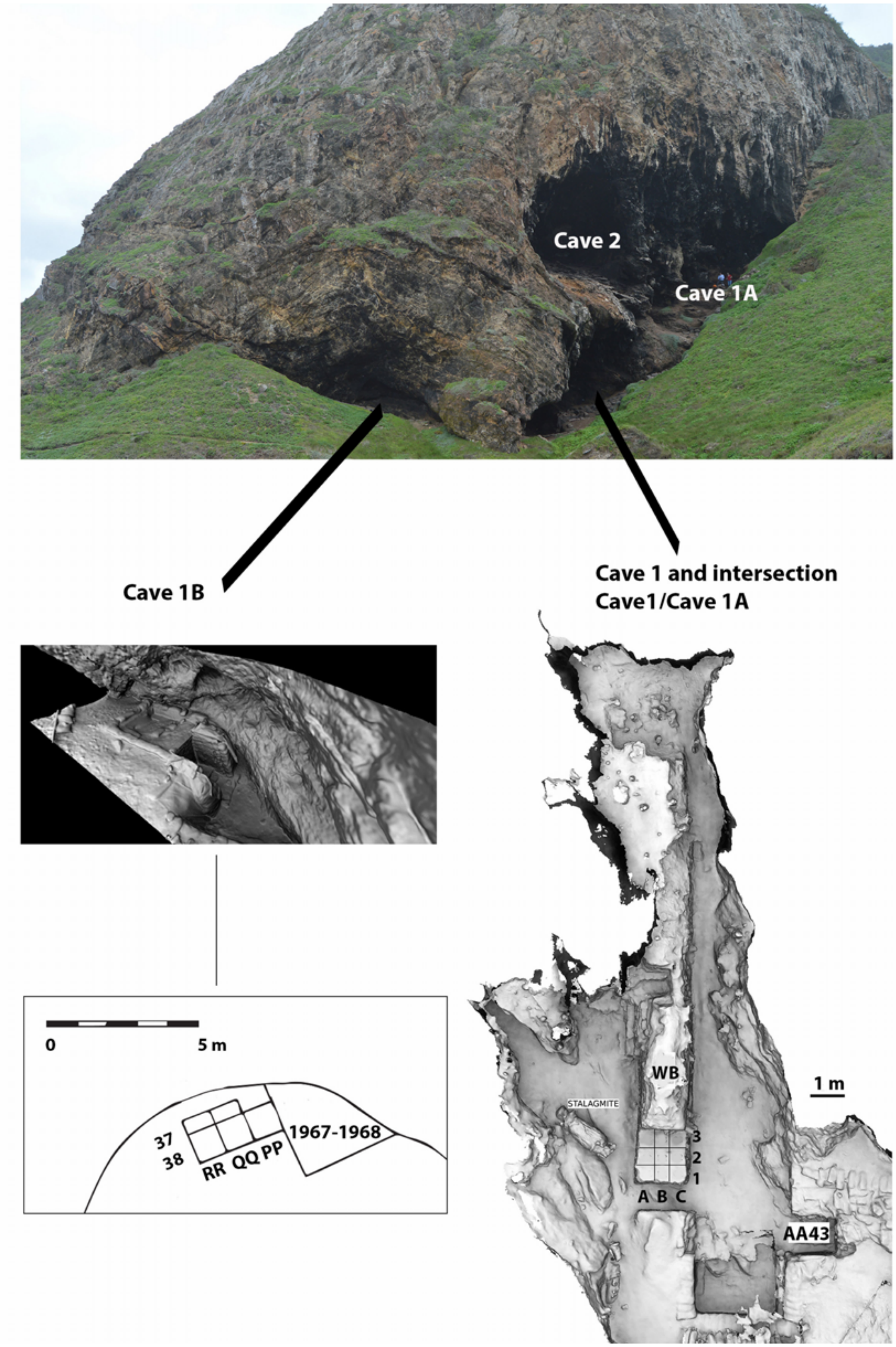

Figure 3: Klasies River main site. The detailed view of Cave 1B shows a 3D model of the excavation area and an overview of the excavations by Singer and Wymer as well as the squares excavated by Deacon. The drawing is digitised from Henderson (1992:Figure 2B). The detailed view of Cave 1 shows a 3D model of the interior of the cave, with the Witness Baulk (WB) excavation and AA43 marked. 3D models by the Zamani project.

Cave 1 was extensively excavated by Singer and Wymer (1982), who left a Witness Baulk (WB) in the centre of the cave. (Figures 3 and 4) The WB is approximately 1.5 m wide, 12 m long and 3 m high. Deacon started excavating a section of the WB and the team lead by Sarah Wurz is currently continuing the work into layers that are >100,000 years old (Wurz *et al.* 2018). The current excavation of the WB started in layers belonging to the lowest part of the Shell and Sand member (SASL) (Figure 4). The lithics found in SASL are classified as MSA II lower phase (Mossel Bay techno-complex) (Wurz 2002). The lithic assemblage includes, for example, heavily reduced cores directed at the production of Levallois-points, points and blades with thick platforms and straight profiles, and artefacts with clearly observable lateral edge damage (e.g., Wurz 2002; Wurz *et al.* 2018).

The overhang named Cave 1B (Figures 3 and 5) is located to the west of Cave 1. Singer and Wymer (1982) excavated part of Cave 1B in 1967-1968 (Figure 3), but here we will focus on the sample examined by Deacon (Figure 5) (e.g., Deacon and Geleijnse 1988; Henderson 1990; 1992). It is not possible to correlate specific layers in Cave 1B directly to layers in Cave 1 (Deacon and Geleijnse 1988), although future research might reveal connections between occupation units in different areas of the site (Wurz *et al.* 2018). Nevertheless, the deposits in Cave 1B can be grouped into the same members as Cave 1 (Deacon and Geleijnse 1988). The SAS member is the uppermost member in Cave 1B, within which the upper layers belong to MSA II upper phase and the lower layers belonging to MSA II lower phase (Wurz 2000: Tabel 11). Additionally, Cave 1B contains an underlying LBS member with MSA I material (Wurz 2000; 2002). There appears to be a trend towards smaller points and bifacial production in the uppermost MSA II layers in Cave 1A at KRM, but bifacial pieces were not recovered from the Deacon excavation of Cave 1B (Wurz 2000; 2002).

Cave 1A (Figure 3) is the name of the area running from the easternmost dripline of Cave 1 more than 15 metres upwards and is not strictly a cave, but an overhang. The easternmost and upper part of Cave

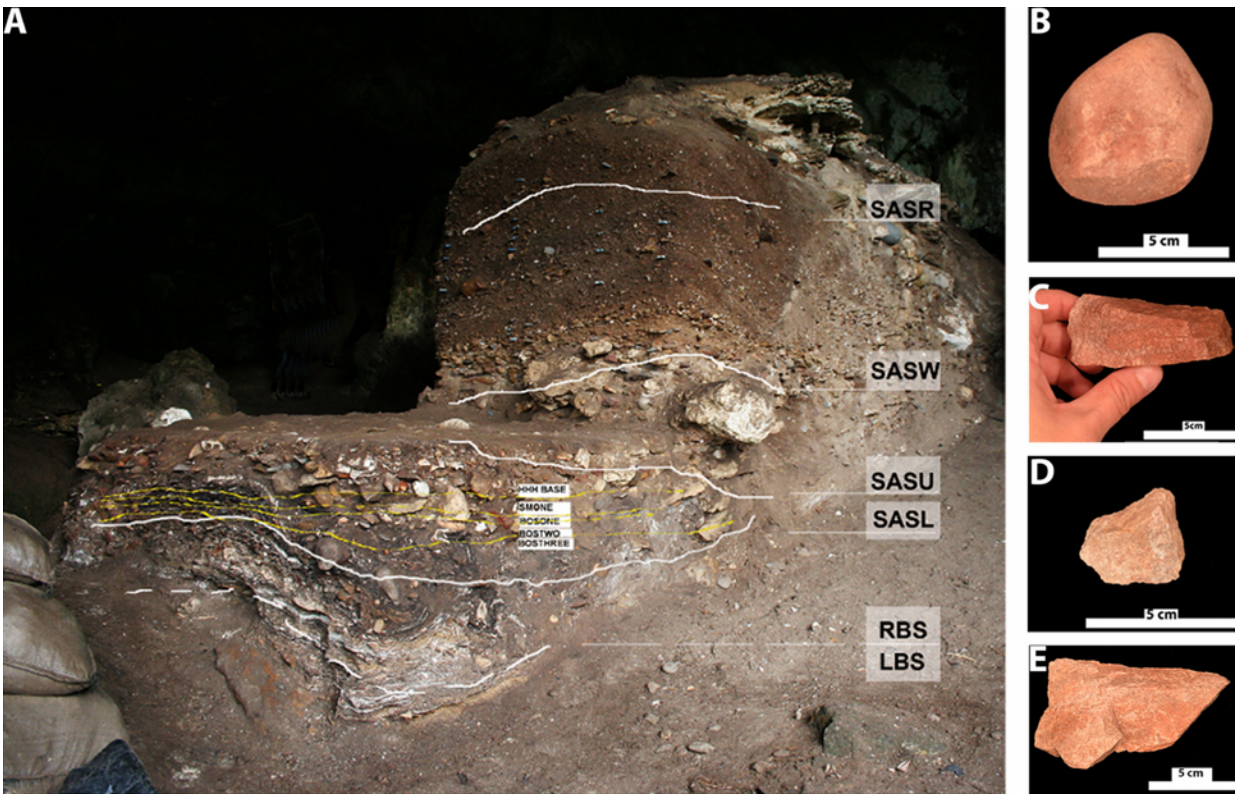

Figure 4: A: The Witness Baulk with its members (white) and layers excavated during the Wurz excavation. B-D: Examples of potentially heated rocks. This figure is based on Figure 4 in Bentsen and Wurz 2019.

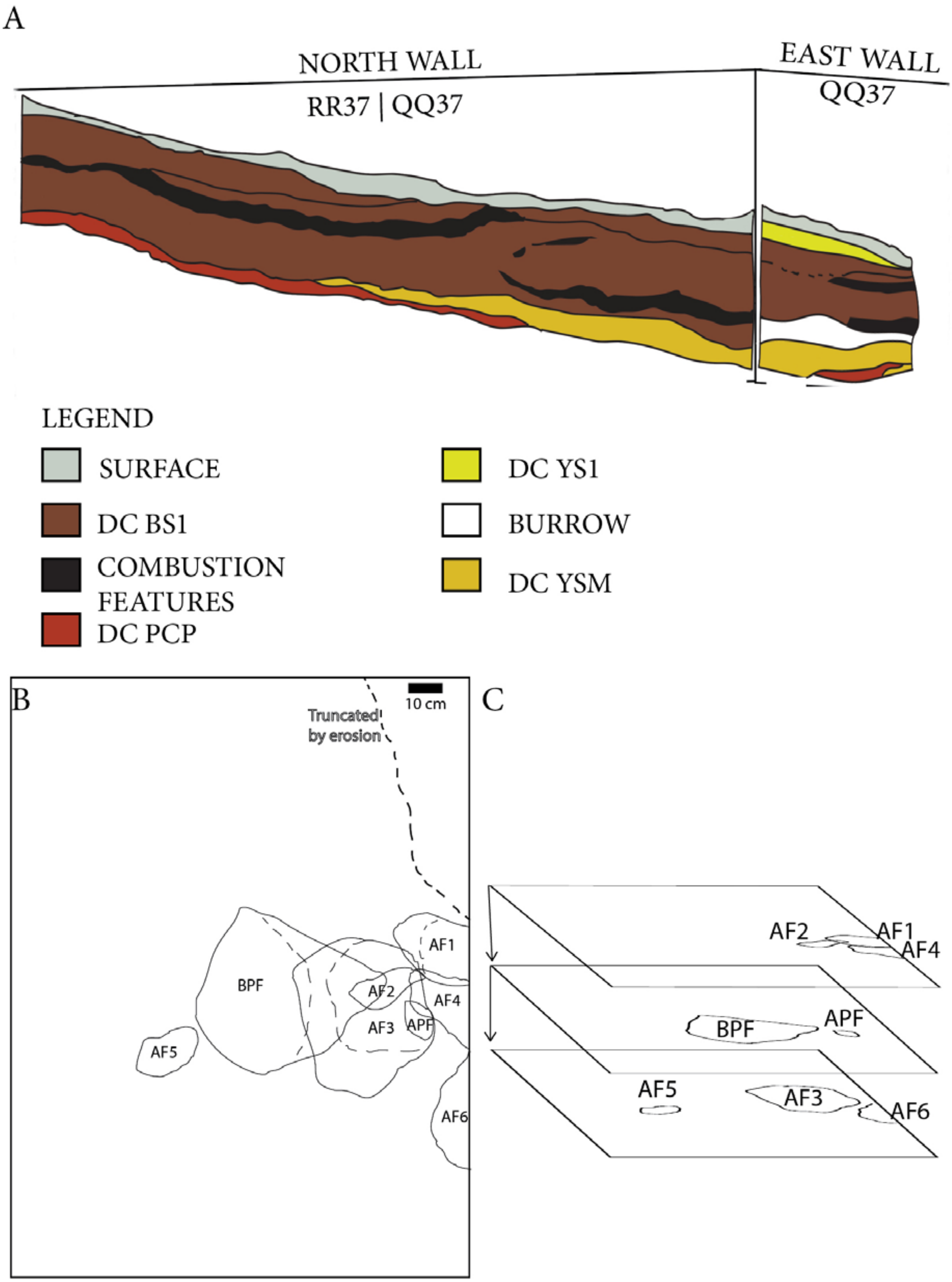

Figure 5: Drawings from the Deacon excavation in Cave 1B. A: North section of squares RR37 and QQ37 and east section of QQ37, showing the extent of the layers in sub-member DC. Digitised after Henderson (1990: Figure 5.3). B: Location of ash features excavated in square PP38 layer DC PCP. C: Sketch showing the vertical placement of the ash features in square PP38 layer DC PCP. B and C are digitised after Henderson (1990: Figure 5.10) and Deacon site notes.

1A contains a Howiesons Poort and post Howiesons Poort assemblage with finely laminated layers, frequently interpreted as hearths (e.g., Wurz 2002). We do not, however, include the entire sequence of Cave 1A here, but focus on the intersection between Cave 1 and Cave 1A, where squares AA43/Z44 (Figures 3 and 6) were excavated by the Deacon team. The physical connection between the deposits in the WB and AA43/Z44 were removed by Singer and Wymer and it has been difficult to establish the relationship between the units due to lateral changes in the layers. We currently work from the hypothesis that the SASL layers excavated in the WB corresponds to the top layers of AA43/Z44, although future research might provide details that lead to a redefinition of the relationship (Wurz *et al.* 2018). Previous analyses (Wurz 2000; 2002) have demonstrated that the Rubble Brown Sand (RBS) and Light Brown Sand (LBS) members under SASL in AA43/Z44 contains lithics classified as MSA I (Klasies River techno-complex). The lithics in the context included here are, however, similar to the BOS layers in the WB (see also Wurz 2000; 2002; Wurz *et al.* 2018).

Selected detailed examples of fire-related behaviour at KRM

We have selected three detailed examples of fire-related behaviour at KRM to illustrate the discussion here. The first example is from the WB in Cave 1, where the recent excavation of the Black Occupational Soils (BOS) layers in the SASL member has uncovered potentially heat-affected quartzite (Figure 4) (Bentsen and Wurz 2017; 2019). The BOS layers are, generally, dark brown layers with fragmented charcoal, lithics and well-preserved bone fragments (see also Wurz *et al.* 2018). The potentially heated rocks ranges in size from small, thin fragments weighing approximately 2 g to larger chunks weighing approximately 1400 g, and the samples display signs of heat exposure such as rubefication and fracturing. Furthermore, the rocks are spread across the surface of the excavation and it has not been possible to refit any of them to larger units. Experimental heating of locally sourced quartzite and digital colour analysis demonstrate similar colour changes during intentional heating, but also that quartzite were not used to boil food in the MSA at KRM (Bentsen and Wurz 2017; 2019).

The next example of fire-related behaviour is from layer Sandy Concretionary Blocks 2 (SCB 2) of AA43/Z44, excavated in 1985, which is situated at the intersection of SAS and the underlying member (van Pletzen-Vos 2000; Wurz 2000; 2002). SCB 2 contained an ash lens named AF1 (Ash Feature 1) (Figure 6) with ash, shell and lithics (Deacon site notes). Based on the site drawings, we calculated the surface area of SCB 2 AF1 to approximately 2024 cm^2.

The last example here is from one of the uppermost layers in the SAS member in Cave 1B (Figure 5), sub-member DC (Dark Carbonized) and layer PCP (Partially Carbonized Pairing). This dark layer was between 5 and 30 mm thick and contained several ash features in addition to artefacts, bone fragments and burnt shell scattered across the surface (Henderson 1990; 1992). The ash features AF1, AF2, AF3, AF4, AF5 and AF6 (Figure 5) were interpreted as distinct hearths used within a reasonably short time span (a few years), and some of them were clearly superimposed on others (see Henderson 1992). The ash features in DC PCP were fairly small, and we calculated their surface areas to between 200 to 550 cm^2 based on site drawings by Henderson (1990). There were also other ashy features containing burnt shell associated with the hearths, particularly Burnt Perna Feature (BPF) located by and partly over AF3 (Henderson 1990). The association between burnt shell and ash features implies cooking of shellfish and the low number of shellfish suggests that the people inhabiting KRM disposed accumulated waste in a disposal area rather than by their hearths (Henderson 1992). Superimposed combustion features (Figure 5C) show some regularity in placement of the hearths, but it is necessary to expose a larger area to draw firmer conclusions on spatial arrangements in Cave 1B (Henderson 1990; 1992). Nevertheless, hearth size, form, and association with cooking have been interpreted as a sign of domestic fires and the nuclear family as the core of the social groups inhabiting the site (Deacon 1995).

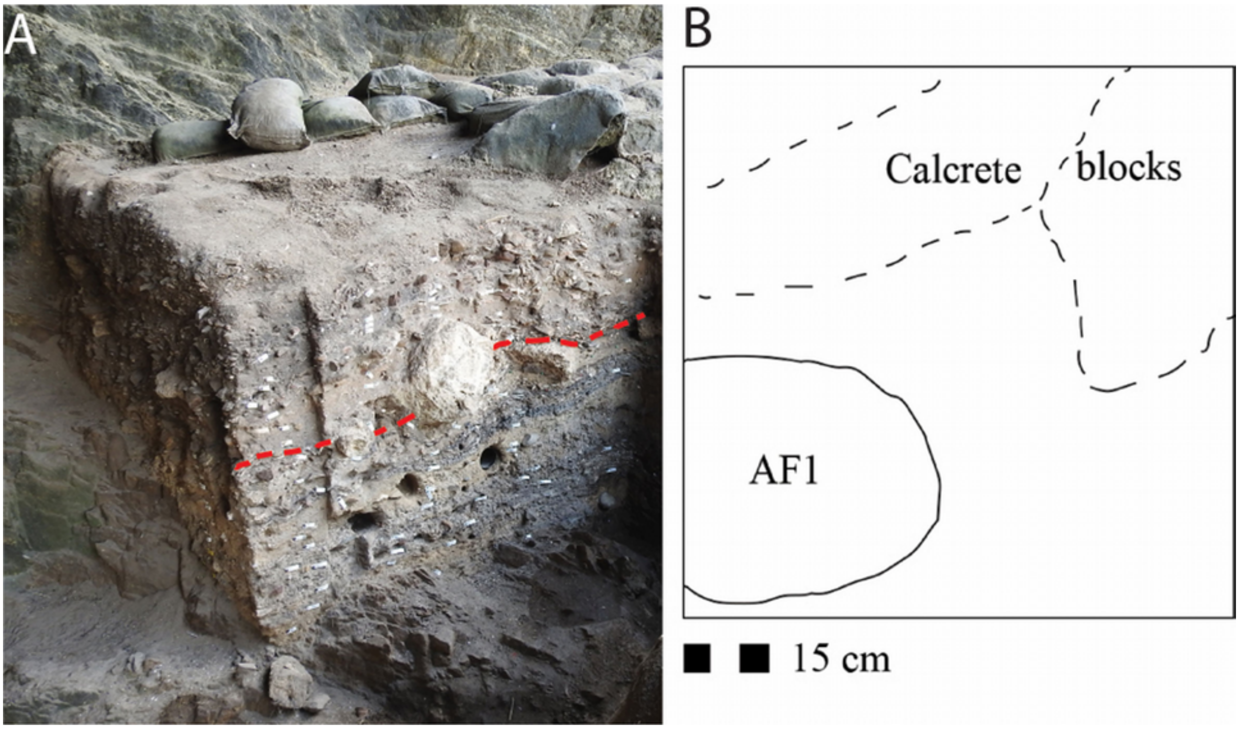

Figure 6: AA43/Z44 in the intersection of Cave 1/1A. A: North section of AA43. White line marks the position of layer SCB 2. B: Location of AF1 (Ash Feature 1) in SCB 2. Digitised after Deacon site notes.

Fire experiments: method

We conducted fire experiments to examine combustion features at KRM, and report preliminary results on wood mass, fire temperatures and the size of combustion features created in order to examine further the *chaîne opératoire* of fire use and pyrotechnical architecture in the MSA. The experimental protocol was similar to previously published fire experiments (Bentsen and Wurz 2017; 2019), which is why this paper only reports a summary of the method. We conducted the experiments (Figure 7) at a sheltered area by KRM and replicated the KRM matrix by mixing sand and shells collected at the beaches by the site. We recorded temperatures with K-type thermocouples attached to a Huato dual channel temperature data logger, Model S220-T2, and only maximum surface temperatures and the duration of temperatures >100°C are reported here. 100°C was chosen as a threshold to illustrate a fire that can be used for a range of cooking and heating activities, although different materials can require different temperatures (see, e.g., review and discussion on cooking temperatures in Aldeias *et al.* 2019; Wandsnider 1997).

We conducted two sets of experiments, the A series and the B series. The wood for both series was collected along the beach, where the salty sea-spray affects the growth of the plants and in some cases lead to the plants dying (van Wijk *et al.* 2017). We mainly collected twigs and small branches for the fires. Previous fire experiments (Bentsen 2012; 2014a) suggested that the hearth area, meaning the area covered by ashes, is an indication of the fuel mass burnt: 5-10 kg of wood produced hearth areas of approximately 960-1390 cm^2 and 14-15 kg of wood produced hearth areas of approximately 1590-1965 cm^2. The A series was conducted to produce smaller hearth areas to replicate the fires in Cave 1B and consisted of five fires burning approximately 1.5 to 3 kg of wood each. We did not use rocks to contain these fires as the fires in Cave 1B did not have rock linings (Henderson 1990; 1992). We subsequently conducted the B series of experiments, which were four experiments burning 1.5 to 3 kg wood to examine heating of quartzite. The experiments heated 29 quartzite cobbles or fragments collected at the beach

Figure 7: Overview over fire experiments

by KRM and each sample was heated two times. We do not report hearth area for the B experiments as the rocks might have affected the result. These preliminary experiments heating quartzite lead to other experiments on colour changes in heated quartzite (Bentsen and Wurz 2017; 2019), which demonstrated the difficulties using visual observations to describe colour changes. Here, however, we are focusing on the pyrotechnical architecture and thus only provide preliminary and visual observations of heat-induced changes in the rock samples.

Fire experiments: results

It took four persons 30 minutes to collect approximately 30 kg of wood from one location, which was about 10 minutes walk from KRM. We did have a car to transport the wood to the location for the experiments, but we realised that the car did not save us much time, as it had to be parked at some distance from the beach. Detailed results from the fire experiments are included in Table 1, so only average observations are mentioned here. The experiments in the A series produced an average maximum surface temperature of 465.3°C and surface temperatures >100°C for 4 hours 14 minutes on average. The A series produced an average hearth area of 378 cm^2. The experiments in the B series

Table 1: Summary of the fire experiments

Fire	Max surface temperature	Duration of surface temperatures >100°C	Hearth area
A1	476.2°C	5h 8 min	396 cm^2
A2	315.8°C	4h 35 min	440 cm^2
A3	774.4°C	4h 45 min	440 cm^2
A4	447.9°C	3h 7 min	300 cm^2
A5	312.3°C	3h 34 min	314 cm^2
B1	548.5°C	6h 5 min	-
B2	452.6°C	4h 46 min	-
B3	524.6°C	7h 18 min	-
B4	306.7°C	9h 10 min	-

produced an average maximum surface temperature of 458.1°C and surface temperatures >100°C for 6 hours 50 minutes on average. Some of the heated quartzite samples did appear to change colour and a couple of samples developed fractures during the heating episodes, but none of the quartzite samples displayed colours, fractures or extensive breakage similar to the archaeological samples. Subsequent heating experiments using more firewood to produce larger fires did, however, produce similar colour changes as observed in the archaeological assemblages (Bentsen and Wurz 2017; 2019).

Discussion: pyrotechnological architecture and the *chaîne opératoire* of fire use at KRM

The fire experiments provided insights into important aspects of fire use and pyrotechnical architecture at KRM. The experimental hearth areas produced (300-440 cm^2) by 1.5 to 3 kg wood were within the range of the ash features observed in layer DC PCP in Cave 1B (200-550 cm^2) and well below the hearth areas of minimum 960 cm^2 produced by minimum 5 kg wood in previous experiments (Bentsen 2012). Phytolith studies from the site Pinnacle Point, Western Cape, suggests small, fast fires burning mainly grasses and some branches or shrubs around ~92,000 years ago and fires burning large quantities of wood and bark around ~100,000 years ago (Albert and Marean 2012; Esteban *et al.* 2018). Our study cannot discern whether the fires in DC PCP at Klasies were built using grasses or wood, but the experimental results do suggest small fires burning a small fuel mass. The small fuel mass needed implies that firewood collection was not a time-consuming activity and, consequently, that little preparation work was needed for the fires. In contrast, AF1 in SCB2 at KRM (2024 cm^2) was larger than hearths of 1590-1965 cm^2 produced with 14-15 kg of wood in previous experiments (Bentsen 2014a), which suggests that more than 15 kg of fuel was burned in this feature. We do not know what kind of fuel was collected, but the general implication is that collecting fuel for this fire would be time-consuming and involve a higher investment than a smaller fire.

The heat of the fire is important not just because it can be used in different activities, but because it limits the movement around and over the fire. For example, a person might avoid walking across hot coals or through smoke. The first set of experiments (the A series) reported here showed that small fires burning 1.5 to 3 kg of wood can produce heat >100°C for approximately 3 to 5 hours (Table 1), thus effectively claiming space and restricting movement around the combustion feature for that time. It is interesting that the small fires of DC PCP were placed in the same area, suggesting repeated use of that area for a similar purpose (Henderson 1990; 1992), even if the fires would produce heat and restrict movement for a very limited time.

We did not test the duration of heat for a large fire such as the one producing AF1 in SCB 2 here. However, results from previous fire experiments allow some general comments. For example, experimental studies have demonstrated that a fire burning > 5 kg wood can retain a temperature >100°C for 8-10 hours (Bentsen 2014a). This suggests that the fire producing AF1 in SCB 2 retained heat for twice as long as the fires producing the ash features in DC PCP. Nevertheless, no statistically significant relationship was found between the fuel mass and the maximum surface temperature of a fire in an experimental study including 39 actualistic fires (Bentsen 2014a). The implication is that AF1 SCB2 might have been produced by a fire that was not necessarily hotter than the fires in DC PCP, but that the former fire probably could be used for longer that the latter fires.

The second set of experiments reported here (B series) produced heat >100°C for a longer time than the A series (Table 1). The main difference between the two experimental series is that the B series included heating of quartzite samples. The heat-retaining properties of rocks can be used for cooking or other activities (see e.g., overview in Bentsen and Wurz 2017) and our experiment show how heated rocks can prolong the heat and, consequently, the restrictions on movements caused by the heat. The heating of rocks might also include other restrictions, such as claiming space around the fire to move or remove rocks before, during and after heating. It seems, then, that the benefit of heat-retaining rocks must be weighed against the added cost of extra steps in the *chaîne opératoire* of fire use; namely in the preparation for the fire (collecting the rocks) and the use of the fire (restrictions of spatial use and prolonged time of use).

The experiments reported here point, furthermore, to implications for the use of the fires. The B series of experiments demonstrated that small fires could not produce fracturing, breakage and visual colour changes similar to those observed in the BOS layers of the Wurz excavations, even when quartzite samples were heated twice in the small fires. Subsequent experiments have, however, demonstrated that fires burning approximately 6 kg wood in combination with repeated heating can produce fracturing, cracking and colour changes in quartzite collected by KRM (Bentsen and Wurz 2017; 2019). The experimental results and the wood masses burned suggest, in summary, that the small fires documented in DC PCP could not have produced rubefied quartzite such as observed in the BOS layers and that a larger fire, such as the one producing AF1 in SCB2, would be needed to induce heat-affected changes in quartzite from the KRM area.

Ash features at KRM are often associated with shellfish, implying fires that were used for cooking (Henderson 1990; 1992). Other signs of cooking in the KRM material include heat-affected fauna (e.g., Wurz *et al*. 2018). The experimental results reported here show that the selected fires in DC PCP at KRM could potentially produce temperatures suitable for cooking various foods (see e.g., Aldeias *et al.* 2019; Wandsnider 1997), even if they would retain heat shorter and might not be able to heat as large quantities of food as larger fires. In comparison and taking into account potential fuel mass burned and estimated duration of the fire, it is possible that AF1 in SCB2 represents a larger group and/or a slightly longer stay at the site than the ash features in DC PCP. Future analyses including micromorphology might be able to reveal more information on similar combustion features at KRM, although the features described here are already excavated.

Although the accumulation of artefacts is less dense in the area of the ash features in DC PCP than in the rest of the excavated area (Henderson 1990; 1992), it is not possible to distinguish different zones around these features such as drop zones or toss zones (Binford 1978). We have, however, seen that the ash features in DC PCP are small and probably used for a short time, which suggests that the features were not used for long enough for such zones to develop. Nevertheless, such features can be regarded as examples of site furniture or pyrotechnical architecture at the site, occupying a fixed point in space that people must move around. The ash features and their association to burnt shell features, such as in DC PCP, can be viewed as evident structures (Leroi-Gourhan and Brézillon 1972). The appearance of heat-affected rocks is an example of potential latent structures (Leroi-Gourhan and Brézillon 1972) relating to pyrotechnical architecture in the MSA.

Summary: is there a pyrotechnical architecture of the MSA?

We have briefly examined three examples of fire-related behaviour at KRM in this paper and found them to represent three different *chaînes opératoires.* (Figure 8) Firstly, the smaller ash features in DC PCP in Cave 1B represent small fires that lasted for a few hours. Little effort in terms of fuel collection was required to prepare for these fires. It is possible that these fires represent cooking fires for a small group of people, and the ash features are associated with remains of shellfish. However, such fires could not produce heat-affected quartzite similar to the samples found in the BOS layers of the WB. Similar small fires were consistently placed in the same area of Cave 1B, suggesting that this area was used for similar activities several times.

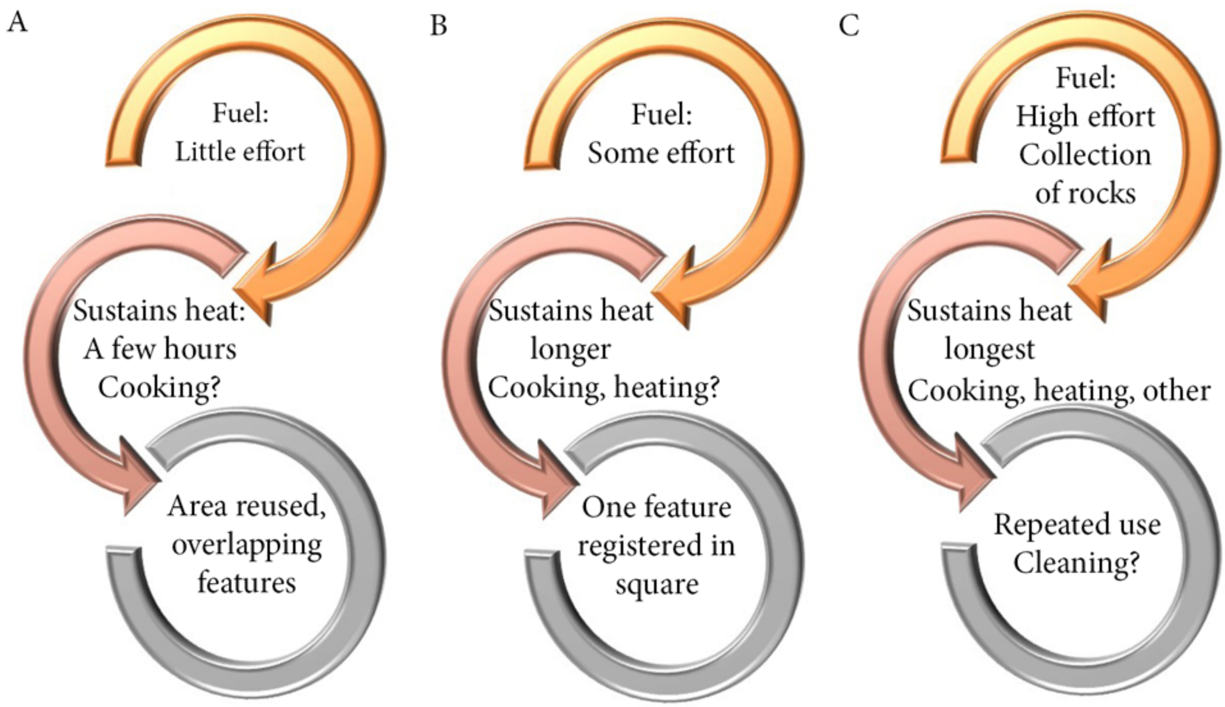

Figure 8: Summary of the chaînes opératoires *described in the paper. A: Cave 1B represented with layer DC PCP containing small overlapping combustion features, suitable for cooking or similar activities. B: Layer SCB 2 in AA42/Z44 (Cave 1A) contained a single large combustion feature, suitable for cooking larger meals and other activities requiring some duration of heat. C: Potentially heated rocks from the BOS layers (Cave 1) represent repeated use and required long duration of heat.*

Secondly, the large ash feature in SCB2 in Cave 1/1A represents a higher level of investment for the humans building the fire. A fuel mass > 14 kg might have to be collected to make this fire, which could potentially retain heat twice as long as the fires of DC PCP. The fire producing AF1 in SCB2 might have been a cooking fire that could cook more food (and support a larger group or a longer stay) than the smaller fires. AF1 in SCB2 was also produced by a fire that could potentially induce thermal alterations in quartzite similar to that observed in the BOS layers.

Thirdly, the heat-affected rocks from the BOS layers represent the highest effort *chaîne opératoire* in this study. The rocks were exposed to large fires, requiring the collection of a large fuel mass. The rocks would also have to be brought into the cave and exposed to the heat repeatedly to induce colour changes, fractures and breaks. When the rocks were in the fire, they would contribute to retaining the heat of the fire so that the heat was of long duration. This could potentially represent a longer stay or a different group than the smaller fires.

We could not discern drop and toss zones by the ash features described here, possibly because they were used for a short time. The ash features do not represent built structures; indeed, the features do not even have stone lining. Nevertheless, the combustion features do represent pyrotechnical architecture in that they are fixed points in space that people moved by and around when the fires were active. Three different *chaînes opératoires* for fire use are represented in our examples from KRM, showing that fire-related behaviour in the MSA was complex and flexible. By examining spatial relations and fire use, as well as detailed studies of the combustion features, one might be able to disentangle more information on fire-related behaviour and the relation between fire technology and other MSA technologies.

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Firing the Earth. The Early Neolithic Ovens of Portonovo (Marche, Italy)

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Abstract

This paper presents a new evidence of underground ovens found in the ancient Neolithic site of Portonovo Fosso Fontanaccia in the Marche region, central Italy. Here 23 underground ovens, dated to the first half of the VIth millennium BCcal, were uncovered. To date no trace of a settlement connected to this site has been found. A multidisciplinary approach has been applied to the study of this extraordinary Italian site in order to understand the life cycle of these structures: construction technique, maintenance, lifespan, function, and social value.

Keywords: Underground ovens, Early Neolithic, Central Italy.

Introduction

Starting from the Neolithic period, the domestic ovens represent a particularly relevant evidence for the reconstruction of food processing or craft activities at the household level or of productive activities related to the entire community. Since ovens are fire structures they are particularly prone to breakage and poor conservation: prolonged exposure to fire makes them brittle and they are often only partially preserved in archaeological deposits.

Domestic ovens are very rare in the Italian Early Neolithic. In the very few cases known the original structure is barely preserved, often only the floor and a few centimetres of the walls. They are small, above-ground, domed ovens, made of clay with a wooden framework. They are often located in open areas inside settlements, as at Ripa Tetta (Apulia), where the base of a clay oven one meter large was found on one side of a large stone-paved area. Sometimes the ovens are associated with other combustion structures or cooking slabs. As an example, at the site of Favella (Calabria) a small oven was located next to a clay platform (Tinè 2010; Mastrantuono 2010), while at the coeval site of Trasano (Basilicata) two clay ovens lie close to some fire pits filled with ashes, charcoal and burned stones. It has been assumed that this area was dedicated to food processing activities, and that the construction technique and the reduced dimensions of the two clay ovens could have been related to the baking of bread and other foods (Grifoni 1996; Radi 2002). All these examples appear to be more connected to the village as a whole, rather than to a single hut. Conversely, the oven at Fornace Gattelli is located inside a hut, associated with a fireplace, linked to the domestic spaces of a single family unit (Degasperi *et al.* 1998). This last evidence recalls the Aegean and Balkan domed ovens that are well known from a large repertoire and are also well represented in clay models. These domed ovens are located inside or outside the houses, sometimes associated with additional structures, as clay platforms as at Achilleion (Gimbutas *et al.* 1989), Dikili Tash (Deshayes 1974; Prévost-Dermarkar 2003), Čavdar (Georgiev 1981), Obre (Benac 1973).

A different type of oven, namely the so called 'Grubenöfen' or 'fours à fosse d'accès' are underground structures, often found in battery close to settlements in France, Germany, Austria, Czech Republic, Slovakia and Hungary (Petrasch 1986; Staššiková-Štukovkhá 2002; Pechtl 2008). They were dug in the loess, that can be easily fired to create an underground chamber. Probably due to their functional characteristics these ovens span a long period of time from the Neolithic to historical times. This type of structure allows concentration of the heat in a subterranean environment, taking advantage of the insulation properties of the soil, which prevents the dispersion of heat. In many cases it was assumed that their use was for baking bread and other foods, although some authors believe that they can also be used for pottery drying (Staššiková-Štukovkhá 2002). The ovens found at Portonovo are underground ovens, which are extremely rare in Italy. Only one similar structure was reported at Ripabianca di Monterado, a site of the later phase of Early Neolithic north of Portonovo, which was excavated in the 1960s by Delia Lollini (Lollini 1991).

Figure 1: Portonovo - Fosso Fontanaccia. a, site location; b, general view of the area with the Neolithic site in the distance.

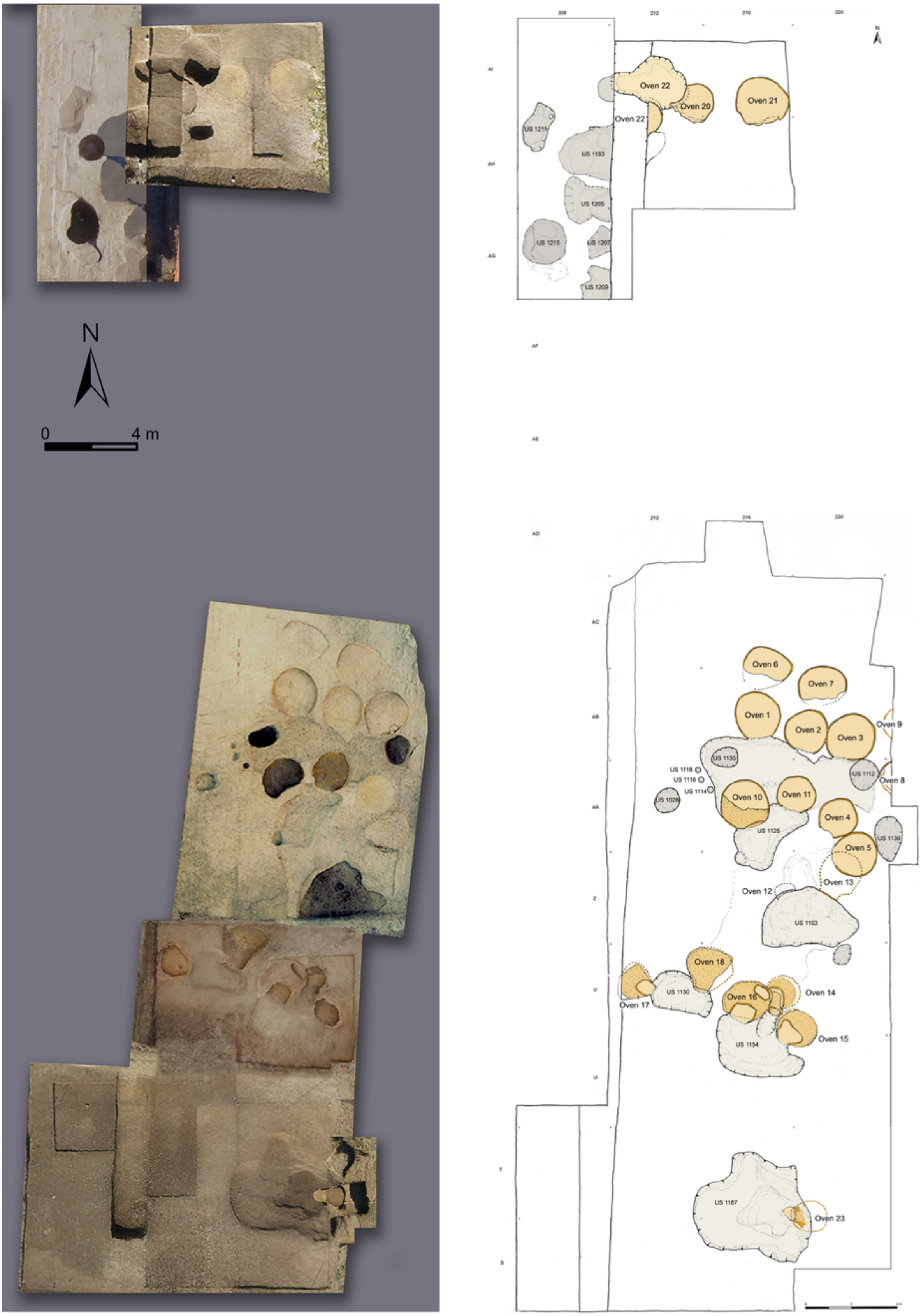

Figure 2: Aerial view and map of the excavated area

The Portonovo underground ovens

The site of Portonovo is located on a slope along the right bank of the river Fontanaccia, at an altitude of about 120m asl. The site is called Fosso Fontanaccia after a stream flowing along the small valley. The stream rises from a spring, today almost dried up. During the Neolithic the valley was less deep and the river flowed a few meters higher than today (Figure 1).

The site is very close to the sea, although this is not easily reachable given the steep, rocky coast. The hillslope where the site is located is south-west oriented, so that it benefits from the sun for many hours a day and it is protected from the Bora, a cold wind that comes from the North and North-East, and from the Scirocco, a warm, humid wind from the South, which are particularly intense along the Adriatic coast during the winter months.

The site was firstly identified by surface materials at the beginning of the '90s. In 1999 and 2006 the local Superintendency opened a few test trenches in the aim to verify the presence of an anthropic deposit. Five excavation campaigns have been undertaken by the Sapienza University of Rome over an area of about 600m^2 from 2011 until 2015 (Conati Barbaro *et al.* 2013).

Twenty-three underground ovens were found so far. Seven of them, located lower on the slope, were entirely preserved because they were protected by a thicker superficial deposit (Figure 2). All the ovens located higher on the slope were instead very badly damaged by natural erosion and ploughing (Figures 3, 4)

How were the ovens made?

The ovens were originally excavated in an eluvial-colluvial soil (Schlier formation) of white or dark-brown colour, or in an eluvial-colluvial red soil. To understand if there was a deliberate choice of a specific type of sediment in which the structures were excavated, we carried out characterization analyses of these three types of sediment. According to the petrographical (thin section), mineralogical (XRPD) and chemical (XRF) analyses (Table 1), the white marly sediment is very rich in calcite, features a low amount of moganite and feldspar, few clay minerals, and numerous foraminiferal mudstone. The white and the dark-brown sediments are very similar: both are very rich in calcite, clay minerals as moganite and feldspar are abundant, and there are numerous foraminiferal mudstone. Conversely, the silty-red sediment is very poor in calcite, it contains a fair amount of moganite and clay minerals, apatite and amphibole are present. The first two colluvial sediments characterize the upper part of the slope, while the red one is visible only lower on the slope.

Table 1: Characterization of the eluvial-colluvial soils of Portonovo archaeological site: 1-3 white e/c soil; 4-5 dark-brown e/c soil; 6-8 red soil.

	Sample	Ill/Ms	Mnt	Chl	Kln	Amph	Ap	Qtz	Mog	K-feld	Pl	Cal	Dol
1	PFO40	X	-	X	tr.	-	-	XX	X	-	X	XXXX	-
2	PFO41	X	-	X	tr.	-	-	XX	X	-	X	XXXX	X
3	PFO36	tr.	-	-	-	-	-	X	X	tr.	tr.	XXXX	-
4	PFO43	XX	XX	X	-	-	-	XXX	XX	X	XX	XXXX	-
5	PFO44	XX	XX	X	?	-	-	XXX	XX	X	XX	XXX	-
6	PFO35	XX	XX	X		-	X	XXXX	XX	tr.	X	X	
7	PFO39	XX	XX	-	X	X	?	XXX	XX	tr.	XX	X	-
8	PFO42	XX	XX	-	X	X	?	XXX	XX	tr.	XX	X	-

Figure 3: The upper slope ovens

Figure 4: The preserved ovens n.14-18

As the ovens are distributed equally among these types of sediment, it appears that no specific sediment was chosen to dig the ovens.

All ovens share similar features and dimensions. They have circular flat bases, with a slight central depression with diameters from 1.50 m to 2.00 m, and a single central opening, on average 50 cm wide and 35 cm high. The vaults are very low, the maximum height does not exceed 50 cm.

The floors were smoothed and in some cases covered with a light coating of clay. The inner lining was obtained by firing the natural sediment.

Large, irregular pits lie in front of each oven or group of ovens. Usually a pit gave access to two ovens. These pits were dug to facilitate the excavation and the access to the ovens (Figure 2). They have been quite deep: as an example, pit 1186, in front of oven 23 was almost 1m deep and 5x4 m wide. Considering the severe erosion of the area, we can calculate that the original pit depth was at least 1.5 m.

What kind of maintenance did they need? How long was each oven in use for?

No evidence of maintenance is visible on the oven walls, vaults and floors.

The ovens were probably abandoned as soon as the vaults started to crack and to crumble in small pieces on the floor. All the intact ovens contain small fragments of the vault spread over the floor, but the entire vault rests on top of the oven's fill. Ovens are filled by a very homogeneous fine sediment with rare, small sized archaeological artefacts.

It is not yet clear for how long such structures could have lasted. According to our experiments, we know that at each firing the ovens are affected by a thermal shock that may cause cracking. However, it is quite difficult to identify how many firings were carried out in each oven, how often and for how long.

How many ovens were in use at the same time ?

The ovens rarely cut each other and there are only two cases of overlapping. Ovens 15 and 16 cut the pre-existing oven 14 (Figure 5). Oven 22, the oldest at the site, was cut by oven 19. Moreover, part of the floor of oven 20 has collapsed on the bottom of oven 22 (Figure 6). In general, we can assume that the position of the previous structures was well known when a new one was dug. We can also suppose that ovens facing the same pit have been made at the same time or in a short interval of time.

The radiocarbon dates obtained so far indicate that the ovens distribution along the slope is not related to a chronological factor (Table 2). As an example, the oldest oven 22 lies in the upper part of the slope, while pit 1186 and oven 23, which are the following structures in our chronological sequence, are located in the lower part of the slope. Moreover, the C14 dates of these two structures confirm the contemporaneity between the ovens and their access pit.

A functional change of the ovens, or at least of some of them, is testified by the presence of burials within oven 1 and 5. Oven 1 contains the remains of two burials, placed in the North-West side of the structure, one layer containing fragments of impressed pottery, lithics and grindstones. This layer could be related to the abandonment of the oven as a fire structure. One burial is of an adult male (T1) 30/35 years old, with partially connected bones; the other is an indeterminate adult of the same age (T2). Oven 5 contains one adult male older than 55. The C14 dates indicate a very limited time gap between the use of this structure as an oven and as a tomb (Table 2). In the nearby area, outside the access pit to oven 13, we found a cremation burial of a young woman no more than 20 years old (Catalano and Di Giannanantonio 2013). The burned remains were gathered up with great care and stored in a container

Figure 5: Stratigraphic relations: ovens 15 (left) and 16 (right) cut oven 14 (middle)

Figure 6: Stratigraphic relations: oven 19 cut oven 22. Part of the floor of oven 20 is collapsed on the floor of the underlying oven 22.

Table 2: The radiometric dates from Portonovo Fosso Fontanaccia.

Structure	Code Lab.	Date BP	Cal 1σ	Sample
Oven 22	LTL15358A	6916±45	5840-5740	charcoal *Cornus* sp.
US 1186	LTL15323A	6734±45	5705-5615	charcoal *Buxus sempervirens*
Oven 23	LTL15990A	6673±45	5635-5555	charcoal *Buxus sempervirens*
Oven 19	LTL15357A	6647±45	5625-5545	charcoal *Phillyrea/Rhamnus*
Oven 14	LTL12777A	6555±45	5545-5475	caryopsis *Hordeum vulgare*
Pit US 1229	LTL15991A	6500±45	5520-5460	charcoal *Quercus* sp. gr. evergreen
Oven 5 - floor	LTL5192A	6500±50	5520-5370	charcoal *Quercus* sp. gr. evergreen
Oven 5 burial	LTL5191A	6418±50	5470-5360	human bone
Oven 13	LTL15989A	6378±45	5390-5310	Rosaceae *Sorbus* sp.

probably made of organic materials, no longer existing at the time of discovery. All these funerary evidence, which are concentrated in the central part of the excavated area, may indicate a different use of the site, possibly dated to a later phase of the Early Neolithic. It is difficult to say whether this functional change was definitive or temporary, because the most recent structure of the site is still an oven (n.13), apparently built for its primary function.

Which fuel was used?

The charcoals found in the ovens belong mostly to the holm oak (*Quercus ilex* cf.) and to the hornbeam (*Ostrya carpinifolia*) (Celant 2013). Only compact and hard woods were therefore selected, because they are denser, less resinous, burn slowly and produce a heat that lasts a long time. The wood taxa recorded at Fosso Fontanaccia are at present the most abundant tree species on the Conero Mount. This may suggest that the firewood for ovens was collected in the close vicinity of the site after an intentional selection of the most suitable taxa.

Which function did these ovens have?

Many charred cereal caryopses were found inside five ovens (14, 15, 16, 23 and 3), and show traces of glumes, suggesting that the structures were used for roasting or drying cereals before storage. Barley (*Hordeum vulgare* L.) is the most attested, while emmer (*Triticum dicoccum* Schübl) is less represented (Conati Barbaro and Celant in press). Cereal grains are always located close to the oven's mouth suggesting that the ovens were always kept clean and that the residues of the fuel and of all that was accidentally in contact with the fire were periodically removed and set aside outside the structures.

Faunal remains were found in the large pits outside the ovens and are very badly preserved due to post-depositional conditions. Therefore only a small percentage of the remains has been determined. Domestic animals predominate, mainly pigs and ovicaprids. Wild animals are scarcely represented by the remains of wild boar, deer, fox, fish, birds and molluscs are also present (Curci pers. com.). The animal bones could testify that the ovens were also used for cooking food and that meals were consumed nearby.

Other possible uses could be pottery firing and/or flint thermal treatment.

A few pottery flakes come from the large pits: these flakes are the result of thermal shocks while firing. Therefore, it could be argued that ovens were in some way connected to pottery firing.

Some flint artefacts show signs of thermal treatment. Various experiments have demonstrated that heating flint at a temperature between 200°C and 450°C improve the efficiency of the raw material for blade pressure flaking, but this procedure requires a good control of the heating system. The ovens provide the possibility of controlling the temperature and therefore could also have been used for this activity, although this could not have been their primary function.

Temperature analysis by means of Powder X-ray Diffraction (PXRD) was essential to understand the functioning of the ovens. 14 samples of the inner coat of four ovens have been analysed. Samples were taken from different parts of the ovens (floors, walls, vaults). The results indicate that the sediments were exposed to temperatures not exceeding 500°C, as shown by the presence of the predominant calcite and the moderate quantity of some clay minerals (mainly chlorite and vermiculite) (Muntoni and Ruggiero 2013). We also analysed 16 ceramic sherds. The average firing temperature recorded for pottery is between 600°C and 800°C (by thin section, XRPD, XRF analysis). Nevertheless, the presence of montmorillonite in some samples may indicate lower temperatures within or slightly below 600°C. Higher temperatures (850°C and 950°C) are recorded only for figulina pottery.

According to these data the temperature reached inside the ovens would be too low for pottery firing, but we cannot rule out their use for drying pottery.

Experimental archaeology

In order to find an answer to so many questions we performed an experimental reconstruction of one oven featuring the same dimensions of the archaeological specimens (1.90 m x 1.80 m in diameter at the base, 50 cm in height; with an opening about 50 cm large and 40 cm high) (Figure 7).

Figure 7. The experimental reconstruction of an underground oven at Portonovo.

Figure 8: The firing phase of the experimental oven

This operation took a total amount of 15 hours of work by a single person using wood and bone tools. Long handle tools allowed us to excavate the oven from outside exploiting the space in front of it. We then fired the internal walls after gradually heating them and we were able to reach a temperature of more than 600°C in about 7 hours, but a single firing consolidation phase was not enough to re-create the thickness of the internal lining of the archaeological specimens (Figure 8). Probably the latter was the result of several phases of firing.

After the consolidation we used the oven to bake some unleavened breads, to roast barley grains and to cook meat at a lower temperature by removing the fire and the embers. The temperature dropped to 300°C in one hour, while maintaining a fairly uniform heat throughout the oven.

By this experiment we were able to test the technique and timing of construction of the oven and of the external pit; the amount of fuel and time required to reach high temperatures and the functioning of the ventilation system with a single opening; the time required to reach the temperature of 500°C (and more). We observed that they could have easily reached temperatures far beyond 600°C. Was it a choice then to stay within 500°C?

Conclusions

The use of the ovens could be connected to seasonal activities of crop processing, which could have been accompanied by the consumption of meals, as evidenced by the remains of terrestrial and marine fauna present in the large pits.

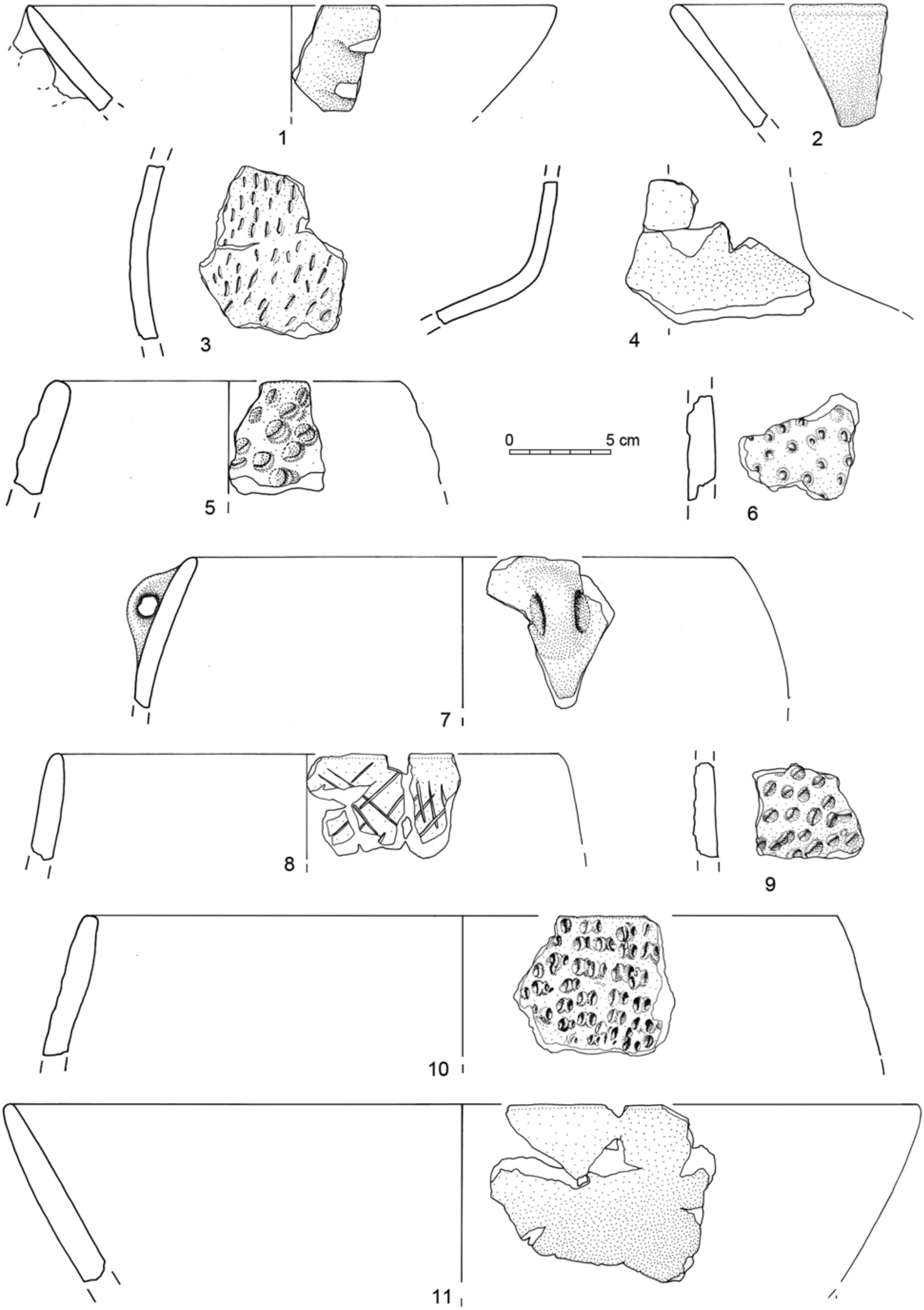

Figure 9: Portonovo Fosso Fontanaccia pottery. Fine and semi-fine pastes (1,2, 4, 7, 11) and coarse pastes (3, 5, 6, 8, 9, 10). Scale 1:3, drawings by Chiara La Marca.

The presence of charred cereals inside some ovens could indicate a seasonal use of these structures for roasting or drying grains in preparation for storage. This activity would have been done after the harvest, in summer or early autumn (July to September). Other evidence of seasonality is lacking: the few bird remains are too fragmented and not determinable to point to a specific season.

The archaeological materials, although not as abundant as other Neolithic sites, attest that food processing and craft activities such as knapping and leather or plant processing (basketry?) were performed near the ovens. In fact, pottery, grindstones, chipped stone, and hard animal artefacts were found mainly in the pits outside and not inside the ovens.

The pottery repertoire consists of few coarse paste jars with typical *impressa* decoration, while simple vessels such as bowls and jars, mainly made of fine paste and fairly large, up to 40cm in diameter, are more frequent. A few necked vases are also present. These vessels could be related to functions such as preparing and serving food or as containers of solids and liquids, rather than as cooking pots (Figure 9) (La Marca 2016; La Marca *et al.* 2017).

The lithic assemblage points to the production of bladelets from local chert. They were used whole or, fragmented, to obtain geometrics, mainly trapezes (Conati Barbaro *et al.* 2014) (Figure 10). According to preliminary use-wear analysis some bladelets were used to cut cereals, while two geometric tools

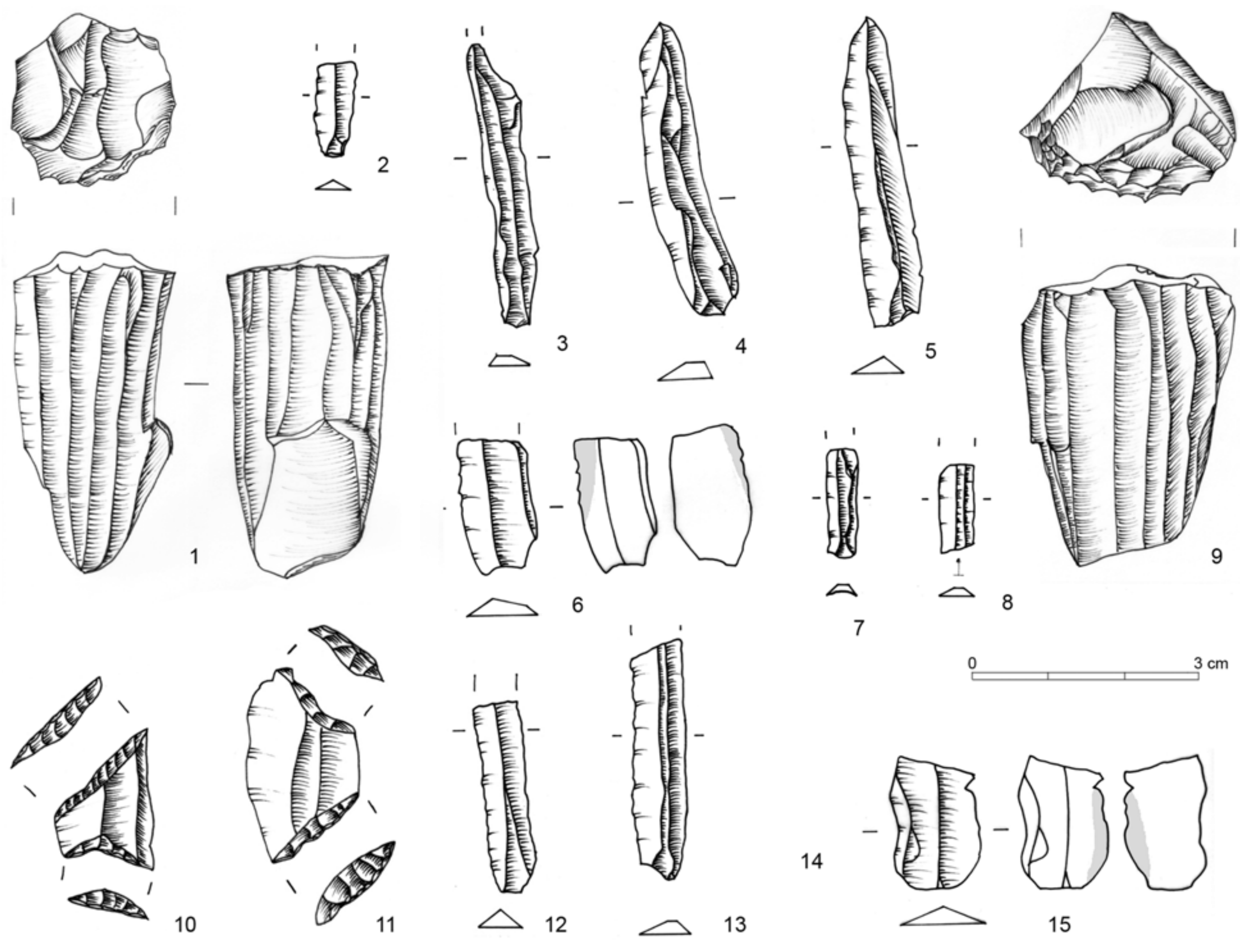

Figure 10: Portonovo Fosso Fontanaccia lithic industry: 1, 9 cores; 2-5, 7,8, 12-14 blades and bladelets; 6, 15 sickle elements; 10,11 geometrics; 14 obsidian bladelet (drawings by C. Silano).

show hafting traces, but no evidence of their use (Lemorini pers. com.). Although grindstones are well represented, their high fragmentation and the bad preservation of their surfaces didn't allow identification of their use (Caricola pers. com.).

The long duration of the site is another important factor to take into consideration. For about 500 years the ovens had been made according to the same model and for the same function by the Neolithic communities that had inhabited the area over time.

The presence of spatially concentrated ovens, even if not always coeval, suggests the existence of communal activities. These activities could have been performed near and within the ovens at the end of annual production cycles, such as the agricultural one, involving the entire community dispersed throughout the territory. As a matter of fact, the excavations haven't revealed any evidence of houses or domestic structures near the ovens. Some daub fragments with wooden imprints were found in the fill of some eroded structures. This could suggest that a hypothetical village or hut could have been located somewhere in the upper part of the slope. Non-systematic surveys carried out during the '90s revealed the existence of other Neolithic sites along the valley.

The link between oven and community is strongly rooted in the rural tradition even in recent times. In the Italian countryside, for example, communal brick or stone ovens were used for many purposes. They were large structures, which could not be used only once and for a single cooking because, to reach the right temperature, the fire had to be lit in advance and kept on for a prolonged time. Once ready for cooking, the oven was used to bake bread of different families, marked by personal signs, sometimes according to a hierarchal order (Zaccheo 1974). Communal ovens were also kept in use for several days. In fact, it was a good practice to exploit the different range of temperatures reached by the oven (from the highest to the lowest) for the various food preparations (baking bread, roasting, stewing meat, cooking soups, etc.).

The re-utilisation of the ovens as burials may be considered an indicator of the communal value of the site. During the Neolithic it was quite a common practice to employ abandoned domestic structures such as huts, silos or pits for funerary purposes, probably because these places retain a collective memory that makes them an important reference point in the territory. This funerary practice could emphasize the end of a life cycle of the individual, but also of the structure that contains it and, perhaps, of the entire working area. The long-term use of the site that covers about 500 years, in which the same model of functional structure is always repeated, seems to end concurrently with the appearance of burial activities.

Authors contributions:

Cecilia Conati Barbaro: project supervision, investigation, funding acquisition, and writing.

Chiara La Marca: pottery analysis, pottery archaeometry.

Vanessa Forte, Alberto Rossi: experimental archaeology

Giacomo Eramo, Italo Muntoni: archaeometry

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Architectures of Fire: The Pyro-proximities of the Chalcolithic Dwelling

Dragoş Gheorghiu

Abstract

The Chalcolithic material culture of the South Eastern European populations in the 5th millennium BC infers a special relationship with fire, visible in the archaeological record under the form of burned horizons and sets of different pyro-objects. Consequently the present text will try to evoke the human agency in relation to different spaces of fire, such as tell-settlements, wattle-and-daub houses, or pyro-objects such as ovens, heaters and fire starters. The somatic outcomes discussed, namely the visual and thermal sensations and the ergonomic distances between the human body and the open fire, or the fire encapsulated in pyro-objects, depending on the type of settlement and season, were identified from experiments. The influence of geometry on pyro-proximities (i.e. the relationship of the human body with fire) will also be discussed.

Keywords: pyro-objects, dwellings, proximity, tell-settlements, Chalcolithic.

Introduction: Fire in the Chalcolithic

The Chalcolithic period of South Eastern Europe is a time of social transformations that can easily be seen in the material culture. In the Gumelnita – Karanovo tradition (4600 - 3900 BC; Mantu 1995; Görsdorf and Bojadžiev 1996) that spread from the south of the Carpathian Mountains to southern Greece, the emerging social stratification is visible not only in the funeral inventory (for example the necropolis of Varna) but also in the different sizes of tell-settlements (Andreescu *et al*. 2003: 72), fortified villages with palisades and surrounded by trenches, some of which had in their proximity flat seasonal settlements or workshops.

This double form of settlement organization was a response to the climatic determinism of the area, the tell-settlements being used during the cold period of the year, and involving a special relationship with the fire.

In the north of the Danube, a loess region, the composite material made of clay, wood and straw used in the construction of the mentioned settlements (for a complete list see Ştefan 2010: 81 ff) created a symbolic landscape, being produced from the region's raw materials, which at high temperatures burned into ceramics. Similar to the burned fields for agriculture (see Payne 2001: 65 ff) the human settlements were subject to burning from time to time as a result of an accident or intentional act (Tringham 1992; Stevanovič 2002). The risk of accidental burning of a compact tell-settlement was minimized by the use of different types of clay or ceramic objects in which the fire was encapsulated and the air-draught controlled. It is worth mentioning that some of these heater objects suggest, by their image of houses or group of houses, that the burning of tell-settlements had a ritual character, since their shape and behaviour during use create images of a tell- settlement in flames.

Method

To understand the complexity of the prehistoric dwelling, this must be viewed as a process of entanglement between objects (Gheorghiu 2001), and between people and objects (Hodder 2012).

In the present case the relation of people with pyro-objects represents a special type of entanglement. Understanding the complexity with which the human body relates to pyro-objects implies a perception of ergonomic relationships (i.e. kinaesthetic, temperature and light) in space and time. In this case the space is represented by the ground surfaces on which different pyro-objects were ergonomically manipulated, and the time is that of the short or long usage of the pyro-objects according to their function.

Consequently, the present text will attempt to discuss the relation to fire of the prehistoric dwelling from the perspective of the somatic experience of the proximity with fire.

Such a subject requires an experimental, but at the same time, an experiential approach to the archaeological record. As a result, the proximity of the humans with fire, was approached using a mix of archaeological experiment and experientiality issued from the experimentalist's postural, visual and cutaneous experience.

An important cultural element for controlling the burning process is the geometry of the settlement and the geometric shape of the objects. Therefore, to understand the functioning of different types of pyro-objects, the physical process of burning will be approached jointly with the geometry of the different pyro-objects.

The archaeological experiments that will be mentioned in the present text, respectively the deconstruction by fire (Gheorghiu 2013; 2014a; 2016) of the wattle and daub buildings, as well as the construction and use of pyro-objects (Gheorghiu 2002; 2007; 2014b) were carried out during the period 2000 - 2016.

The physics of burning

All Chalcolithic pyro-objects functioned according to a common principle, namely the air-draught. A basic definition of the phenomenon of air-draught would be the property of a heated pyro-object to create an ascending flow of hot air that will carry the flames of the fire. By their shape, with perforations or empty spaces, these objects allow a suction of the air through their bodies, the air that circulates thus feeding the fire from the inside (Gheorghiu 2002; 2016). Pyro-objects (fire starters and heaters) come in the form of geometric bodies (cones, parallelepipedic volumes, half cylinders) with perforations on the entire surface, or with openings and holes on one or two surfaces.

Even the spatial organization of the tell-settlements generated an air-draught due to the narrow corridors created between houses, especially in the settlements with a strong geometry of the plan.

The air draught phenomenon can also be generated in the fabric of the architectural elements made of clay, wood and vegetal fibres, which during the sintering process (Kingery 1992: 68; Kruger 2015: 888), at temperatures above 500°C, will begin to burn, creating empty spaces that will act as suction channels for the air that will fuel the combustion.

Tell–settlements and fire

The tell-settlements (Dumitrescu 1986; Chapman 1991; Comsa 1997; Gheorghiu 2003; Gheorghiu 2005) are specific dwelling forms during the Chalcolithic period in the South East Europe area. With compacted spatial plans, the tell-settlements were positioned on strategic places (Morinz 1962) against enemies (human or wild animals), allowing a good view of the landscape and a protection against floods. We can infer that the surrounding flammable vegetation was cleansed 'to break the chain of fuel between homes and natural vegetation'.[1]

[1] www.ext.vt.edu [accessed 10.02.2019]

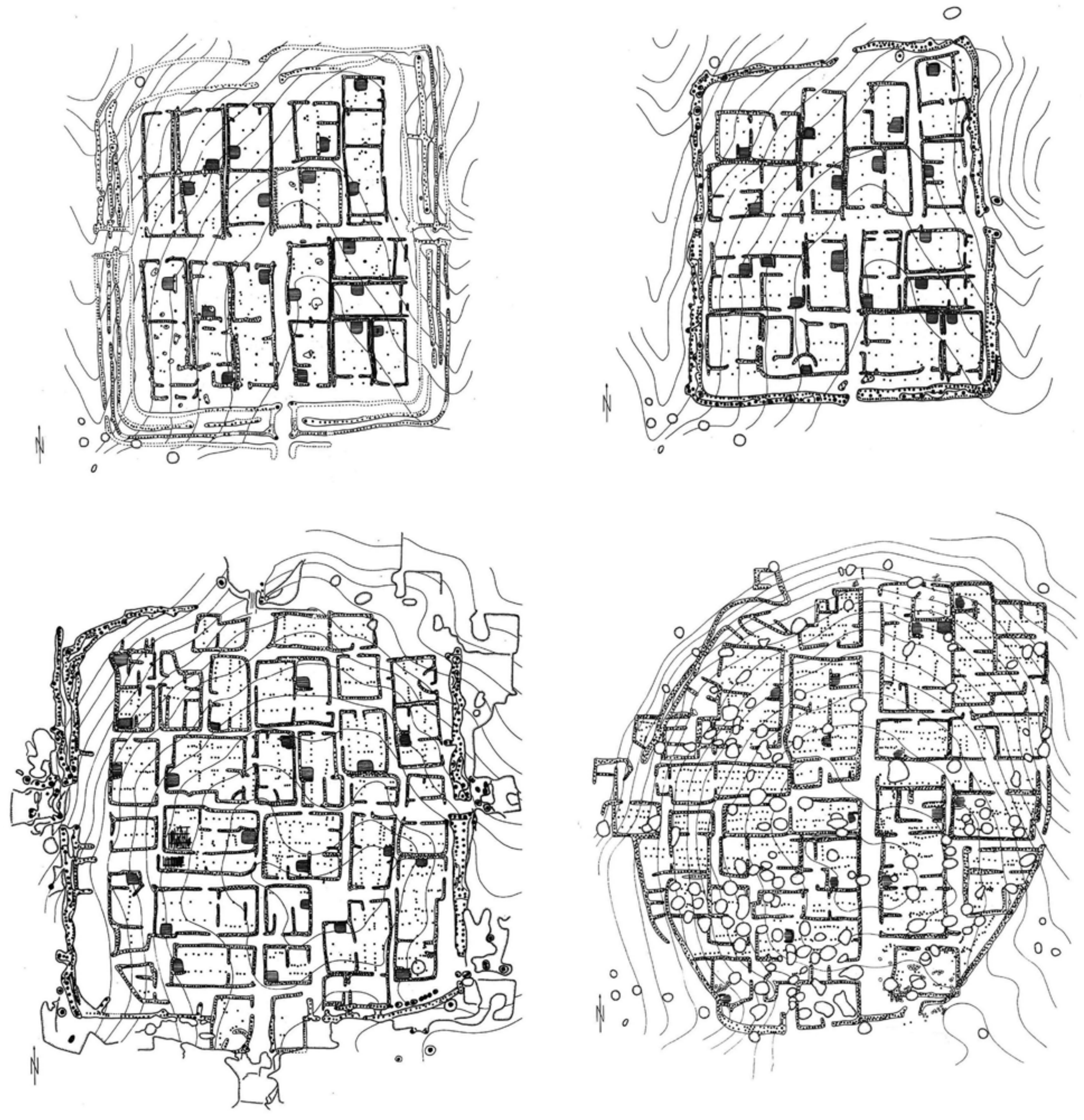

Figure 1: Tell Poljanica at different stages of growth (from Todorova 1982)

The positioning on relatively high and open areas exposed to air currents has the advantage of rapid drying during humid periods but involves a high risk of fire. To this also contributed the dense, sometimes even orthogonal dwellings' organization, which was the result of a predetermined spatial planning process with a strict geometry in the southern Danube area (see Todorova 1982: 182-233, plates 113-192). (Figure 1)

Such a dense space organization created narrow spaces between buildings (for example 80-90 cm at Bordusani – Popina tell; Popovici *et al.* 2003), which in the event of an accidental fire during atmospheric turbulences could allow the formation of combustion corridors, and in the case of an extremely strong air-draught could transform the architecture of wattle and daub in a mass of ceramic fragments with scoria, where the temperature rises above 1100°C.

Figure 2: A burned surface produced by a corridor made of panels (Vădastra experiments 2006) Photo D. Gheorghiu

It is possible that the gaps in the palisades of the settlements with very dense built surfaces positioned next to major circulation paths (like Poljanica or Radingrad, see Todorova 1982: 206 ff), may have played a role in the rapid evacuation of the tell–settlement's population in the event of a disaster.

The formation of combustion corridors was tested using gypsum panels positioned around a burning house (see Gheorghiu 2014: 223), which somehow recreated the dimension of the empty spaces between buildings, and consequently the air-draft during the combustion of the settlement. (Figure 2)

During the cold season each house individually produced a rising current of hot air, the attic being much warmer than the ground floor (see Beck *et al.* 2007: 152-153).

The heating of all the houses of the entire settlement could produce a strong air flow of hot air which could create an air draught inside the tell-settlement. This thermal situation seems to have been realized and visualized in the form of the functional-symbolic heaters representing individual houses or groups of houses with palisades, which could emit smoke through the perforations on their surface.

A tell-settlement functioned as a refugee shelter during the cold period of the year, being surrounded by a small open space separating it from seasonal open settlements and workshops (Comşa1972; Hansen *et al.* 2005), which could also function as rescue places in cases of arson. For example, at Tell Uzunu, 20 km north of the Danube River, a settlement with several overlapped layers of burned dwellings, the flat settlement subordinated to it was positioned at the base of the tell-settlement's hill, at approx.

Figure 3: Tell Uzunu (the arrow points to the subordinated flat settlement) Photo D. Gheorghiu

Figure 4: People near the burning house (Vădastra experiments 2006) Photo G. Serseniuc

20 m - 30 m (Figure 3), a distance from which one can watch the burning process without any risk, as demonstrated by the intentional firing experiments of the houses (Figure 4).

It can be stated with certainty that at the end of the Gumelniţa B cultural phase, the burned layer of houses was the result of an intentional action, because during this period the settlements in the Lower Danube area were abandoned.

Architecture and fire

To understand the process of burning, experimental studies with replicas of prehistoric houses or ethno-archaeological studies (Bankhoff and Winter 1979; Appel *et al.* 1997; Rasmussen 2007; Kruger 2015) tried to produce models for explaining the stages of combustion and the dynamics of the collapse of houses.

From the experiments carried out by the author it was found that in the case of the combustion inside of a wattle and daub house with wood structure plastered with layers of clay, the fire goes out after consuming the flammable substances. But if the clay-protected wooden structure is directly exposed to fire, the internal combustion of the walls may begin. In the houses without ceilings, the fire lit inside will immediately ignite the roof, and will spread to neighbouring buildings, carried by the air currents that can be created between the houses.(Figure 5)

A wattle and daub house (Kruger 2015: 885-7) works as a fireproof object up to a certain level of temperature and air-draught, when the process of rapid desiccation of the clay will produce cracks

Figure 5: The roof in flames (Vădastra experiments 2006) Photo D. Gheorghiu

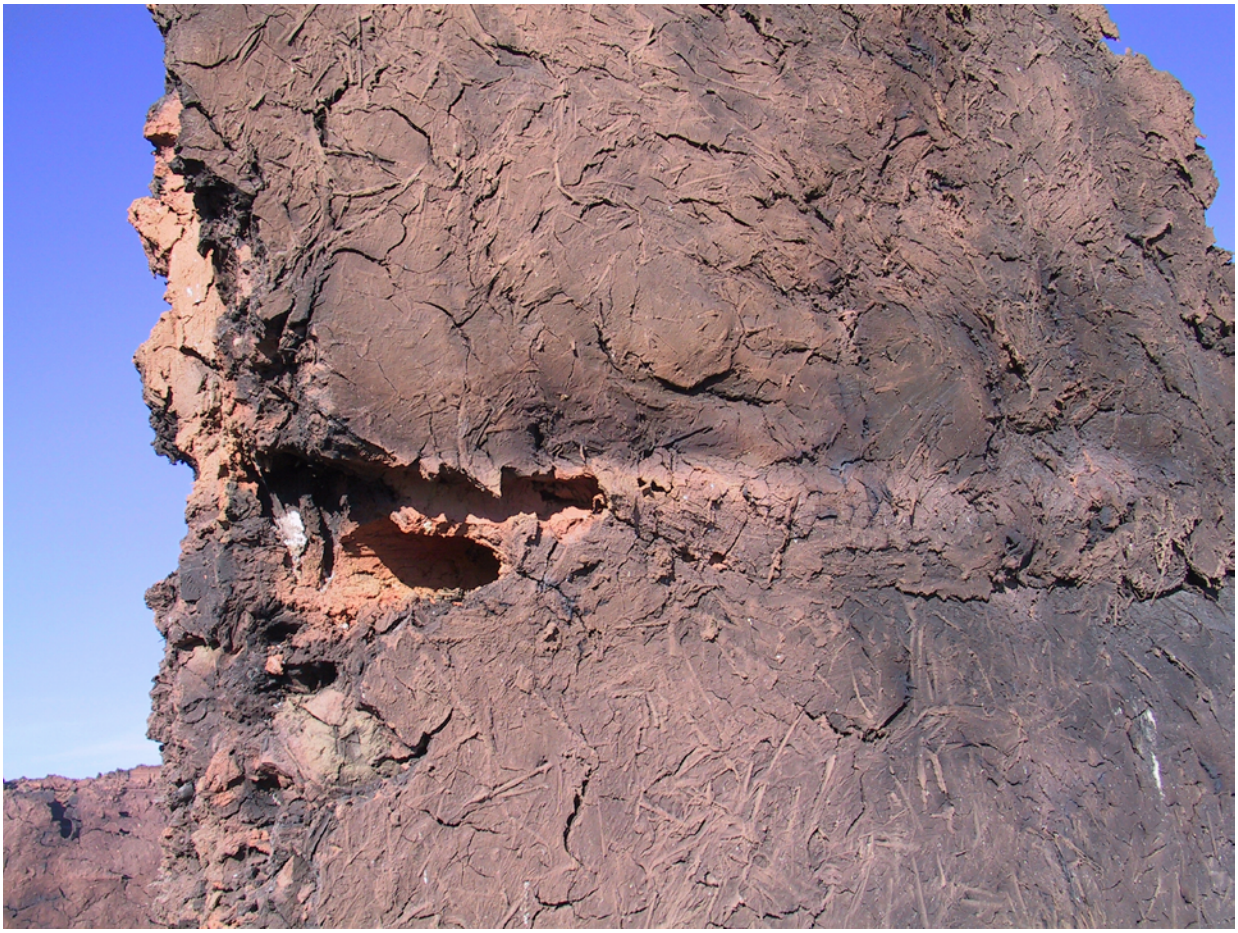

Figure 6: Channel inside the wall, after the consumption of the wooden structure (Cucuteni experiments 2006) Photo D. Gheorghiu

that will put the ligneous structure in contact with the flames. Due to the openings of the doors and windows, the house allowed a natural air-draught that helped to evacuate the smoke of fireplaces and ovens through the vegetal roof. These openings increased the intensity of the combustion in the event of a burning during strong atmospheric turbulences.

Burning the internal structure of the walls weakened their resistance and allowed people to collapse them intentionally inwardly to insulate the fire. Due to the consumption of the wooden structure of resistance, the channels formed inside the walls (Figure 6) initially allowed an increase in airflow and later a fragmentation of the walls along these weak resistance lines.

Even in the most advanced period of the fire it is possible to approach the building in flames coming from the direction of the air currents without suffering from the high temperature. In this case, it was even possible to touch the exterior walls by hand, when the combustion was at its maximum. The collapse of the walls over the charcoal of the ceiling structure and the roof creates a pyro-object that can function like an air-draught kiln, with the air circulating through the free spaces between the architectural fragments. In this way, the large amount of ceramic material resulting from the combustion of a house of wattle and daub, can be explained because when the roof is burnt, and when the walls of the building remain standing, the short time of the combustion and the upright loss of heat will not allow the fire to turn the clay into ceramics rather than on small surfaces. When the collapsed walls allow an air draught between them, the combustion of the wood inside the walls can last for days, depending on the atmospheric turbulences; the high temperatures over 1100ºC that transform ceramics into scoria could be reached only in this way during strong air turbulences.

The collapse of the architectural elements over the burning wood of the ceiling and attic will not stop the burning process, but will generate a slow cooking action of the daub, the cold exterior surface of the crumbled walls allowing rather promptly the movement of people over the place of the combustion.

Interior architecture pyro-design

To control the different uses of fire inside the house, fire was permanently encapsulated in various clay or ceramic pyro-objects, some fixed on the ground while others were movable things.

Many of the rectangular houses consisted of two rooms, the pyro-instruments being located (with few exceptions, see Popovici and Rialland 1996) far from the entrance, in a peripheral location, for the conservation of thermal energy and a good thermal control (Wilkins 2009: 129). It is possible that the first room functioned as a stable, in this case contributing to the thermal level of the dwelling.

Ovens

In this internal spatial organization of the house one of the immovable pyro-object, the oven, was positioned in the houses facing the North-South direction on the East-facing wall (see Comşa 1990: 72, fig. 33), which may have been the result of a symbolic decision to place the fire in the direction of the sunrise.

It is supposed that the window was on the same wall as the oven to allow an efficient air-draught to keep the fire and eliminate the smoke.

The shape of the ovens varied, from rectangular or square ones (Comşa 1976: 105, fig. 2) to those with round vault (Dumitrescu 1965: 223). It can be deduced that the construction of the ovens was preceded

Figure 7: From right to left: the oven, the grinding place, and a bench (Vădastra experiments 2003) Photo D. Gheorghiu

by foundation rites, as inferred by the presence of two human skulls buried in the ground near an oven at the Căscioarele tell–settlement (Dumitrescu 1965: 224).

A relationship not only functional but also symbolic may have existed between the oven and the places of functional - ritual activities such as the grinding space or the bench, which were located near it (Comşa 1990: 88, fig. 47; Harţuche and Bounegru 1997: 32). (Figure 7)

Fireplace

Another fixed pyro-object was the fireplace, an open burning space, fenced with a clay border; historical and ethnographic data give it a strong symbolic value, in ancient Greece being assimilated with Hestia (see Vernant 1990: 156 ff), the goddess whose cult was of great significance (see To Hestia in The Homeric Hymns 1914).

Fireplaces were built directly on the ground on different foundation shapes (Şimon and Paveleţ 1999-2000). The most common form was the rectangular one (Dumitrescu 1965; Haşotti 1997; Parnicand Chiriac 2001; Lazarovici and Lazarovici 2007: 120). To be able to use them, a squatting position of the operator was required, or the use of furniture with very short legs, as inferred by the ceramic miniatures of furniture. Numerous fireplaces have also been discovered outside the houses and their repeated repairs (Lazarovici and Lazarovici 2007: 123) denote an intensive use.

The thermal spaces created by these pyro-objects were different: the oven radiated an intense heat cone in the space in front of its opening, the lateral working areas benefiting from lower temperatures. During the night, when the mouth of the oven is closed the radiant heat of the walls equalizes the temperature. In the case of the fireplace, the heat distribution was made vertically (see Beck *et al.* 2007: 143, fig. 7), creating an ascending air draught through the reed roof, which carried the smoke, in the cases where there was an opening in the ceiling of the room. The elimination of the smoke through the attic could have been a strategy of continuous food preservation in winter and the creation of normal breathing conditions.

Figure 8: The airdrought created between the oven and the window (Vădastra experiments 2007) Photo D. Gheorghiu

Experiments have shown that air-draught in the oven can control the smoke emission especially if there is a wall opening nearby. (Figure 8)

Their position (central or attached to a wall) allowed the simultaneous access of several people around them.

From the point of view of the proximity to the pyro-objects, it was the oven that allowed activities to be carried out in its immediate vicinity on the lateral parts (such as grinding or sleeping) without creating thermal problems, these being related more to the activities of the habitat.

From the point of view of the night illumination, the light of the fireplace allowed a total illumination of the space of the habitat, as opposed to the lighting provided by the oven that is unidirectional. (Figure 9)

From the point of view of the use time, the two fixed pyro-instruments worked intensively during the indoor dwelling, at least for the windows, as their numerous repairs show.

Movable pyro-objects

Internal movable pyro-objects such as fire-starters or heaters can be divided into two categories: functional objects and functional-symbolic or metaphorical objects.

Figure 9: The light emitted by the oven during night time (Vădastra experiments 2004) Photo D. Gheorghiu

Functional heaters were of different shapes and sizes, from purely geometric forms, such as parallelepipeds or simple cylinders or cylinders with a perforated lid (Figure 10 a,b), perforated tables (Lazarovici and Lazarovici 2007: 121, fig. Vc.55), to torque-like vases (Dumitrescu and Marinescu-Bilcu 2001: 129, fig. 5).

Perhaps the most representative ceramic functional object for fire control was the fire starter, (also called Bunsen Lamp by Wood 2007), modelled in the form of a trunk of a cone with a hole at the top and the surface covered by perforations that allowed, when it was placed on burning coals, an air-draught that produced a flame on the top. (Figure 11) The truncated cone shape, which is to be found also in the shape of the Chalcolithic up-draught kilns (Gheorghiu 2014: 174, fig. 1), allows the flame to exit through the aperture at the apex of the object. Of all the pyro-objects of the dwelling it was the one in the closest relationship to the human body.

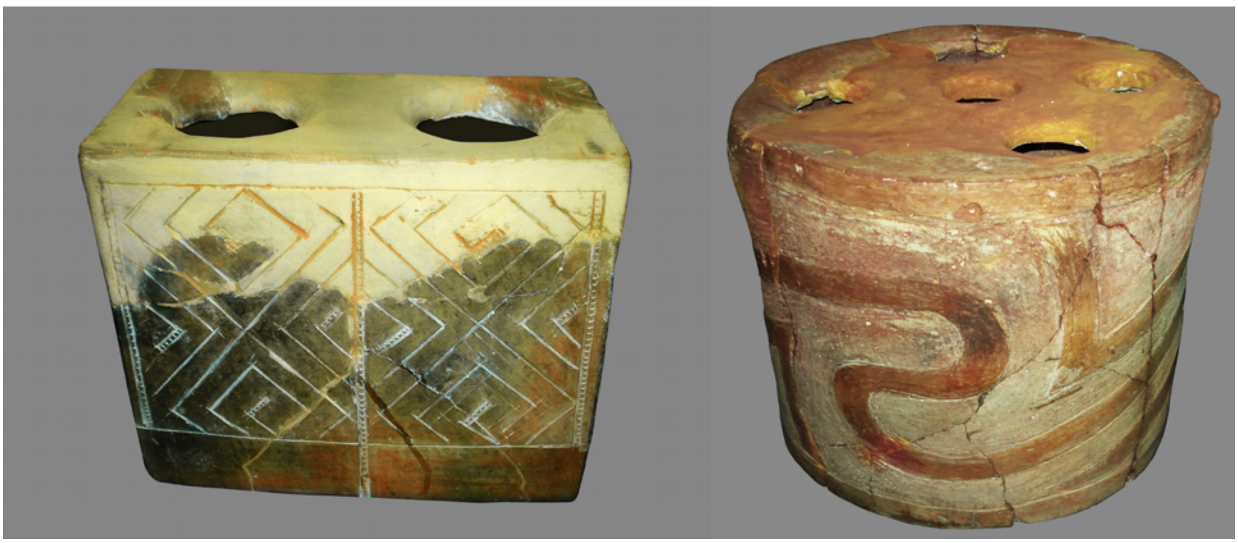

Figure 10: Two Gumelniţa heaters. Photo D. Gheorghiu

Figure 11: Fire starters (Vădastra experiments 2002) Photos C. Catuna

Figure 12: Gumelniţa heater in the form of a house. Photo D. Gheorghiu

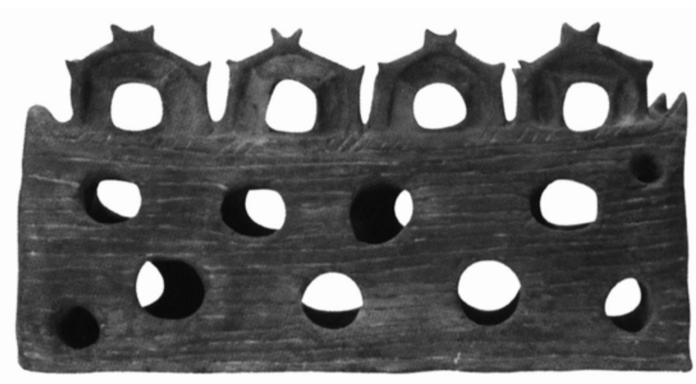

Figure 13: Gumelniţa heater in the form of a settlement surrounded by a palisade

Functional-symbolic heaters were modeled in the form of houses (Figure 12) or group of houses (Figure 13) and presented round perforations at the top or on sidewalls. My interpretation of the latest type found in the Căscioarele tell-settlement is that it represented the image of a tell–settlement with houses surrounded by a palisade, and the number of the perforations for smoke evacuation evoke the number of houses in the settlement (Gheorghiu 2007). (Figure 14)

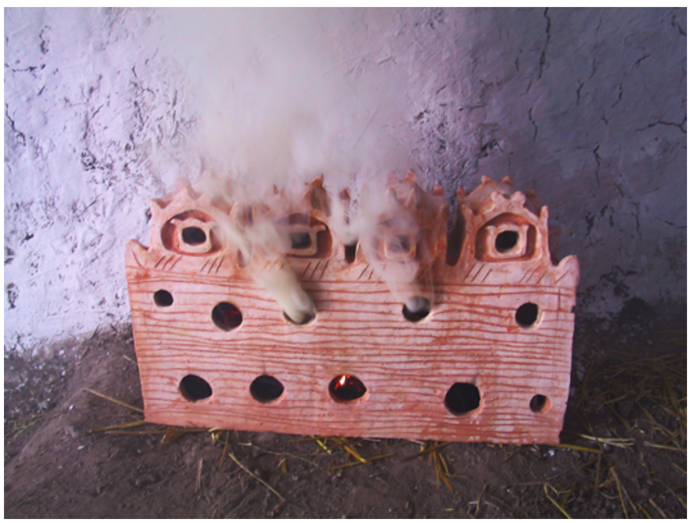

Figure 14: Ceramic model of a Gumelniţa heater in the form of a settlement surrounded by a palisade (Vădastra experiments 2004) Photo D. Gheorghiu

The role of the bottomless heaters, apart from heating the inhabited space, was to heat dishes with food or drink. In the funeral ritual at the necropolis in Varna (Ivanov 1988; Ivanov and Avramova 2000) bottomless vases with four arms supported the plates that had to be heated. The space formed by the supporting arms between the two vessels allowed the generation of an air-draught which kept the combustion in the interior. The importance given to this ritual of heating food or liquids can be deduced from the fact that it was used in one of the richest inhumations with prestige objects, the heater being positioned at the head of the deceased in Grave 43 (see Lensch *et al*. 2014: 166, fig. 1d). (Figure 15)

Drinking hot beverages is not only 'a personal adjustment to cold' (Wilkins 2009: 17), but may be a way to speed up the absorption of alcohol in the body by heating a fermented beverage, such as a heated *Sake* called *Kanzake*.[2]

One can infer that some heaters were rarely handled (vessels-supports and vessels with arms), because they were decorated in the technique of crusted ware, such as those of the Varna II necropolis (*Le premier or* 1989; see also Dumitrescu and Marinescu-Bilcu 2001), Durankulak (Dimov *et al*. 1984, Pl. VI/1) or Gumelniţa eponymous site (Dumitrescu and Marinescu-Bilcu 2001: 129, fig. 5), which could have had a special ritualistic role.

Figure 15: Grave 43 from Varna necropolis. (Varna History Museum) Photo D. Gheorghiu

An additional ergonomic element for this type of crusted ware objects was the use of contrasting colours (red and white), to make the user aware of their hot surface.

The encapsulation of the flames allowed the mobile pyro-objects a safe proximity to the human body. Equally the relatively small dimensions of the mobile pyro-objects (diameters between 20 and up to 45 cm) allowed their easy handling. During their use, when positioned on an amber surface, these objects could not be touched by hand, having a hot surface and remained on the combustion surface until they cooled and could be handled. Although there is no clear archaeological evidence of their place of discovery, it can be deduced that they were used on or near the fireplace to reduce the risk of house fire.

The thermal spaces created by the mobile pyro-objects were small in size and vertically directed, and in the case of dish heaters, most of the thermal energy was transmitted to the cups and plates placed on them.

[2] http://atsu-kan.com/?page_id=5316&lang=en [accessed 02.02.2019]

Figure 16: Working position in front of the oven. (Vădastra experiments 2007) Photo D. Gheorghiu

The analysis of the ergonomic utilization of all the pyro-objects of the household shows that due to the fact that they were positioned on the ground, the working position of the operator involved crouching (Figure 16), or kneeling.

The cylindrical shape of some heaters allowed an easy access around them and inferred a communal and not only an individual use.

The diurnal and nocturnal pyro-spaces

Some of the daily domestic activities could have taken place around the fireplace and near the oven. (Figure 17) Perhaps for symbolic and not only for functional reasons, the position of the grinding space was near the oven (for Radovanu tell see Comşa 1990; for Ovčarovo tell see Todorova 1982: 40, fig. 24).

As the dimensions of the miniaturized pieces of furniture made of ceramic (see Todorova 1982: 69, fig. 31) show, one can infer that the domestic activities were carried out near the floor level, at the opening of the oven mouth or around the fireplace.

It is possible that the interior space has been partitioned around the heat sources by means of screens, as inferred by the ceramic miniatures from Ovčarovo (see Todorova 1982: 69, Fig. 31), in this way stopping the air currents and creating a microclimate.

The intensity of the light emitted by the fireplace allowed the execution of relatively fine operations near it. Apart from the oven whose mouth closed with a ceramic plate, the night space was also lit by fire-starters and heaters, whose brightness was adjustable and could be repositioned as needed. The

Figure 17: Night activity near the oven (Vădastra experiments 2003) Photo D. Gheorghiu

light emanating from the mobile pyro-objects allowed the perception of the interior space at night time.

During the night the thermal space in front of the oven and along the nearest wall could have been used for sleeping.

The pyro-proximities of the tell-settlement

It can be concluded that the tell-settlements involved a high degree of proximity to the fire, in the form of functional and ritual cultural relations (Gheorghiu 2007).

From the domestic daily activities to the abandonment of the burned settlement all the proximities with fire had a ritual character, being repetitive and standardized. The Chalcolithic rites of fire had a paradoxical character: they coalesce and separate, so fire was worshipped in both its avatars: as a life giver and as a destroyer.

This paradoxical character is to be found in the tell-settlement's own existence: it is an architectural object with a high degree of fire risk starting with the construction of the settlement due to its geometry and its materiality, that ends as a hot surface of ceramics.

Fire control was effective inside dwellings by controlling the air-draught in clay or ceramic objects. In these cases the inhabitants were directly related to the phenomenon and controlled it by regulating the air circulation.

The encapsulated fire allowed a proximity involving small distances between the users and the burning areas. The act of controlling the fire might have had a sacred dimension, as the ignition of a fire starter or oven can be interpreted as an animistic transfer, since the operator with his/her breath drives the fire.

Another type of control seems to have been a cognitive one: the geometry of the pyro-object shapes was a way of mentally controlling the phenomenon. The rectangular space of the tell-settlement, or of the house can be found in the geometric form of the space of the fireplace or of the oven. This analogy can be supported by the analogy between the form of the house and that of some ovens, as shown by some miniature models of ovens (see Lazarovici and Lazarovici 2007: 142, fig.Vc. 84).

Likewise the three-dimensional space of the tell-settlement is to be found in the geometric form of the different heaters with architectural forms and finally in a single flat ceramic surface, which is the final result of the fire of the settlement.

The positioning of the fire on the ground had a symbolic and a sacred significance in Antiquity (cf. Vernant 1990: 157) and it can be inferred that the proximity to the fire and the earth of the inhabitants of the Chalcolithic house could have had an analogous character.

It is possible to imagine the interior space of the Chalcolithic house at night as a firescape, analogous to the burnt fields or to the burned house during the final stage of the combustion. From a sensory

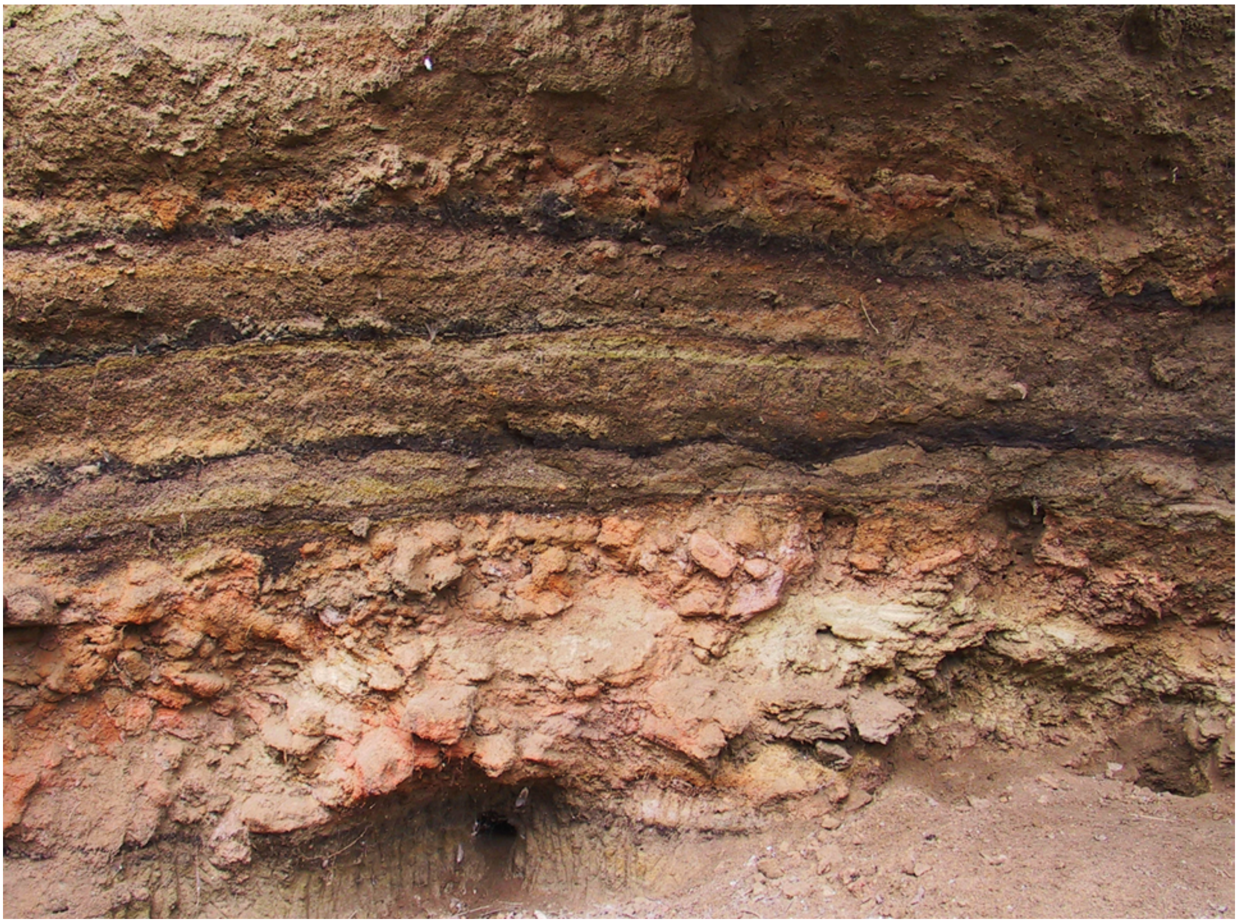

Figure 18: Burned layers at tell Hârşova. Photo D. Gheorghiu

perspective, this surface that emits light and heat became an attractor for the human body, which was crouching to reach it.

The analogy between the floor surface of the house at night with the burned down house is not accidental.

Heaters in the form of dwellings or settlements that emit smoke and flames demonstrate that the burning of the settlements was an event present in the consciousness of the community.

It can be noticed that although the risks were known, people always came back and built above the previous burned settlement transformed by fire into a ceramic layer, creating a pyro-cycle of habitation (a repetitive action and consequently a ritual). (Figure 18)

In conclusion, the proximity between people and the pyro-objects in a tell-settlement revealed itself as being a somatic and cognitive experience of interconnection and destruction.

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Italian Pottery Kilns and Production Areas from the Bronze Age to the Archaic Period (2200-500 BC). A Typological Approach

Agostino Sotgia

Abstract

This paper proposes a typological approach to study the structural evidence related to pottery kilns and craft areas. Starting from a systematic survey of pottery kilns attested in the Italian peninsula from the Bronze Age (2200-950 BC) to the Orientalizing and Archaic periods (725-500 BC), this research provides a reconstruction of different kiln types by putting particular emphasis on craft areas, with the main goal of identifying common features, similarities and dissimilarities among different sites. Moreover, ethno-archaeological data have been taken into account in order to provide a more complete overview of extant evidence.

Keywords: kilns; production areas; craftsmanship; proto-history; Italy; typology.

Introduction

Despite of traditional studies focused on final products, in this paper, I propose an alternative approach, aiming at reconstructing ancient pottery manufacturing models focusing in particular on the analysis of structural evidence and related craft areas.

Indeed, starting from the study of the morphology and consequent function of kilns, and how they change during the time, we can better understand the technological choices – on the basis of pottery production - occurred in the Italian Peninsula from the Bronze Age (2200-950 BC) until Archaic periods (725-500 BC). Also, the areas chosen to host this production show specific characteristics helpful to describe in a clear way the production itself.

Thanks to a typological approach, able to underline the principal characteristics of both structures and areas, we can follow the development of organization of pottery production. The chronological and technological classification of the kiln types here presented allows to draw a scheme that is not limited to a 'straight evolutionary logic', but to the understanding of the craft activity, with its peculiar forms of specialization (Sotgia *in press*).

Also the discovery of a series of common traits for production area, not related to chronology and location, allows outlining more clearly the pottery workshops organization and consequently the steps of production.

State of research

Current knowledge of pottery kilns and production areas in Italy is still unsatisfactory[1], even though studies on this topic have increased over the last decades especially for the pre-Roman period. Few partial-works can be mentioned as a starting point.

[1] This gap is not only due to the lack of clear archaeological contexts for earlier phases, but also to the specific state of preservation of the kilns that do not always allow a correct understanding of these structures.
A kiln, in fact, is most of the times a temporary installation made of a poor quality mixture of mud and straw or other insulating materials mostly raw. Moreover, even in well-organized production areas, after a few firings, a kiln was frequently replaced by a new one. In fact, the high temperatures during the firing process and the exposure to weather conditions caused very easily cracks and crevices in kiln walls. Artisans were therefore forced to frequently repair and partially reconstruct the structures, and consequently entirely rebuilding the structures after a relatively short time was more convenient.

Table 1: Comparative table, showing different typological schemes for Italian protohistoric.

Current proposal	**Iaia (2009)**	**Levi (2010)**	**Jones et al. (2014)**
Type 1	Open Firing	Open Firing	*Open Firing*
Type 2	Single-chamber kiln	Single-chamber kiln	*Single-chamber kiln*
Type 3.1	Two-Pit Kilns without perforated floor	Two-Pit Kilns	*Updraft kilns with a separation between firing and fuel chambers*
Type 3.2	Two-Pit Kilns with perforated floor	*Updraft Kiln*	
Type 4.1			
Type 4.2			
Type 5			

The first classification for the Italian pottery kilns was proposed by N. Cuomo di Caprio (1971). As I will explain later in this paper, this work is compromised by the so-called sceptical approach.

The first study on specifically protohistoric kilns (alongside to a classification of ovens) is provided by N. Negroni Catacchio (1995). However, the low amount of samples analysed makes this work not exhaustive.

A higher number of data were analysed by C. Iaia and A. Moroni Lanfredini (2009) and S. Levi (2010). However the current proposal differs from these previous classifications for the use of more detailed examples that not only allow to better define known types but also to add new types (Table 1).

Focusing on the Italian Prehistory, the lack of clear evidence and the peculiarity of these structures, allowed many scholars to follow the so called 'sceptical' and 'problematic' approaches, as defined by Cristiano Iaia (Iaia and Moroni Lanfredini 2009: 57-59).

The main exponent of 'the sceptical approach' is N. Cuomo di Caprio (2007: 502-503), who described the most ancient evidence, dated to the Bronze Age-Early Iron Age, as simple methods of firing techniques. Cuomo di Caprio writes that these kilns are limited to mere holes in the ground filled with ash and coal.[2]

In regard of the 'problematic approach', it is proposed by, among others, M. Vidale (2007: 42), who raised doubts about both the excavation methods applied on the kilns contexts and the published works on such structures.[3]

Despite the fact that Vidale's observations on issues concerning excavation methodology are valid, especially in regard of past fieldworks, the problem with the 'sceptical-problematic' approach is that its conclusions led to avoiding alternative research strategy on this topic.

Following the arguments by Cuomo di Caprio, it seems that in pre- and proto-historic periods the form of craftsmanship was very basic (see footnote 2). Therefore, she thought that, regarding the Protohistory,

[2] 'Structures dating to proto-historic periods [...] consist of pits or holes, filled with ashes, charcoal and pottery fragments, often not easy to interpret. These primitive structures continue to be used throughout the Iron Age and even later. If one wishes to use the term 'Kiln' one might highlight the non-fixed nature of the structure by using the expression 'temporary kiln pit''. (Cuomo di Caprio 2007: 502–503) *[The translation of the quote from Italian is mine]*

[3] 'The furnaces in the classic or historic period have been studied significantly better than the prehistoric and proto-historic ones [...]. Moreover the textbooks, as is common in other fields, tend to copy or 'imitate' each other, passing on only a few images or reconstructions that have become canonical, although approximate or unnecessary'. (Vidale 2007: 42) *[The translation of the quote from Italian is mine]*

the investigation of ancient production rather than the study of kilns and production areas would be more interesting.

The starting point of this research, on the contrary, is the awareness that various morphologies of kilns are linked to production requirements and to the introduction of new types through time. This suggests a certain degree of craft specialization and work planning.

Moreover, by integrating the detailed analysis of each kiln's evidence within their context (production area), it is possible to gain a better understanding on scale and modes of pottery production across space and time.

My chrono-typological classification, indeed, not only reflects technical developments, namely the shift from simple kilns during earlier periods (Type 1 and 2) to more complex structures (Type 3 and 4) in later times, but it is also related to the organization aspects of production.

The simplest and oldest types were never wholly abandoned, and they are documented alongside the more recent types (even within the same sites), probably as a response to the need for producing different wares.

Consequently, the research question concerns the possibility to investigate the pottery production following the technological development of pottery kilns.

In this sense, the work of C. Iaia (Iaia and Moroni Lanfredini 2009) is fundamental. He proposed to examine the structural evidence of pottery workshops putting emphasis on the cultural choices behind every production process. With this perspective, it is possible to overcome the simplistic evolutionary model of the 'sceptical approach' in order to suggest a linear path from simple kilns during earlier periods to more complex structures in later times.

Pottery kilns

Building a typology

The classification proposed here starts from and expands on the typological studies by C. Iaia (Iaia and Moroni Lanfredini 2009) and S. T. Levi (2010). Essential are also the works on firing methods written by O. S. Rye (1981) and P. M. Rice (1987; 1994). On the one hand, these works are integrated with ethno-archaeological studies (see the references in the text), on the other hand they refer to experiments conducted by Balansky *et al.* (1997) in the Oaxaca Valley, the Italian experiences developed inside of the Parco Archeologico della Terramara di Montale in 1997 (Cardarelli and Levi 2004) and at the park of Broglio di Trebisacce in 2006 (Vanzetti *et al*. 2014).

In regard of the Parco Archeologico di Broglio di Trebisacce I had the possibility to work during the 2014 summer and the 2015 winter with G. Pulitani at the restoration of an experimental kiln (Figure 1). On that occasion, I had the unique opportunity to take part into the process of building and using a kiln as well as to directly experience a production area.

In order to isolate peculiar attributes, the hierarchical scheme of classification takes into account:

1. the presence/absence of building structures;
2. the position of pots and fuel inside of the kiln;
3. the kiln morphology.

Figure 1: The author during the restoration of the kiln at the Parco Archeologico di Broglio di Trebisacce. Summer 2014 (photo by G. Pulitani)

This first distinction is therefore between *non-kiln firing* (Type 1; i.e., firing without building structures) and *kiln firing* (i.e., firing made in fixed, or semi-fixed structures). However, such distinction is not always clear. In the case of (semi-)fixed structures, another distinction can be made between kilns in which the fuel is placed in direct contact with the artefacts during the firing process (Type 2) and those in which there is a division between the firing chamber and the area where the fuel was burnt (combustion chamber). Finally, depending on the shape formed by the arrangement of the two chambers, it is possible to define the remaining types (Types 3-5).

This typology is a part of my research work (Sotgia 2013) on the Final Bronze Age kiln, discovered in the site of Monte Cimino (VT). In order to study this proto-historic evidence, I made comparisons among Bronze Age evidence. However, after a first survey of the kiln dated to this broad period, I realized that the small amount of available evidence (12 Sites – 35%), did not allow a significant sample. As a consequence, I choose to make the sample more significant by adding up also the evidence dated to the Iron Age (14 Sites – 40%) and to Archaic period (9 Sites – 25%). I chose to fix the chronological boundary at the 6th century BC because after that moment the pottery production turns definitely in a huge 'industrial' production - with new type of kilns and workshops organization.[4]

The resulting sample (Table 2) is composed by 118 kilns - discovered in 35 sites - spanning all over the Italian peninsula (Figure 2).

[4] See the examples of Satricum, Lavinium, Laurentina-Acqua Acetosa and Caere in Nijboer 1998.

Table 2: Comparative table, showing different typological schemes for Italian protohistoric.

Sites	Kilns	Chronology	Types
Basilicanova - Montechiarugolo (PR)	1	XII-XIII cent. B.C.	3.1
Bellinzona - Castel Grande - Canton Ticino	1	XV-XIV cent. B.C.	3.1
Bologna - Quartiere Fieristico (BO)	1	IX-VIII cent. B.C.	3.1
Bologna - San Vitale (BO)	14	IX-VIII cent. B.C.	4.2
Casteldebole - Borgo Panicale (BO)	4	IX-VIII cent. B.C.	3.1
Cures Sabini - Fara Sabina (RI)	1	VII-VI cent B.C.	4.1
Fidene - Roma (RM)	1	IX-VIII cent. B.C.	3.1
Lavinium - Anzio (RM)	3	VII-VI cent B.C.	2 - 4.2
Le Chiarine, Puntone Nuovo - Scarlino (GR)	2	XI-X cent B.C.	3.1 - 3.2 - 5
Matelica - IPSIA (MC)	3	IX-VIII cent. B.C.	3.1
Matelica - Palazzo Chirichetti (MC)	5	IX-VIII cent. B.C.	3.2
Matelica - Via Pergolesi (MC)	2	IX-VIII cent. B.C.	3.1
Montagnana - Borgo S. Zeno (PD)	5	IX-VIII cent. B.C.	1
Monte Cimino - Soriano nel Cimino (VT)	1	XI-X cent B.C.	4.2
Monteriggioni - Campassini (SI)	5	VII-VI cent. B.C.	1 - 3.2 - 4.2
Montedoro - Senigallia (AN)	1	VII-VI cent. B.C.	3.2
Montericcio di Imola (BO)	1	IX-VIII cent. B.C.	4.2
Padova - Piazza Castello (PD)	1	VII-VI cent. B.C.	4.2
Porto Perone (TR)	1	XV-XIV cent. B.C.	2
Posta Rivolta (FG)	13	XIX-XVI cent. B.C.	4.1
Punta La Terrare - Brindisi (BR)	1	XV-XIV cent. B.C.	2
Roma - Foro di Cesare (RM)	1	IX-VIII cent. B.C.	3.1
Roma - Palatino SW (RM)	1	IX-VIII cent. B.C.	3.2
Salapia - Trinitapoli (BT)	1	XI-X cent B.C.	3.2
San Nicola - Amendolara (CS)	3	VII-VI cent. B.C.	3.1
Santa Maria di Ripalta - Cerignola (FG)	1	XV-XIV cent. B.C.	2
Santa Rosa a Poviglio - Poviglio (RE)	1	XII-XIII cent. B.C.	2
Satricum (LT)	2	VII-VI cent. B.C.	2
Savignano sul Rubicone (FC)	12	VII-VI cent. B.C.	3.2
Scalo di Furno - Porto Cesareo (LE)	1	XV-XIV cent. B.C.	2
Torre Chiaruccia - S. Marinella (RM)	1	IX-VIII cent. B.C.	1
Torre Galli, Drapia (VV)	1	IX-VIII cent. B.C.	3.1
Trebbio - San Sepolcro (AR)	3	VII-VI cent. B.C.	3.1
Tufarriello (SA)	19	XIX-XVI cent. B.C	1
Veio - Formello (RM)	4	IX-VIII cent. B.C.	2 - 3.1 - 3.2

Figure 2: Overview of the structural evidence analyzed in this work

Classification

The classification is organised as follows: for each type is provided a detailed description and a list of all the evidence and for each context is further specified the site's name, its relevant municipality, chronology and bibliographic references.

Some kilns have been listed as *variants* due to the presence of specific features that cannot be assigned to a specific known type; other kilns have been interpreted as *uncertain attributions* as the extant literature does not precise exact types.

Type 1 - Open Firing (Figure 3)

This type of 'kiln' consists of a small area in the ground, where dried pots are stacked in piles and covered with wood; dung and straws are usually employed as fuel and as thermal insulating material. This technology is the oldest and the simplest one. The fuel (dead branches, reeds, weeds, dung and other materials easily available on-site) is placed at the bottom of the pit, underneath the and between the artefacts, and, in cases of 'stacks', it is also added to the top and all over the heap (Sillar 2000).

The fire is directly lit on the heap; flames rise suddenly as well as the temperature all at once, thus determining an irregular atmosphere between the vases in the heap.

The pots are fired for a short time and, at the end of the process, the 'stacks' are demolished to retrieve the pots. In this firing process several pots may be deformed because of the weight of the covering material, or may result not evenly fired.

Type 1, as opposed to the other, produces a higher amount of damaged pottery and requires higher fuel consumption. The archaeological evidence is hard to discern; a reddening/blackening of the soil is often the only visible sign.

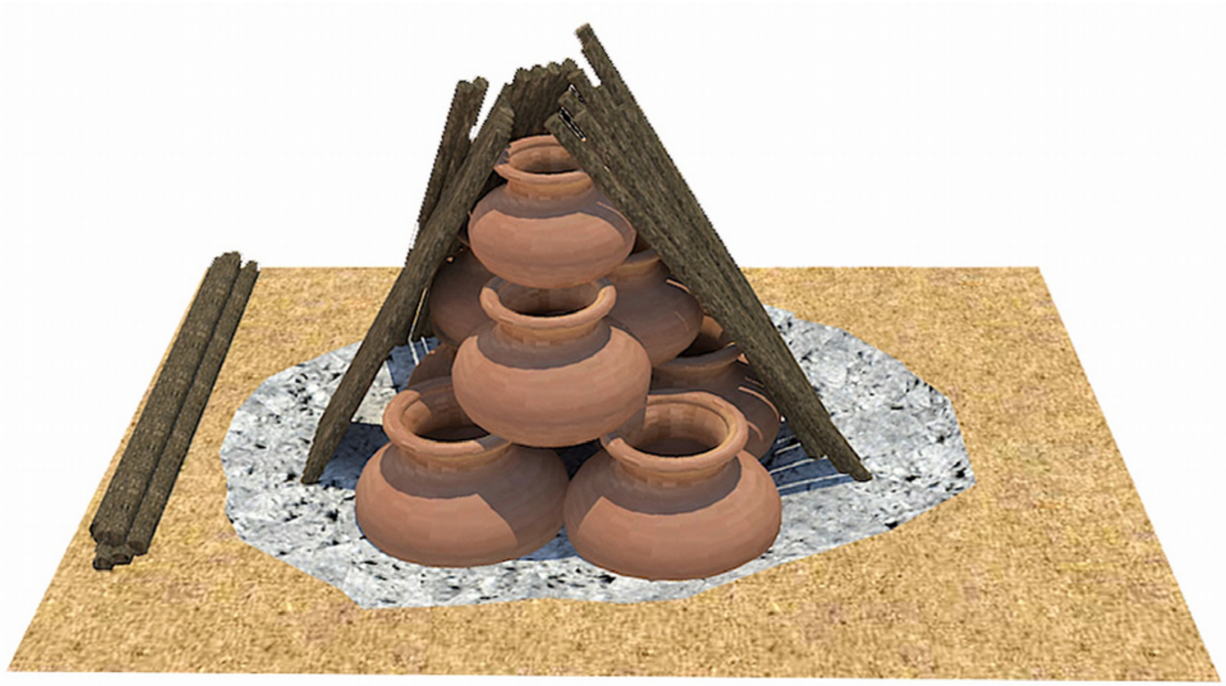

Figure 3: 3D reconstruction of the Type 1: Open Firing and archaeological example from Montagnana Borgo S. Zeno (after Bianchin Citton 1998)

Several ethno-archaeological studies provide support to the understanding of the archaeological evidence (Arnold 1985; Arthur 2014; Beaudry and Kenoyer 1987; Colton 1951; Diop 2000; Kristiansen 1981; Lauer 1974; Nicklin 1981; Okpoko 1987; Rye and Evans 1976; Saraswati and Behura 1966; Shepard 1956; Sirika 2008; Skibo 1992: 61-62; Tobert 1984).

Documented Sites:

Tufariello Buccino (SA) [Early Bronze Age/Middle Bronze Age] (Holloway 1975); Montagnana Borgo S. Zeno (PD) [Final Bronze Age/ Early Iron Age – 11–8th century BC] (Bianchin Citton 1998; Paiola 1998); Torre Chiaruccia, Santa Marinella (RM) [uncertain attribution: the floor was heavily reddened by fire and many carbons are present, indicating that a direct contact between the fuel and the vases occurred; however, the discovery of three stones, put close to each other, might suggest their use as spacers or as stands for pots] [Early Iron Age] (Barbaranelli 1956); Monteriggioni-Campassini (Pit E) [Archaic Period – 7th century BC (Ciacci 2004)

Type 2 - Pit Firing (Figure 4)

Type 2 consists of a pit dug into the ground, filled with dried pots and fuel and sealed with mud (or other insulating material such as stone, dung or straw). In the most complex form of pit-firing structures the floor is paved with a thick layer of potsherd for additional thermal insulation.

This kind of technology is generally interpreted as an improvement of the 'Open Firing' kiln, as it allows more firings to be performed before demolition (only the temporary dome was broken in order to retrieve the pots). Moreover, it makes easier to control the temperature, thanks to the several openings in the dome.

An idea of the use of this type of kiln is provided both by experimental *replica* of Balanksy *et al.* (1997) and by the ethno-archaeological research of Rye and Evans (1976) in Pakistan.

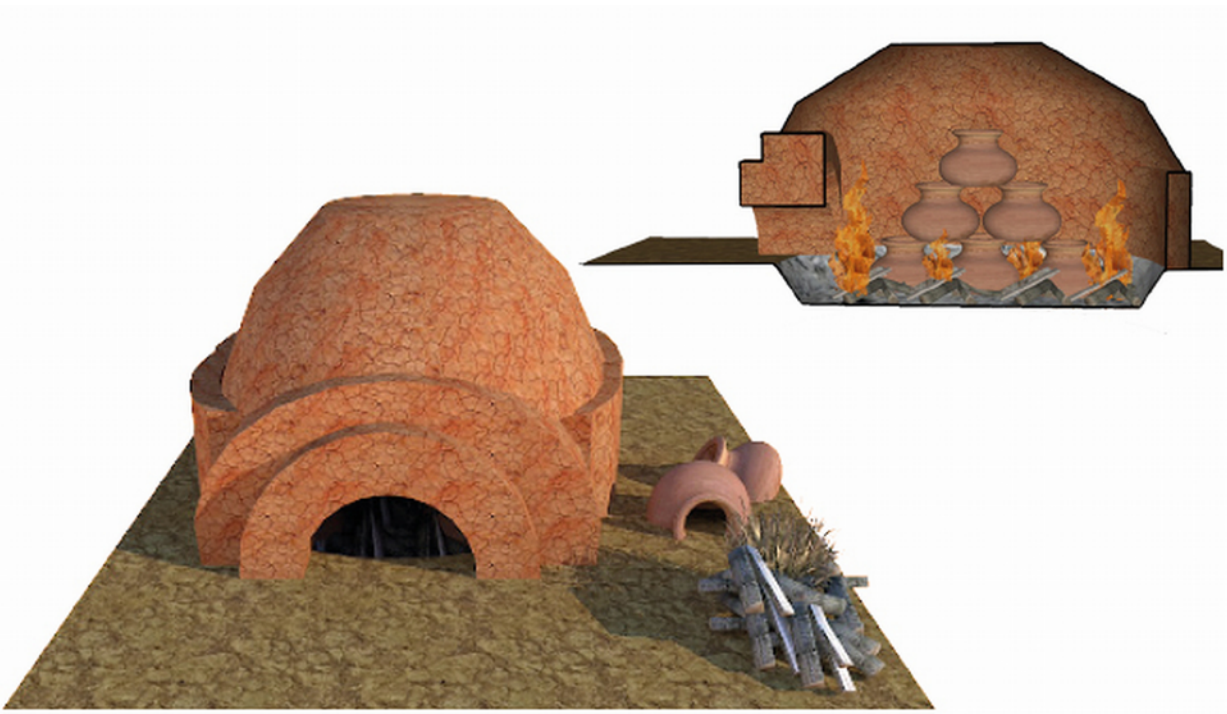

Figure 4: 3D reconstruction of the Type 2: Pit Firing and archaeological example from Santa Maria di Ripalta (after Nava and Pennacchioni 1981)

Documented Sites:

Santa Maria di Ripalta, Cerignola (FG) [Middle Bronze Age – 15-14th century BC] (Nava and Pennacchioni 1981); Punta La Terrare, Brindisi (BR) [uncertain attribution: De Juliis mistakenly defines this kiln as an 'open firing' one, but the structure, the floor insulated with refractory mud and the coverage (even if hypothetical) clearly show that it was a more complex structure] [Middle Bronze Age] (De Juliis 1981); Porto T [Middle Bronze Age] (Pacciarelli 1992; Peroni 1996; Radina and Battisti 1987); Satricum – Kiln A [7th century BC] (Nijboer 1998); Scalo di Furno, Porto Cesareo (LE) [Middle Bronze Age] (Lo Porto 1986); Santa Rosa a Poviglio, Poviglio, (RE) [Recent Bronze Age – 13th century BC] (Bernabò Brea and Cremaschi 1987); Veii, Formello (RM) [Early Iron Age - 9th century BC] (Boitani *et al.* 2009); Lavinium, Anzio (RM) (a kiln, uncertain attribution) [Early Iron Age – 8th century BC] (Fenelli 1984).

Type 3 – Two-Pits Kiln

This kiln consists of two parallel pits in the typical 'figure-eight' shape, which kept the fuel separated from the pots. One chamber acts as firebox where the fuel is burned, while the other contains the pots to be fired.

The 'firing chamber' (and sometimes also the firebox) is covered with a mud layer, which, at the end of the firing process, is broken in order to retrieve the pots.

This type of kiln allows to add more fuel during the process and to reach higher temperatures, on the average above 700°C. The gasses produced are channelled through a chimney located on the top of the temporary dome.

There are two variants known for this type, depending on the arrangement of the chambers: horizontal (Figure 5) or vertical (Figure 6). In the latter, pots are placed on a perforated floor above the second pit that creates a further separation between fuel and vessels.

A reconstruction of this type of kiln was made in 1997 inside the Museo Archeologico Etnologico of Modena and a video[5] of this experiment shows both the steps for the construction of this structure and the firing methods.

Variant 3.1 - Documented Sites:

Bellinzona-Castel Grande, Canton Ticino [Middle Bronze Age] (Donati 1986); Basilicanova, Montechiarugolo (PR) [Recent Bronze Age – 13-12th century BC] (Cattani 1997); Le Chiarine, Puntone Nuovo, Scarlino (GR) (Kiln A) [Final Bronze Age – 12-10th century BC] (Aranguren 2008; 2009); Fidene, Roma (RM) [Early Iron Age – 9th century BC] (di Gennaro and Iaia 2004); Bologna (BO) – Quartiere Fieristico [Early Iron Age – 9-8th century BC] (Tovoli 1997); Casteldebole, Borgo Panicale, Bologna (BO) [Early Iron Age – 8th century BC] (Bellucci *et al.* 1994); Matelica (MC) - Via Pergolesi [Early Iron Age – 8th century BC] (Silvestrini and Sabbatini 2008); Matelica (MC) - IPSIA [Early Iron Age – 8th century BC] (Silvestrini and Sabbatini 2008); Torre Galli, Drapia (VV) [Early Iron Age] (Orsi 1926); Veii, Formello (RM) [Early Iron Age - 9th century BC] (Boitani *et al.* 2009); Veii, Formello (RM) [Early Iron Age – 8th century BC] (Boitani *et al.* 2009); Rome (RM) – Foro di Cesare [Early Iron Age] (De Santis *et al.* 2010); Trebbio, San Sepolcro (AR) [Archaic Period – 7-6th century BC] (Acconcia *et al.* 2009; Ciacci *et al.* 2009; Iaia and Moroni Lanfredini 2009); San Nicola, Amendolara (CS) [Variant of this type: this kiln would be pertinent to Variant 3.1 but it differs from the latter because of the firing method. Indeed the kiln from Amendolara shows a covered corridor instead of the second pit]. [Archaic Period – 6th century BC] (De la Genière and Nickels 1975).

[5] *3500 anni fa nella grande Pianura – 2009 – directed* by F. Vannini; Produced by Comune di Modena.

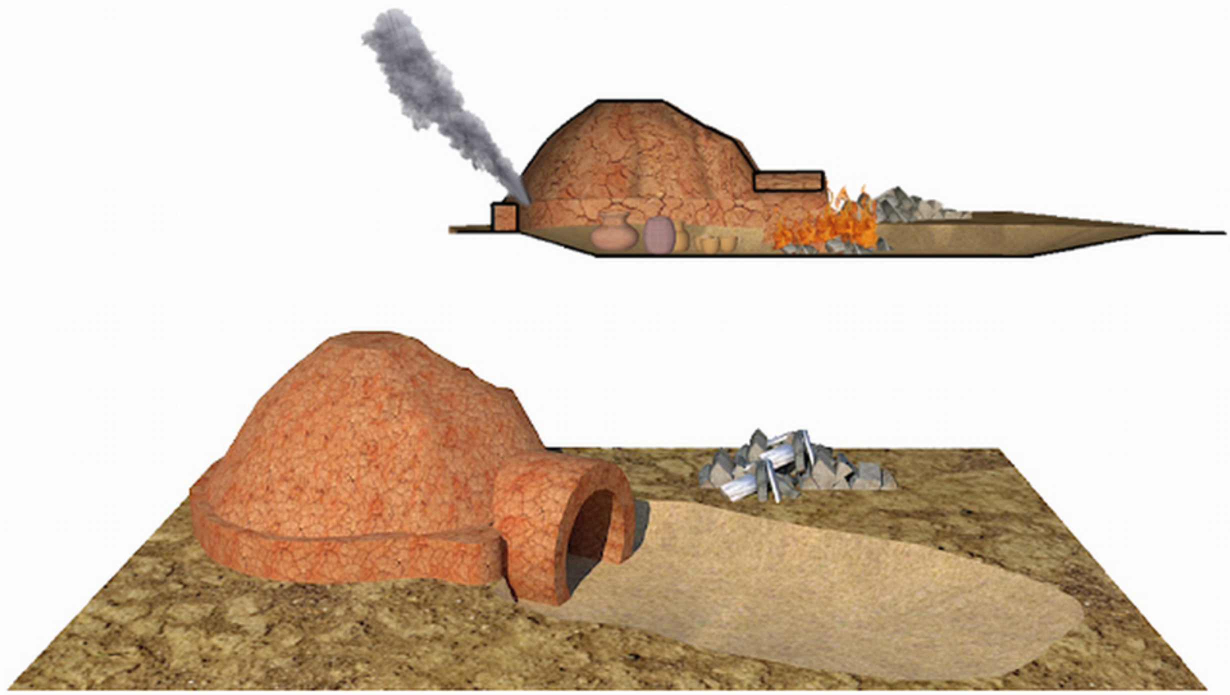

Figure 5: 3D reconstruction of the Type 3.1: Two-pits Kiln with horizontal arrangement and archaeological example from Bellinzona-Castel Grande (after Donati 1986)

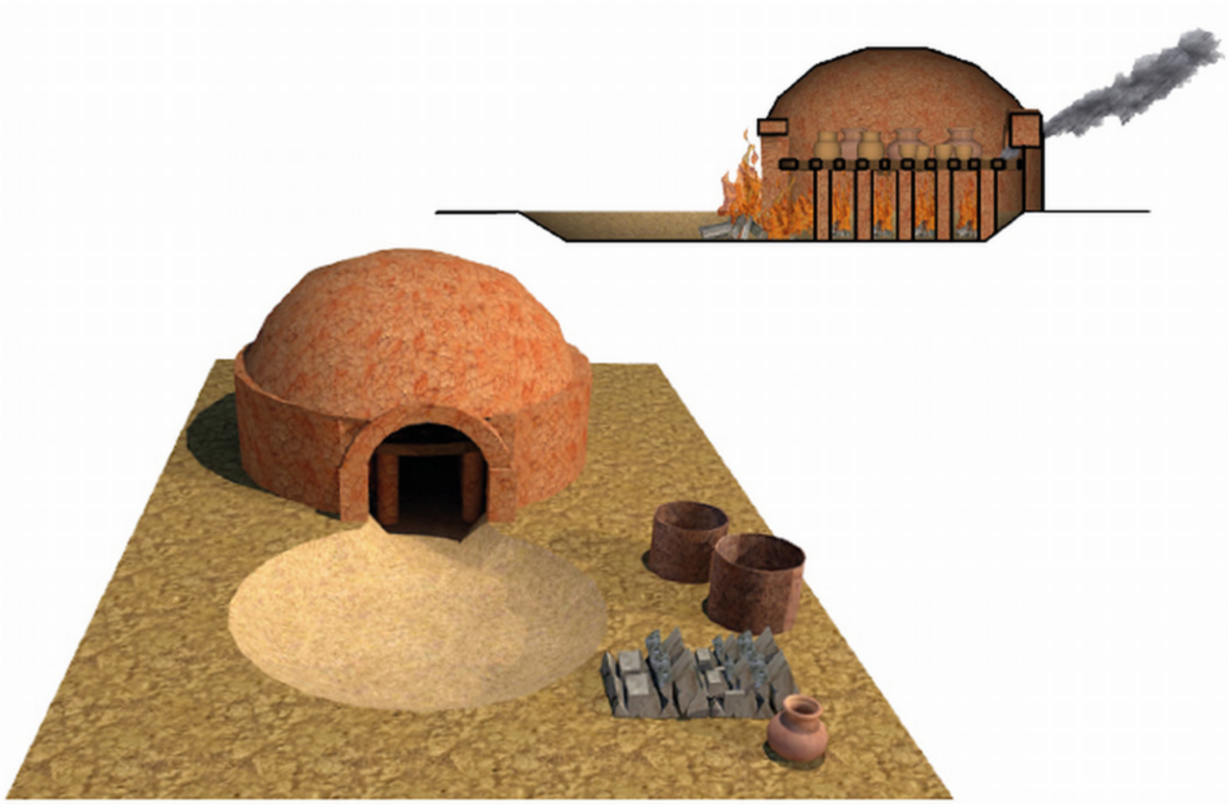

Figure 6: 3D reconstruction of the Type 3.2: Two-pits Kiln with vertical arrangement and archaeological example from Savignano sul Rubicone (after Miari 2003)

Variant 3.2 - Documented Sites:

Salapia, Trinitapoli (BT) [Final Bronze Age – 11-10th century BC] (Alberti *et al.* 1981); Le Chiarine, Puntone Nuovo, Scarlino (GR) (Kiln C) [Final Bronze Age – 12-10th century BC] (Aranguren 2008; 2009); Matelica (MC) – Palazzo Chirichetti [Early Iron Age – 8th century BC] (Silvestrini and Sabbatini 2008); Rome - Palatino SW [Early Iron Age] (Brocato 1995); Monteriggioni-Campassini (SI) (Pits L, G, D) [Archaic Period – 7th century BC] (Ciacci 2004); Savignano sul Rubicone (FC) [Archaic Period – 7-6th century BC] (Miari 2003); Montedoro, Senigallia (AN) [Archaic Period – 7-6th century BC] (Gobbi 2002); Veii (9th century BC) (Boitani *et al.* 2009).

Type 4 - Single Deep Pit with Vertical Structure

This kiln consists of a deep pit with two superimposed chambers. The fuel is burnt at the bottom of the pit, and pots are placed in the other chamber. As in the case of two-pits kilns, the gasses found their way out through a chimney or other openings present on the temporary dome.

There are two known variants within this type, depending on the absence (Figure 7) or presence (Figure 8) of a perforated floor.

The first variant does not feature the perforated floor above the firebox, and pots are placed on a 'carved shelf' dug out in the pit.

In the second version, above the fire there is a perforated floor embedded in the pit or supported by columns.

Variant 4.1 - Documented Sites:

Posta Rivota (FG) (Pits L, H, D, R) [uncertain attribution: Tunzi Sisto offers only a partial description of seventeen structures and pictures do not allow for accurate evaluation. The kiln presented here should be considered as an uncertain attribution, until more extensive reports are published.] [Early Bronze Age / Middle Bronze Age] (Tunzi Sisto 2012); Cures Sabini, Fara Sabina, (RI) [Early Iron Age/Orientalizing Period – 8-6th century BC] (Guidi *et al.* 1985; Guidi *et al.* 1988).

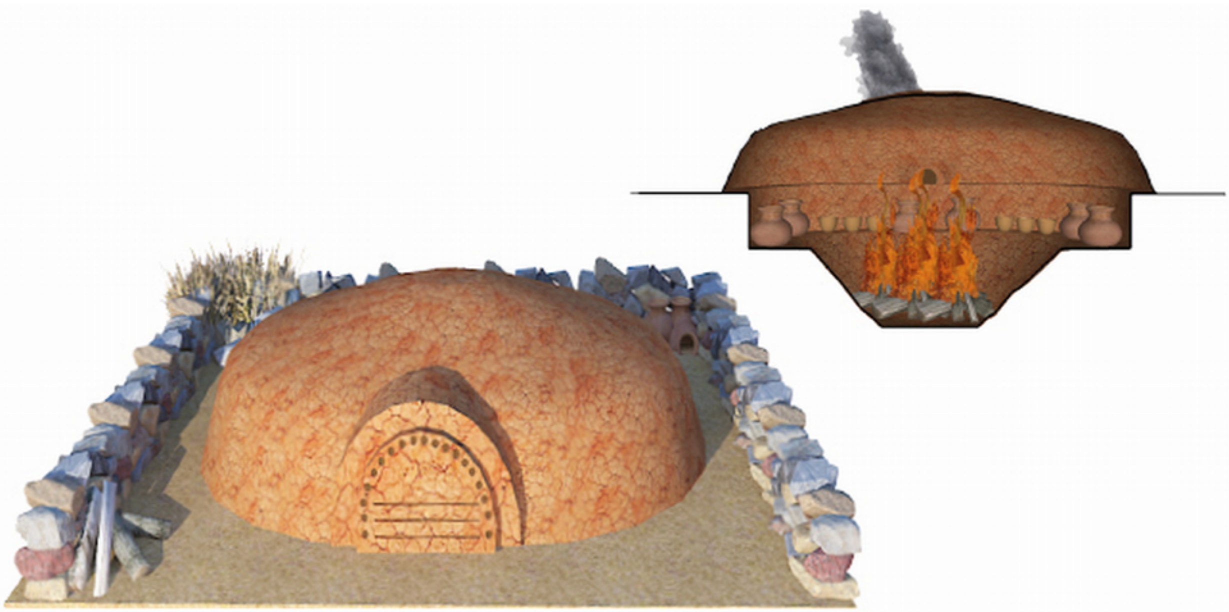

Figure 7: 3D reconstruction of the Type 4.1: Single Deep Pit without perforated floor and archaeological example from Posta Rivota (after Tunzi Sisto 2012)

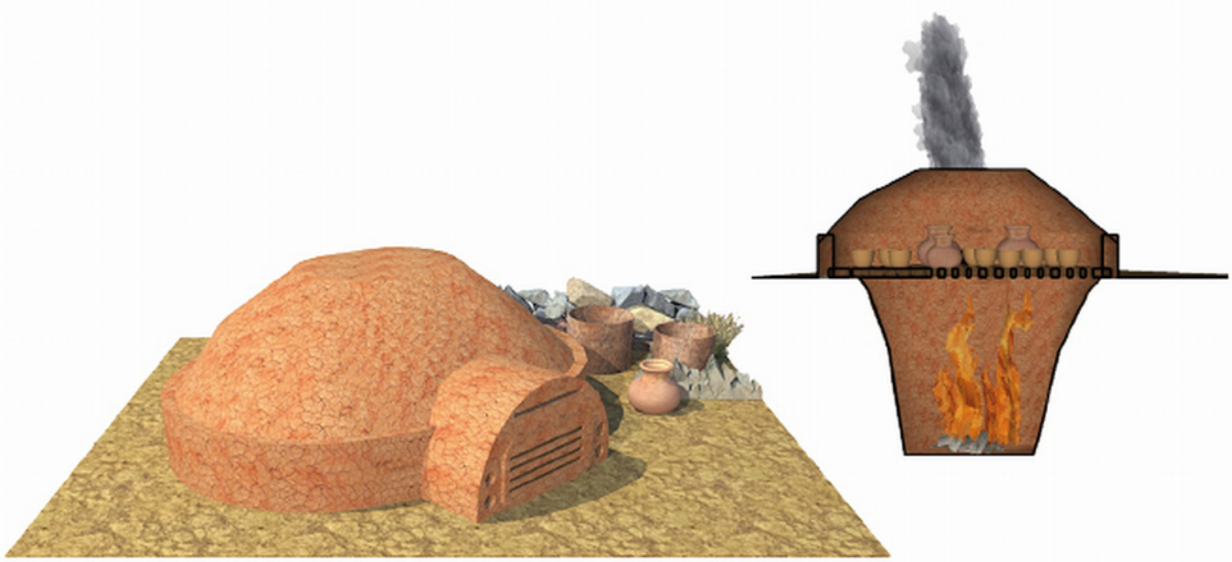

Figure 8: 3D reconstruction of the Type 4.2: Single Deep Pit with perforated floor

Variant 4.2 - Documented Sites:

Monte Cimino, Soriano nel Cimino (VT) [Final Bronze Age – 10th century BC] (unpublished); Bologna (BO) - S. Vitale [Early Iron Age – 8th century BC] (Taglioni 1997); Padova (PD) [Archaic Period – 6th century BC] (De Min *et al.* 2005); Lavinium, Anzio (RM) (Kilns B,C) [Archaic Period – 6-5th century BC] (Fenelli 1984); Monteriggioni-Campassini (SI) [Archaic Period – 6th century BC] (Acconcia and Aiello 1999); Montericcio Imola (BO) [Variant: This structure, for its peculiarity of being built partially with mud bricks, represents a variant of the type with a pit featuring a vertical structure and a perforated floor.] [Archaic Period – 6-5th century BC] (von Eles 1985).

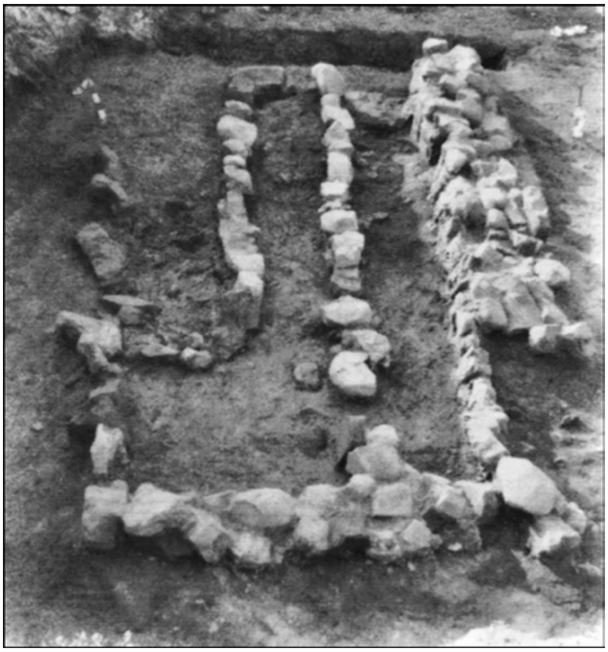

Figure 9: Archaeological example of Stonework Kiln from Le Chiarine, Puntone Nuovo (after Aranguren 2008)

Type 5 - Stonework Kiln

This kiln is the only permanent type, while all other types are usually demolished after a few runs. It is totally or partially built in stone. Much like in the 'Two-pits Kiln', the firing process takes place into a firebox while the pots are placed in a second chamber, above or alongside the fire. In Italy, this type has been found only in the site of Le Chiarine, Puntone Nuovo, Scarlino (GR) (Kiln B – Figure 9) [Final Bronze Age – 12-10th century BC] (Aranguren 2008; 2009). However, a comparison can be made with a similar structure found in the nearby site of Golfo di Baratti (Populonia), although interpreted by the excavators as a kiln for salt production (Baratti 2010). Lastly, this structure found a parallel with the evidence coming from the Aegean site of Kommos (Crete) [Late Mycenaean Iron Age] (Shaw *et al.* 2001) that is also the base-model used in the 2006 Broglio Experiment (Vanzetti *et al.* 2014).

Production area

Also for the production areas, it is possible to identify some common attributes shared by all the sites analysed. In this case, a strict classification like the one proposed for the kilns appears not functional, whereas a discussion of these attributes based on the comparison with ethnographical and experimental material is useful to better understand both the archaeological evidence and the cultural choices made by potters.

Starting from the analysis of archaeological evidence for the period under investigation, clear production areas are attested at Veii Piano di Comunitá (8th century BC - Bartoloni *et al.* 2013), Savignano- Via Montigallo (7-6th century BC – Miari 2003) and Padova - Piazza Castello (6th century BC - De Min *et al.* 2005).

The first of these sites, Veii, is characterised by the presence of three kilns, several pits for the settling of clays and a big cistern for water supply (Figure 10).

At Savignano (Figure 11), 12 kilns have been identified, pits for processing or settling the clay are also attested alongside several worktops for the forming of vases. Moreover, some of these workspaces featured a roofing system, as the potholes found on the ground near the kilns may indicate.

Lastly, the production area of Padova presents the same characteristics of Veii and Savignano, i.e., a series of basins for settling of the clay or silos and partly underground vases for the creation of 'pottery recipe'. In addition, also the location chosen for the production area provides some interesting information. Indeed, the

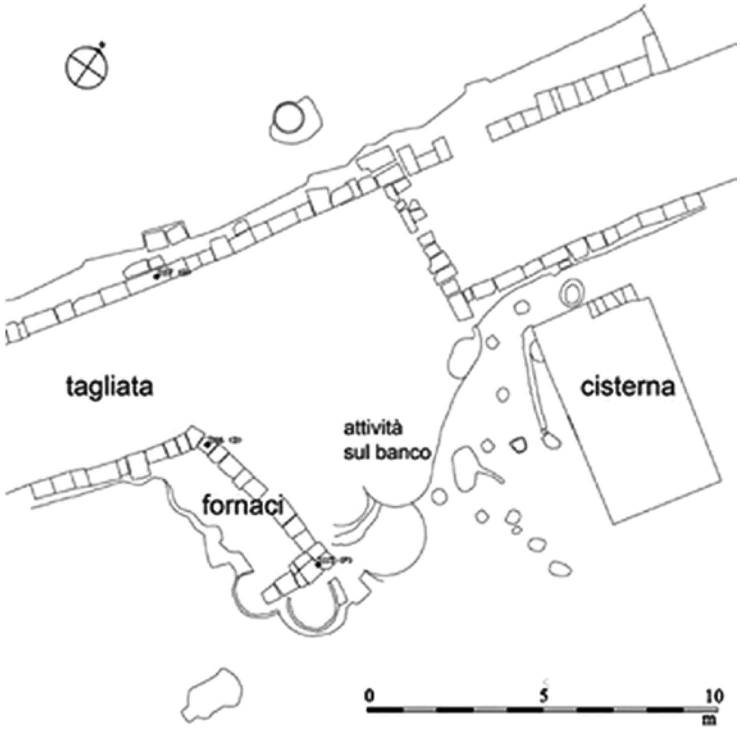

Figure 10: Veii (after Bartoloni et al. 2013)

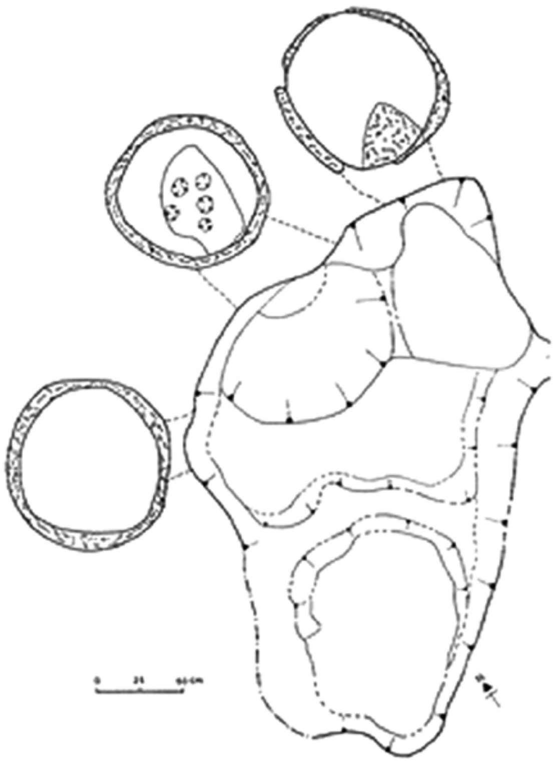

Figure 11: Savignano sul Rubicone (after Miari 2003)

area is located at the margin of the settlement close to the river, in all probability functioning as water supply for the workshop.

It appears clear that the shared attributes distinctive of the production area are the presence of more than one kiln as well as the presence of additional structures connected with the manufacturing process, like water reservoirs or pits for the settling of the clay.

These particular characteristics are documented in other archaeological contexts that can be interpreted as production areas, even if in these cases the scale is smaller than in the previous examples, or if they share only some of this attributes.

Vats and cisterns are attested in the context of Cures Sabini (8-6th centuries BC - (Guidi *et al.* 1985; 1988) and Monteriggioni (7th century BC - Ciacci 2004). In the latter site roof structures are also attested as well as at the site of Matelica - Via Pergolesi (8th century BC - Silvestrini and Sabbatini 2008). The installation of such structures in marginal areas of the settlement can be proved also at Monte Cimino (10th century BC – (Barbaro *et al.* 2013) or Roma - Foro di Cesare (Early Iron Age - De Santis *et al.* 2010) and for the areas of Bologna - S. Vitale (8th century BC - Taglioni 1997) and Torre Galli (Early Iron Age - Orsi 1926). The latter areas were so peripheral that have been subsequently turned to burial grounds.

Comparing archaeological, ethnographic and experimental evidence

The main attributes of pottery production areas retrieved in the archaeological record have been then compared with one relevant ethnographic example and with an experimental evidence. Inside the

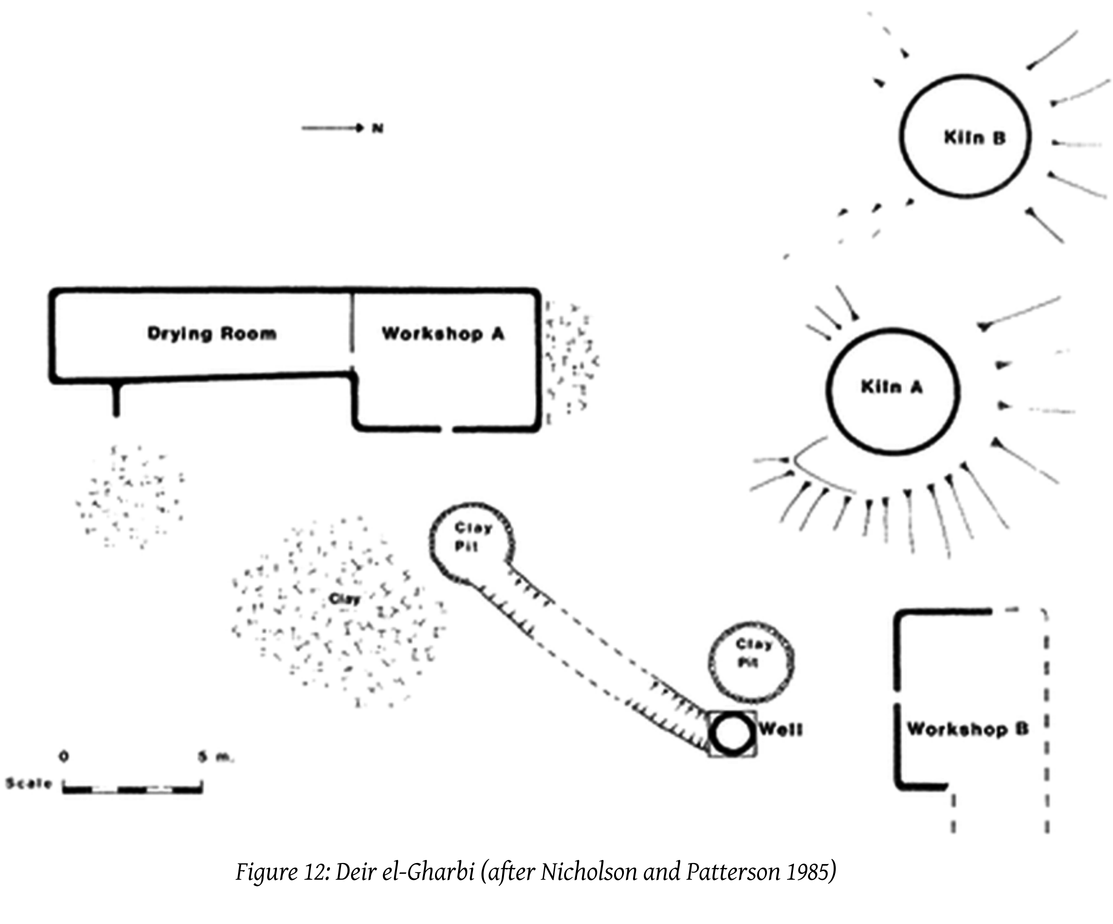

Figure 12: Deir el-Gharbi (after Nicholson and Patterson 1985)

Figure 13: Parco Archeologico di Broglio di Trebisacce (Photo by the author)

numerous research on this topics I chose as case study the work of Nicholson and Patterson (1985) at Deir el-Gharbi (Egypt) because is one of the most complete researches on pottery workshops. For the experimental evidence, indeed, I gave priority at my (personal) experience matured at the *Parco Archeologico di Broglio*, so I chose to compare the archaeological evidence, among the others, with this research. Both the proposed examples do show the same attributes of the archaeological contexts.

At Deir el-Gharbi, in Upper Egypt, local pottery workshops cluster in groups of three to five around their respective clay puddling, trenches and wells, with the kilns lying off to one side. As the archaeological evidence shows, some of the attributes designated as typical for the production areas are clearly identifiable: a water supply (well), pits and worktops (trenches and clay puddling) and more than one kiln (Figure 12).

During the restoration of pottery kilns at the Parco Archeologico di Broglio, the yard organised by G. Pulitani features some of the typical production areas attributes mentioned above (Figure 13): not only that one of the first operations was the setting up of roofing structures to protect the kilns from bad weather, but we also created pits and specific areas for the storage and processing of clay. Many empty water casks, moreover, were placed near the roof to collect the rainwater.

Actually, even if this production area is a modern one, the choices at the base of the spatial organization are most likely the same that were made in antiquity.

Everything needs to be at hand, from raw materials to water or kilns, to substantially reduce the time invested between one production step to the other.

Concluding remarks and further research

This paper is a contribution to a better definition of both the structures for firing pottery and the production areas.

In regard of pottery kilns, the value of their typological classification lies in explaining:

1. technological developments concerning the shift from simple kilns during earlier periods (Type 1 and 2) to more complex structures (Type 3 and 4) in later times, and
2. the relationship between kiln's types and production strategies. Indeed, as argued above, the simplest and oldest types were never wholly abandoned, and they are documented alongside the more recent types, probably depending both on the production and on demand of different wares.

The typology to which I referred as a starting point, is the one proposed by Cristiano Iaia in 2009 (Iaia and Moroni Lanfredini 2009). My new typology partly agrees with but mostly expands Iaia's scheme. Especially, new and more detailed examples are now provided, and Iaia's hypotheses have been elaborated.

I am well aware of the fact that my classification proposal requires further confirmation, either by expanding the sample, or by providing analytic and experimental tests.

The production areas have been analysed assessing contexts, archaeological evidence, ethno-archaeological research and experimental reconstructions. They clearly show a series of common traits irrespective of their chronology and location. These traits are:

- the presence of more than one kiln in the areas;
- the choice of placing these areas mainly in marginal areas of the inhabited space;
- the proximity to water sources, or in the absence of these, the creation of tanks or reservoirs to collect water;
- the presence of trenches for clay settling and workspaces;
- the creation of roof structures to protect the furnaces ensuring a longer use.

In this light, the area investigated must have looked like the reconstruction proposed below (Figure 14).

On the basis of these observations, this model sheds light on the organization of craft contexts from the Bronze Age to the Archaic period. Certainly, more archaeological samples are necessary to confirm the model.

One of the goals of this research is to promote an integrated methodological framework for the study of ancient pottery workshops in order to move beyond the 'sceptical-problematic' approach that in some ways prevented to deepen our knowledge on the matter. In conclusion, I wish to have demonstrated the potentiality of pursuing a new path of research aimed at a better understanding of the fragmented knowledge of production systems. Moreover, by challenging traditional evolutionary explanatory models, I hope to have provided a valid platform for discussion and a stimulus to implement this research topic.

Figure 14: Hypothetical reconstruction of a production area (drawing by the author)

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Shifting Focus: Expanding the Potential of Experimental Metallurgical Reconstructions

Jessica L. Slater

Abstract

The study of craft has served to focus attention on how habitual actions serve to create and recreate space. Whilst experimental (re)constructions of pyrotechnical methods have become commonplace, seldom do these endeavours move beyond answering questions of technical performance. By shifting our focus from technical processes towards the practitioners themselves we can begin to evaluate the role pyrotechnical architecture plays in structuring space and performance.

Keywords: craft, experimental archaeology, metallurgy, space, time-geography

Introduction

Material culture has long been one of the main tenets of archaeology, forming the foundation of chronologies and cultures, establishing networks of trade and cultural interaction, and more recently used to indicate social differentiation (Childe 1944; Miller 1987; Thomsen *et al.* 1836). But can material culture even be treated in such a monothetic manner? The practices that produce material culture are socially situated and cannot be meaningfully reduced to technical processes (Pfaffenberger 1992, 1999). Whilst some insist there is a reducible technical aspect to practices (Heeb and Ottaway 2014), to do so is to ignore the ever-present performative aspects that bring such technical processes into life (Budd and Taylor 1995; Dobres and Hoffman 1999; Gell 1992). Craft may be understood as a form of technology, but moreover it represents a class of routine practices that involves materials, knowledge, and tradition.

Craft can be considered the physical manifestation, the realisation, of agency through performance or practice. If we can confidently acknowledge that craft is agency put into practice, then is it not self-evident that ‘technology concerns the active involvement of social actors in the day-to-day creation of their material world’ (Dobres 1995: 27). As archaeology seeks to better understand how human communities manage to sustain life under a diversity of conditions, the role of material culture production and use becomes a central concern, not for how it constitutes traditional archaeological categories, but more in terms of how it becomes part of life.

The study of craft has often found itself wedged in place between science and theory as described by Boivin, ‘scientific practice generates data that answers one set of questions, while theoretical practice focuses perhaps on an entirely different set of issues’ (Boivin 2005: 177). Scientifically-based artefact studies have long held a prominent place in archaeological discussions, providing a useful form of evidence contributing to our investigations of past craft production. At first science seemingly offered a concrete understanding of these objects that did not rely on subjective ideas of similarities and differences; unlike previous typologically-based work. The fallacy of this argument is not necessarily the urge to view metallurgy as either art (typologies) or science (chemical compositions), but the notion that science is inherently objective and therefore better at explaining the past (Barrett 1990: 31; Edmonds 1990; Latour and Woolgar 1986). Investigators’ eagerness to strictly investigate the chemical and physical properties of materials at the expense of the social role of these materials largely leaves these objects decontextualised. By widening our definition and understanding of what craft actually is, we might begin to extend the scope of our study far beyond artefacts. We must expand our focus to include not just recognisable by-products and residues, but the range of materials that occur at varied scales, including atomic chemical traces and even sub-atomic magnetic signatures that are spatially located and in some way related to routines of production. In this way we begin to acknowledge the importance of the arena of production in concert with the artefacts produced therein.

Situated practice

Space is frequently studied through the media of structures and monuments, often ignoring the areas in between - the places defined by actions not architecture (Merleau-Ponty 2002). These enduring features are potent, but there is a need to incorporate more routine, and often mundane actions, which occurred outside their confines, into our analytical frameworks. The study of craft, and in particular metallurgy, can focus attention on how habitual actions create and recreate space (Lefebvre 1991).

As we focus on the human body, it becomes apparent that individuals have a recursive and reflexive relationship with the structures they inhabit (Ingold 2000; Tuan 1977). It is at the scale of the human body that we can begin to understand practice in space both at the macro- and micro-scale. The relationship between the human body and the built environment has been realised for some time in archaeology, though it is usually only understood for structures that people inhabit internally. We need to move away from the theoretically naïve techniques such as spatial syntax (Hillier and Hanson 1984) and define new methods for recording and interrogating structural/featural/architectural data. The predominant interest in controlled access to space (Foster 1989b, 1989a) sees architecture as a disembodied force for preventing action as opposed to the very means of enabling practice within a particular locale.

Architecture as a category needs to be expanded to embrace technological architecture. Features such as furnaces and kilns are unusual structures that are not inhabited internally but do serve to structure action. Through their use the transformative environments in and around them are negotiated by craft practitioners. The alignment or placement of a furnace or kiln within a space will greatly impact how individuals engage with and are bound to these features during the process of production. In accommodating pyrotechnical structures as architecture, we open them up for what, in craft studies, would be novel forms of analysis.

Experimental (re)constructions of pyrotechnical equipment have become more common and can aid in elucidating preferred operating conditions and constraints upon technical performance (Crew and Crew 1997; Merkel 1982), however seldom have these experiments been used to interrogate practitioners' real engagement with these productive features. Experimental archaeology is an increasingly popular method of investigating ancient technologies, often undertaken in cooperation with living practitioners, of 'traditional' crafts (Gosselain and Smith 1995; Skibo 1992). However, there are many differing opinions as to the role experimental archaeology can play in our research programmes, especially when debating the role of the individual in the experiment.

Reynolds, one of the earliest and strongest proponents of experimental archaeology (1979), was keen to dismiss the role of the individual in an experiment, 'no experiment can be designed to enhance our understanding of human motive or emotion in the recent or remote past' (1999). This idea has reinforced the belief that experimental archaeology is only scientific, and thus only relevant, when such projects are devoid of human subjects. While there is certain value in purely laboratory-based experimentation (Outram 2008), in large part we have been experimenting with *process* and have spent comparatively little time looking at *practice*. Too often we force ourselves into pseudo-objective roles that deny any sort of agency to be discerned through the reconstruction of past activities.

However, at the very heart of craft production is the *skilled knowledgeable agent* (Ingold 2000), versed in techniques of the body that define craft practice. To remove such central figures in experimental studies is to remove the very object of study that archaeologists should seek to reveal. The experimental crafter is inextricably caught in the experimental performance and should be accepted as an integral component. It is only through accommodating the role of the experimenter in craft experiments that we can hope to use these endeavours to provide insight into practice. Rather than debate the degree of objectivity, we should seek to understand what we can from such *experiences*, both when we act as the central figure and when we observe.

Experimental methodology

To investigate the interactions between metallurgical practice and detectable residues, an experimental campaign of metalworking was conducted. Numerous other experimental endeavours have considered metallurgical production before, though the majority have done so from the perspective of technical and material requirements. In contrast, the experiments carried out as part of this study were focused on the direct observation of practitioners' engagement with experimental features and the experimental space itself, in order to examine the relationship between practice and the formation of archaeological contexts. This type of experimentation might seem uncritical but whilst experimentalists might enthusiastically pursue process accuracy, they should be cautious of confusing their actions for adequate representations of any archaeological meaningful *chaîne opératoire* (Doonan 2013; Dungworth 2013). Experimentation *constructs* rather than *re*constructs practice but this by no means lessens the import of experimental endeavours. Experimental archaeology seeks to construct new frames of reference from which to approach the archaeological record. Experimentation therefore allows the experimenter

Figure 1: Examples of the variety of metallurgical practices undertaken. (A) Copper smelting furnace. (B) Shaft furnace for bloomery iron production. (C) Smithing of an iron bloom.

Figure 2: Various sites of experimental metallurgical activity. (A) The author using the pXRF in situ at a control site. (B) The copper smelting site being sampled in situ. (C) The copper smelting site showing the tape and stakes used to define the 0.25x0.25 m sampling resolution on the 3x3 m grid. (D) The iron smelting and smithing site where soil samples have been taken for ex situ pXRF measurement in the lab.

to recognise the embodiedness inherent in our Being-in-the-World, that is, to discover elements of a common ground between past practice and present engagement (Jackson 1989: 135).

Multiple metallurgical practices were explored at differing scales across three different sites, including iron smelting, iron smithing, and copper smelting (Figure 1) (full methods and materials are detailed in Slater 2015). The experimental activities were all performed within defined areas that were sampled on a grid system at varying resolutions (Figure 2). Before experiments began, the localities were all subjected to geochemical and geophysical survey with Niton XL3T handheld pXRF and a Bartington MS2 Magnetic Susceptibility Meter probe to establish initial soil conditions. These readings were repeated over the course of the experiments and in some instances followed up for some time after the termination of activities. Additionally, a time-geography analysis (Hägerstrand 1970; Pred 1977) was undertaken to study the movements of the experimental practitioners within one site. Data were collected during the course of the experiment utilising time-slice photography taken by a Canon PowerShot A560 camera mounted on a pole three metres above the site at the bottom centre of the area, programmed to take pictures every 30 seconds. These images were combined in Windows Movie Maker to create separate films for each day of experimentation in order to analyse the movements of the experimenters in time and space.

Figure 3: Examples of the time-slice photography taken at the copper smelting site for the time-geography analysis

The method of time-geography provided an external record of actions, allowing for a more complete understanding of our varied engagement with the experiment and the pyrotechnical features. Informants are not capable of giving complete information as to their activities, and in some ways we are our own worst informants (Freeman *et al.* 1987). In the course of experimental activities, it is not difficult to forget all actions undertaken as well as the locations where specific processes occurred. By utilising cameras taking time-slice photographs to record the process of experimentation, we are better equipped to later analyse the results of geochemical and geophysical surveys of experimental areas (Figure 3). Here we are interested in space and the residues of practice, and through experimental practice we are afforded the opportunity to examine the actions that produce specific signatures. A better understanding of these processes can inform our study and analysis of the spatial characteristics of routine metallurgical practice. Experimental undertakings allow us to consider the constraints placed upon individuals within an arena of practice. Ideally, analysis of individuals' bodily movement and engagement during an experiment can provide a complementary perspective to the more familiar work involving the analysis of geophysical and geochemical signatures of particular activities.

Results and discussion

Across all experiments it was not the presence of heavy metals in the soil that was most indicative of past practice, in spite of the variety of metallurgical activities undertaken. Strontium, Ca, and K, introduced into the environment as components of wood ash, were particularly adept at demonstrating the location of high-temperature processes and their by-products (Figure 4). The influence of these elements on the soil often spread beyond the confines of the furnace or hearth and demonstrated an ability of elemental analysis to highlight where coals or ash were deposited. An interesting feature of the enrichment of sites' Sr, Ca, and K through wood ash was the material's mobile nature (Figure 5). Though ash was often deposited in certain locations at the experimental sites, it was dispersed by the movements of the experimenters, highlighting the pathways taken when traversing the sites, illustrating areas of high traffic around a furnace with contrasting levels of high and low concentration, as well as an intriguing capacity to indicate handedness of an experimenter. Alone, these elements are of course only indicators of past burning, but along with evidence of heavy metals as well as any macroscopic debris or preserved metallurgical features, the enhanced presence of these elements can reveal composite signatures representative of practice.

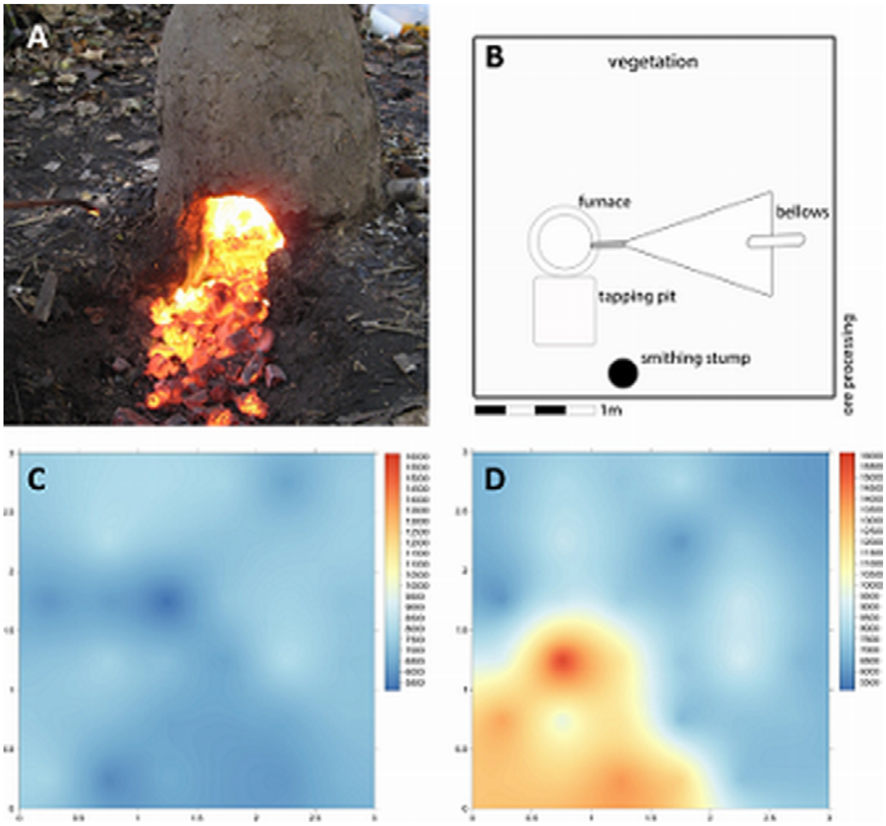

Figure 4: The iron smelting and smithing site exhibiting an enhancement in K over time. (A) The shaft furnace in operation. (B) Plan of the iron smelting and smithing site. (C) Baseline levels of K on 26 Oct. (D) Levels of K on 9 Nov.

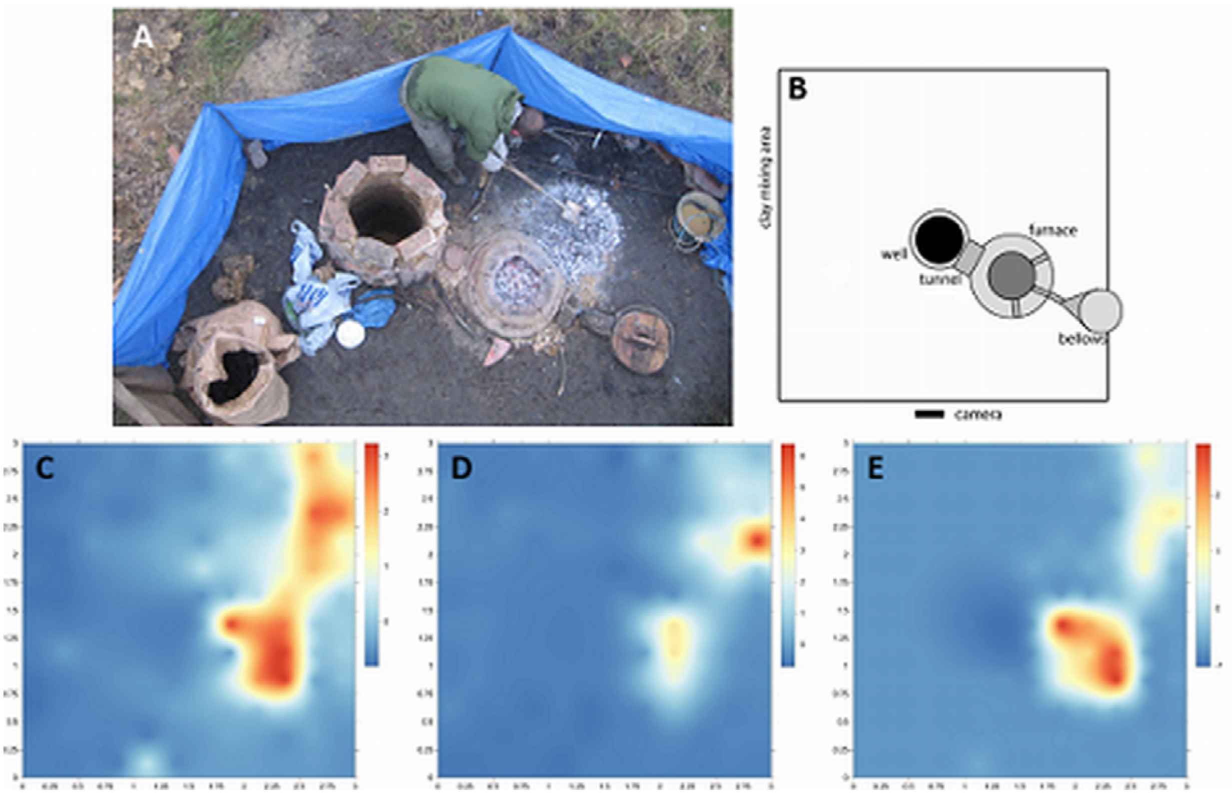

Figure 5: The copper smelting site exhibiting enhancement in Ca, K, and Sr over time. (A) Overhead image of the copper smelting site. (B) Plan of the copper smelting site. (C) Calcium enhancement following multiple smelting campaigns. (D) Potassium enhancement following multiple smelting campaigns. (E) Strontium enhancement following multiple smelting campaigns.

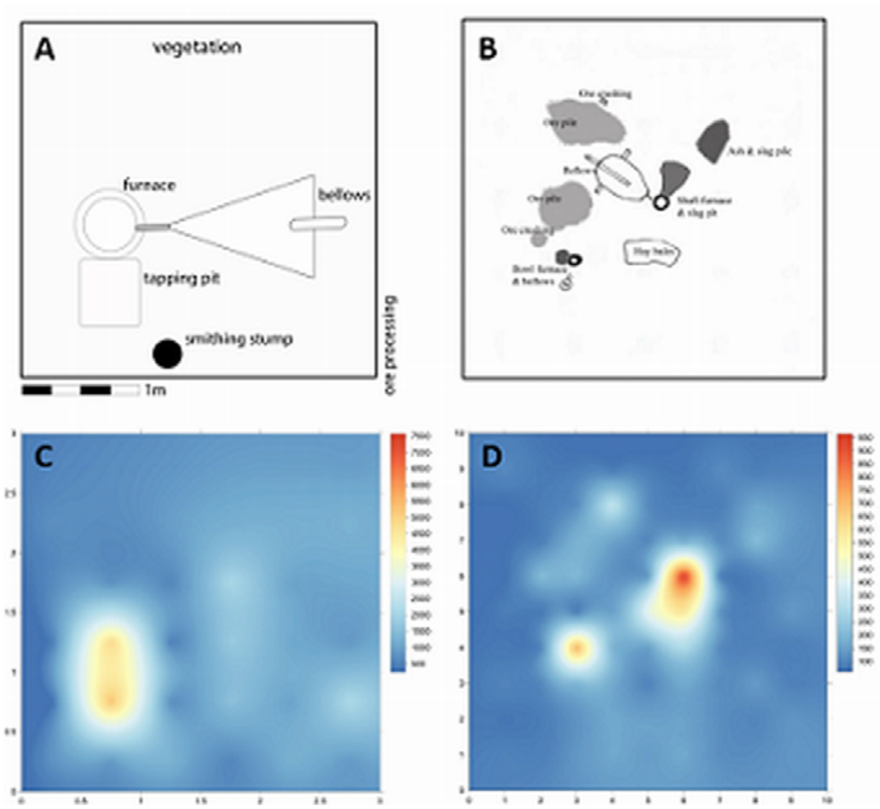

Figure 6: (A) Plan of iron smelting and smithing site. (B) Plan of iron smelting and copper smelting site. (C) The iron smelting and smithing site exhibited a distinct magnetic susceptibility signature in the location of the furnace and tapping pit. (D) The iron smelting and copper smelting site shows two discrete areas of increased magnetic susceptibility in the locations of the two furnaces.

Magnetic susceptibility proved a reliable indicator of furnace and hearth locations as well as ore and slag spreads; convincingly detecting the locations of furnaces, hearths, and fires in all but one experiment (Figure 6). The patterns of enhancement demonstrated by magnetic susceptibility often confirmed the structured, rather than random nature of anomalies. As has become evident, no one element or even one technique is capable of fully resolving metallurgical activities. Together with other forms of evidence, pXRF and magnetic susceptibility readings provide middle-ground, linking metallurgical features to the products of those features.

In the context of one experiment, involving a large low squat copper smelting furnace with an attached well, the technique of time-geography was utilised alongside pXRF and magnetic susceptibility survey to examine how two experimental practitioners used space for the duration of the experiment. The small size of the experimental arena put additional constraints upon the participants, leading them to rapidly learn to negotiate both the limited space and the immediate dangers of a well and a furnace operating in excess of 1000°C.

Time-geography was adept at revealing the fixity of the productive architecture of metallurgical practice which necessitates a situatedness and inhabitation of place, often manifested in a 'tethering' of the body to the furnace over extended periods of time. The operation of bellows is another demanding process that requires immediate proximity to the furnace or hearth (Figure 7). The need to carefully control the timing and rhythm of metallurgical activities directly impacts the manner in which *loci* of production are organised. Along with these constraints there are also physical limitations placed upon the human body (for instance heat exposure and physical exertion) that cannot be discounted and must be acknowledged within experiments (Crew 2013; Rehder 1994).

It was also notable that despite the similar operating temperatures of the low squat furnace used in this experiment and other shaft furnaces used for smelting iron, it was quite difficult to approach this

Figure 7: Images of bellows being used for forced draught with iron (left) and copper (right) smelting furnaces.

Figure 8: (A) The copper smelting furnace with shapes drawn to indicate the direction in which its heat radiates. (B) The iron smelting furnace with shapes drawn to indicate the direction in which its heat radiates.

furnace during a smelt as the apparent heat intensity was much higher, likely a product of the greater radiant area and the low sitting form of the furnace (Figure 8). These observations suggest that specific bodily practices are appropriate to specific furnace forms.

Through analysis of the time-slice photography, it was evident that movement within the experimental site was defined not by the specific practitioners but by their practices. There were two primary roles for these individuals delimited in space, or more accurately, the roles described two *places* within the arena of performance. These roles, which were immediately apparent when viewing footage of the furnace being operated solely with a set of bellows (Figure 9), were filled by both individuals at varying points over the course of the day. However, the introduction of new practices led to a shift in the *loci* of places

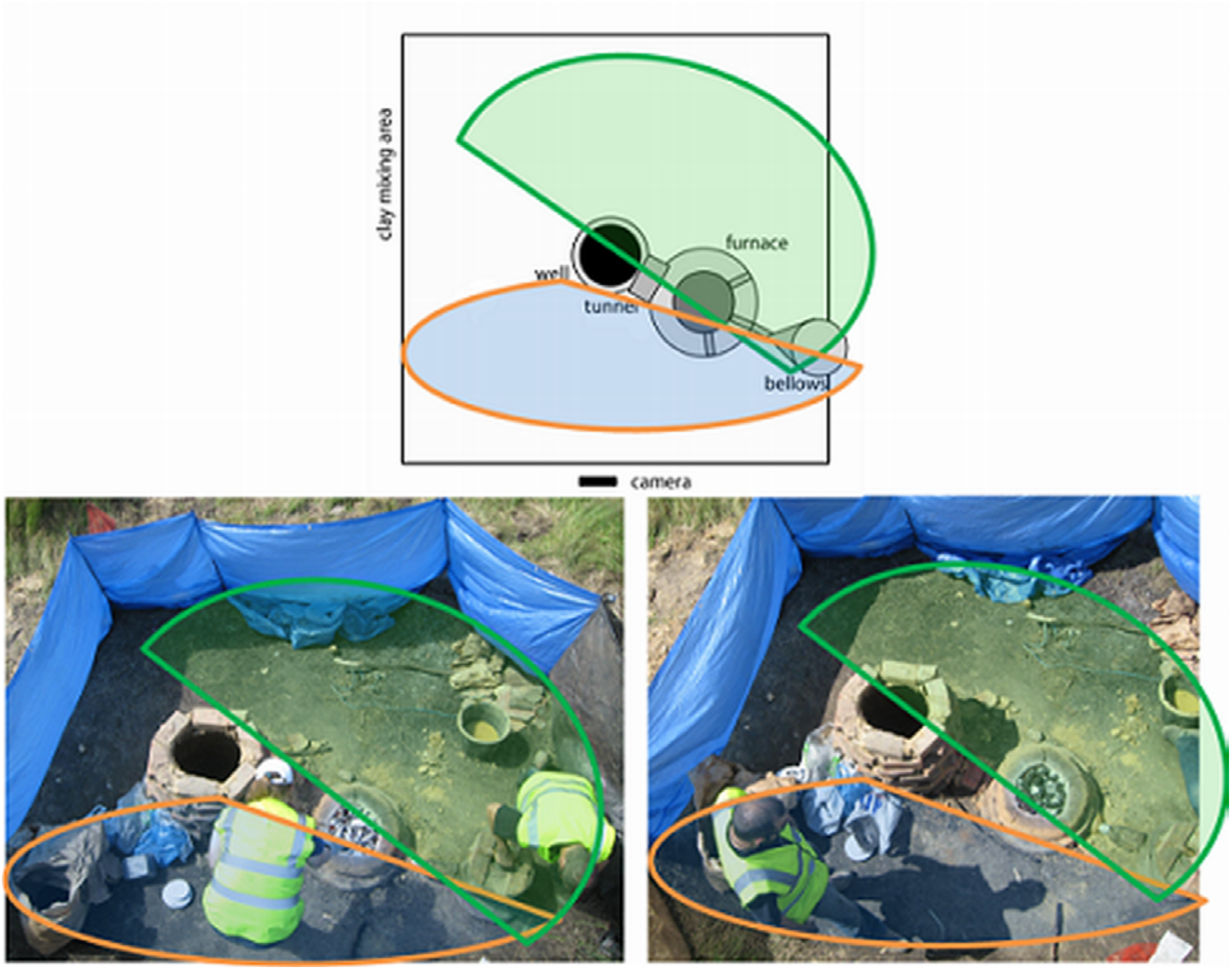

Figure 9: Plan of copper smelting furnace above two images of the furnace in operation showing two places outlined in green and orange corresponding to two roles that were filled interchangeably by both practitioners when the bellows were utilised as the sole source of forced draught.

within the experimental arena (Figure 10). The way in which practices were divided suggests that rather than being able to study specific individuals we can only observe the results of their actions, which in the case of this experiment were not specific to the particular individuals. It is of course entirely possible and plausible that the roles that the two experimenters shifted in and out would have been more fixed for ancient practitioners more specialised in their crafts.

The fact that two separate zones of space were chosen, when operating the furnace with limited overlap, may be considered significant. These roles were never discussed and simply emerged through practice as an understanding of the space and performance of the furnace developed. This experiment revealed in quite a compelling manner, how such performance was dictated by the size, shape, and placement of a fire and not simply the metallurgical process being reconstructed. We view fire as a necessary ingredient of metallurgical production, but in many ways fire is an active participant rather than simply a technical requirement. We cannot consider the term 'fire' an adequate place-holder for the diversity of pyrotechnical architecture encountered in the past and experimental reconstructions.

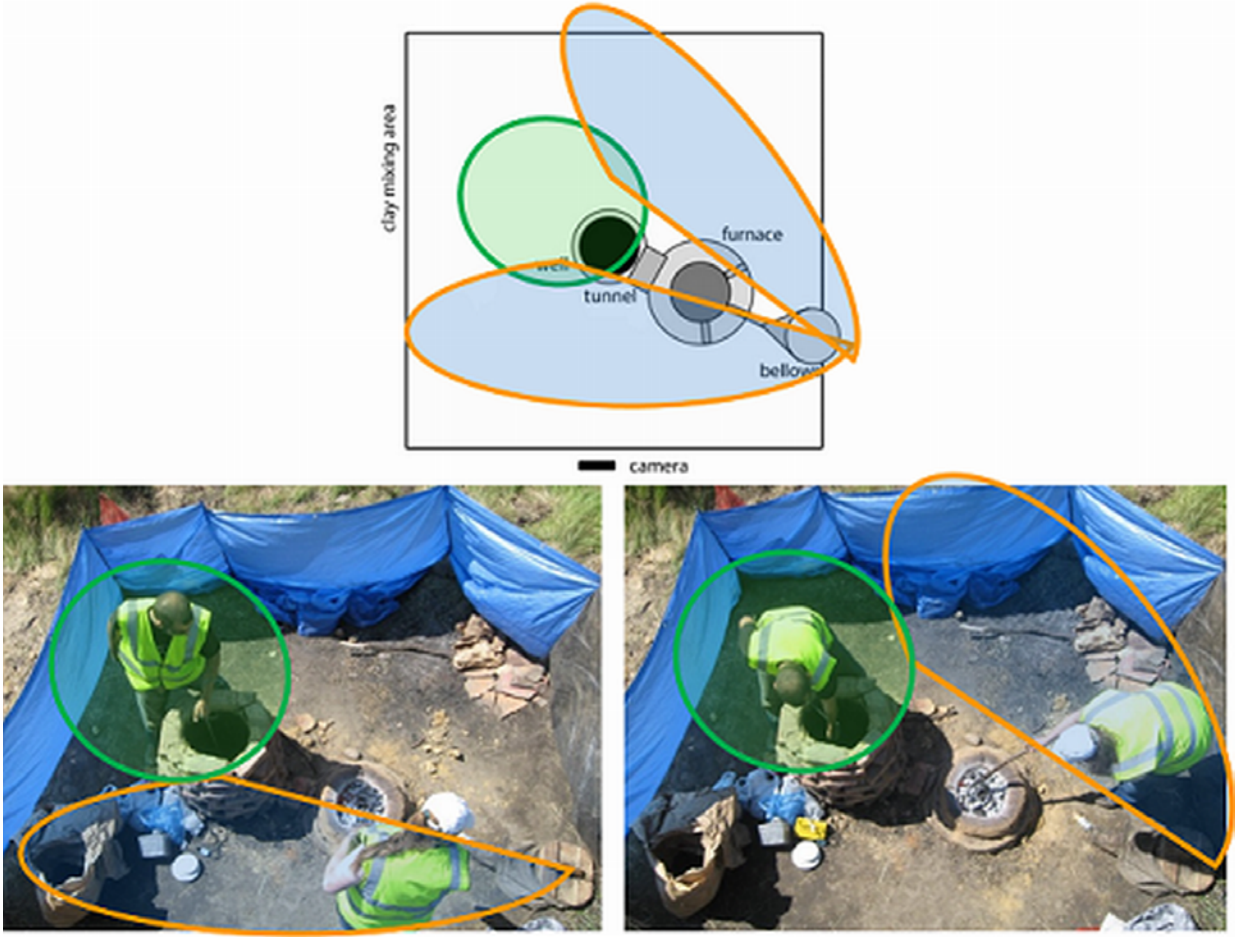

Figure 10: Plan of copper smelting furnace above two images of the furnace in operation showing two different places outlined in green and orange corresponding to two roles that were filled interchangeably by both practitioners when the bellows were not in operation and the well was being utilised to force draught.

Conclusions

To date, the study of space in archaeology has largely focused on mapping archaeological evidence at a number of scales, rather than thinking space through, or experiencing it, in terms of how it was inhabited. Such analyses, along with many archaeological studies, have tended to consider only space bounded by architecture, often monumental, and have paid scant attention to routinised behaviours that unfold in *localised* spaces not bound by permanent constructions. Unlike the effects of imposing architecture on practice, craft practice often delineates its own *loci* of action through routine behaviours, habitual practices and in turn, the structured deposition of material residues - creating a *signature of practice*.

To study the impact of routinised behaviours in space, we must be able to appreciate (both theoretically and archaeologically) the places that these actions made recognisable - those arenas of practice that constitute place. Place is much more than permanently bounded space. Place, rather than representing a container for action to fill, is the arena that comes into existence as practices are enacted. While it is those practices that serve to produce and reproduce places as routinised behaviours are carried out, the structured deposition of residues in these locales serves as a tangible material condition that substantiates the *sense* of place. Craft then may not involve monumental architecture, but nonetheless effectively creates place through the routine deposition of residues. For metallurgy, this sense of place is borne out through the hearth and its relation to slagheaps, ash scatters, and raw material 'dumps'. In comparison to monuments, these residues are ephemeral, yet these products of daily routines not only testify to those arenas of practice as constituting place, but they also act as historical indicators to the specific syntax of production routines. Unlike technical choices, the material residues of practice, that collectively give rise to *signatures of practice,* do not reveal individual choice in the same manner. Instead, *signatures of practice* are the amalgamation of individuals' routinised actions; they are a cumulative phenomenon, as was evinced through the application of time-geography to experimental reconstructions.

An increased understanding of the importance of practitioners' bodily performance in metallurgical production is one of the measurable outcomes of this sort of experimentation. The time/geography approach used to complement geochemical and geophysical data seemingly is only applicable to sociological or anthropological studies, yet can indeed give us insight into the remote past. The analysis of how two experimenters engaged with a metallurgical activity in time and space, illustrates how practice is less about individuals but rather actions and ways of going on. Experimentation can reveal that certain repeated actions, for example the emptying of a hearth or the repeated path taken by an individual across a site, do impact their environment and can be detected by archaeological means. Further, by demonstrating that the paths of individuals are often difficult to disentangle, the activities performed by them that impacted the soil become less a record of *past people* and rather of *past practice*. It becomes clear through our experimental endeavours that though actions are constrained by and considered through the medium of the body, the residues of those actions do not represent a singular individual act. The excavated residues of past actions are the product of individuals' agency, but we must be careful not to conflate residues of agency with evidence of the specific agents themselves. What are captured in the soil are *signatures of practice*, the collective traces of quotidian actions performed in a routine and spatially circumscribed manner.

Space is an essential aspect of craft, yet often unrecognised, and hence underdeveloped, within craft studies. The idea of space as a *technological choice* might appear odd, but the routines of practice are as much spatially, as they are materially, derived. Experimental reconstructions are uniquely effective in helping us to realise the dynamic role played by metallurgical features and the ways in which they actively structure practice. While we can detect spatial patterns, and represent them in a variety of ways, craft remains inscrutable, unless it is somehow brought to life through practice. Experimental archaeology therefore becomes a valuable means by which to explore how dynamically active features (i.e., metallurgical architecture), facilitate and constrain a variety of actions.

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Ergonomics as a Tool for Fire Structures Reconstruction. Case Study of a Kiln Located in the Garncarskie Rock Shelter in Polish Jura Chain

Michał Wojenka and Małgorzata Kot

Abstract

The paper discusses the problems raised by the location of the kiln in a rock shelter. Pottery kilns were usually placed in separate buildings with opening roofs. In this case the potter decided to use a rock shelter, which has its pros and cons. The rock shelter and a vicinity of the rocks have their influence on the moisture conditions. On the other hand, the rock gives a natural shelter. What was probably the most important reason, is a perfect wind protection of a rock wall. The kiln was located exactly under an almost vertical rock fissure with eastern inclination, which creates a perfect natural flue, still providing a rain protection due to its slight inclination.

This example offers an extraordinary opportunity to study the place of the kiln from a point of view of human-space interaction, and to see the rocks not as inanimate nature and landscape mark, but as usable and creativity requiring space.

Keywords: pottery kiln, ergonomics, rock shelter, ethnography, potter workshop.

Caves fascinated people for thousands of years. Throughout millennia their dark and moist underground spaces have responded to different human demands, offering a room for various activities. In practical content the caves were recognised as places of meeting for diversified practical and religious needs. In prehistoric times they could serve as places of short-term occupation, shelter, protection or hideaway, but on the other hand, in spiritual meaning, the impenetrable darkness of caves could have offered a scene for the theatre of ritual (see Dowd 2015: 1-5). Over time their functions changed. As regards Polish examples, before the Middle Ages caves apparently lost their spiritual meaning. Occasionally, they could have been still places of shelter or hideaway, but their function had shifted towards more practical or even economic use. If only they were located inside the inhabited area and not far away from the dwellings, the caves and smaller cavities – called rock shelters – were frequently incorporated into the infrastructure of individual plots of ground and served as a background for casual or occasional activities. According to written sources and the results of ethnographical surveys, in the Post-medieval period (16th-19th century) caves were used as cold storage, barns, byres or stables (Wojenka 2018).

Needless to say, the archaeological picture of historical-age cave activity is blur. The common lack of readable stratigraphical context usually makes a single settlement horizon hard or even impossible to determine. As regards the functional meaning of a single cave, the analyses from a point of view of space interaction and ergonomics usually doom to fail as they need to be based on a palimpsest of repeating single occupation events. Only in case of a single occupation episode, one can analyse in detail the way people interacted with such spaces as rock shelters and caves. We believe that the topic of this case study - Garncarskie rock shelter in Ojców, a 19th century kiln-site, gives such an opportunity.

The site is located in the southern part of the Kraków-Częstochowa Upland (southern Poland), a karstic region widely recognised for its rich speleo-archaeological potential. It lies in a small village Ojców (*c* 25 km north from Kraków) in the Ojców National Park, on the right bank of Sąspówka creek (Figure 1). The rock shelter is situated within the group of perpendicular limestone rocks called 'Garncarskie' and it takes the form of a large niche 8 m high and 6 m wide. It is dry and light. The opening, around 5 m above the bottom of the valley, is facing north-east (Gradziński *et al*. 1996: 51). The surface of the site is flat and covers approximately 10 sqm. It is noteworthy that from the west, south and north-west the rock shelter is surrounded by rocks protecting the potential site users from wind and rain (Figure 2).

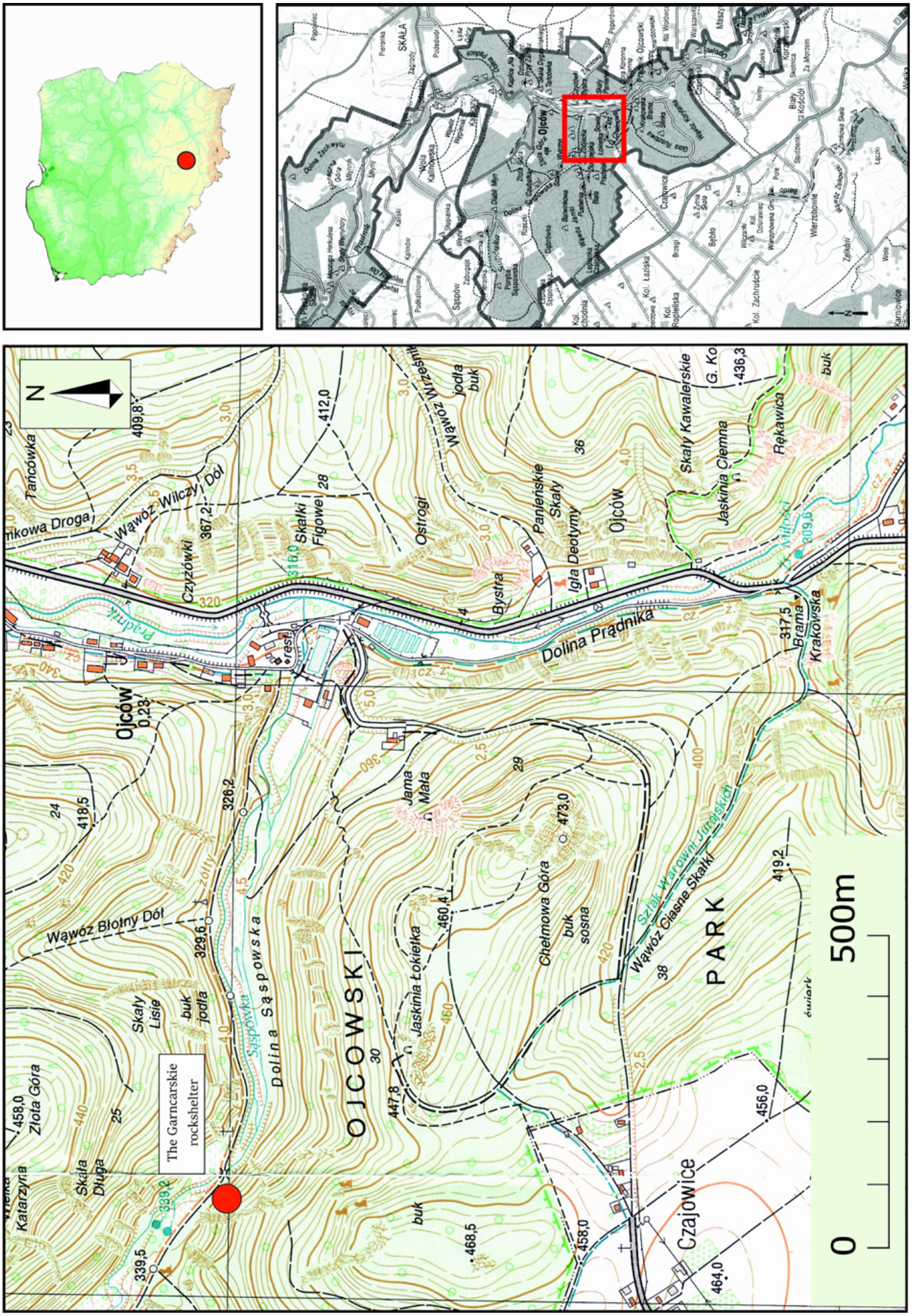

Figure 1: Localisation of the site. Drawn by M. Wojenka

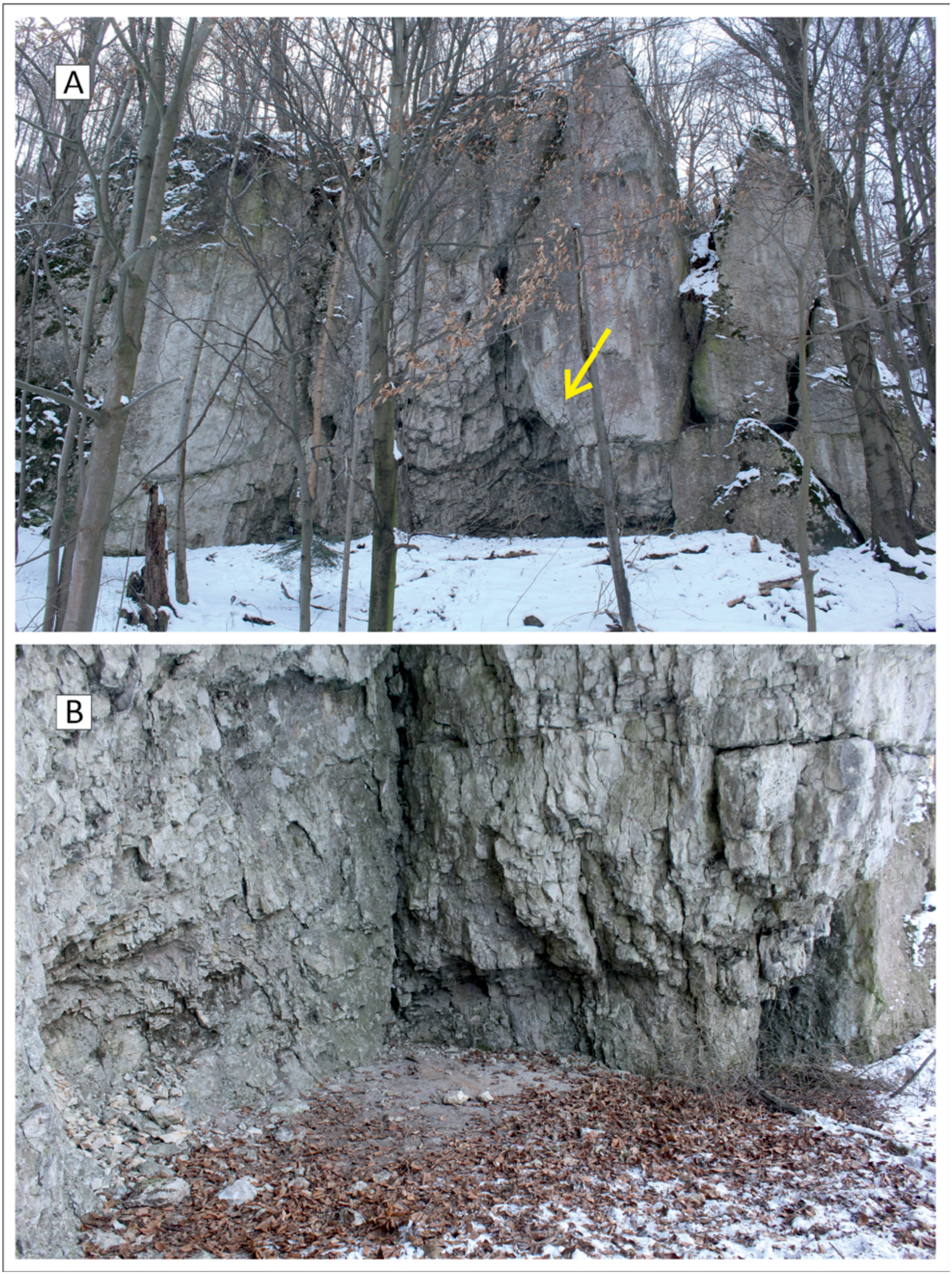

Figure 2: The Garncarskie rock shelter in Ojców. A – view from the north; B – view from the east. Photo by M. Wojenka

The name of the rock shelter – Garncarskie – is a derivation of the word 'potter' (Polish: 'garncarz') and directly echoes the past functional meaning of the site as a place of ceramic firing. The first account on the cavern is relatively late. It is contained in the very first catalogue of the caves in the environment of Ojców and Kraków published in 1911 by Stanisław Jan Czarnowski, an amateur archaeologist concerned with exploration of the cave sites in the nearby area. In describing the caverns of the Sąspówka valley, he noted as follows: *the potter's rock shelter in a rock of the same name, by wild fruit trees once forming a part of the household of a potter, who dwelled there* (Czarnowski 1911a: 66; see also Czarnowski 1911b: 324; Czarnowski 1912: 246). Later on, the site was mentioned only by Kazimierz Kowalski in his catalogue of caves of Poland (Kowalski 1951: 320-321) and up to the early 1960s it was beyond the focus of scientific research.

In 1962 the rock shelter was excavated by Waldemar Chmielewski and Teresa Madeyska (Chmielewski 1988: 11, 13; Madeyska 1988: 162). The exploration was only part of a wider research program focused on defining the chronological position of human activity in the most promising cave sites of the Sąspówka river valley. The excavations dealt with one trench (ca. 4 × 2-2.5 m), localize d in the central part of the rock shelter (Figure 3). Contrary to expectations, the site did not reveal any sequence of Holocene deposits. The limestone bedrock was reached soon, and – as Madeyska reports – it was covered with dozens of 'modern-era' ceramic fragments mixed with the remains of a pottery kiln (Madeyska 1988: 162).

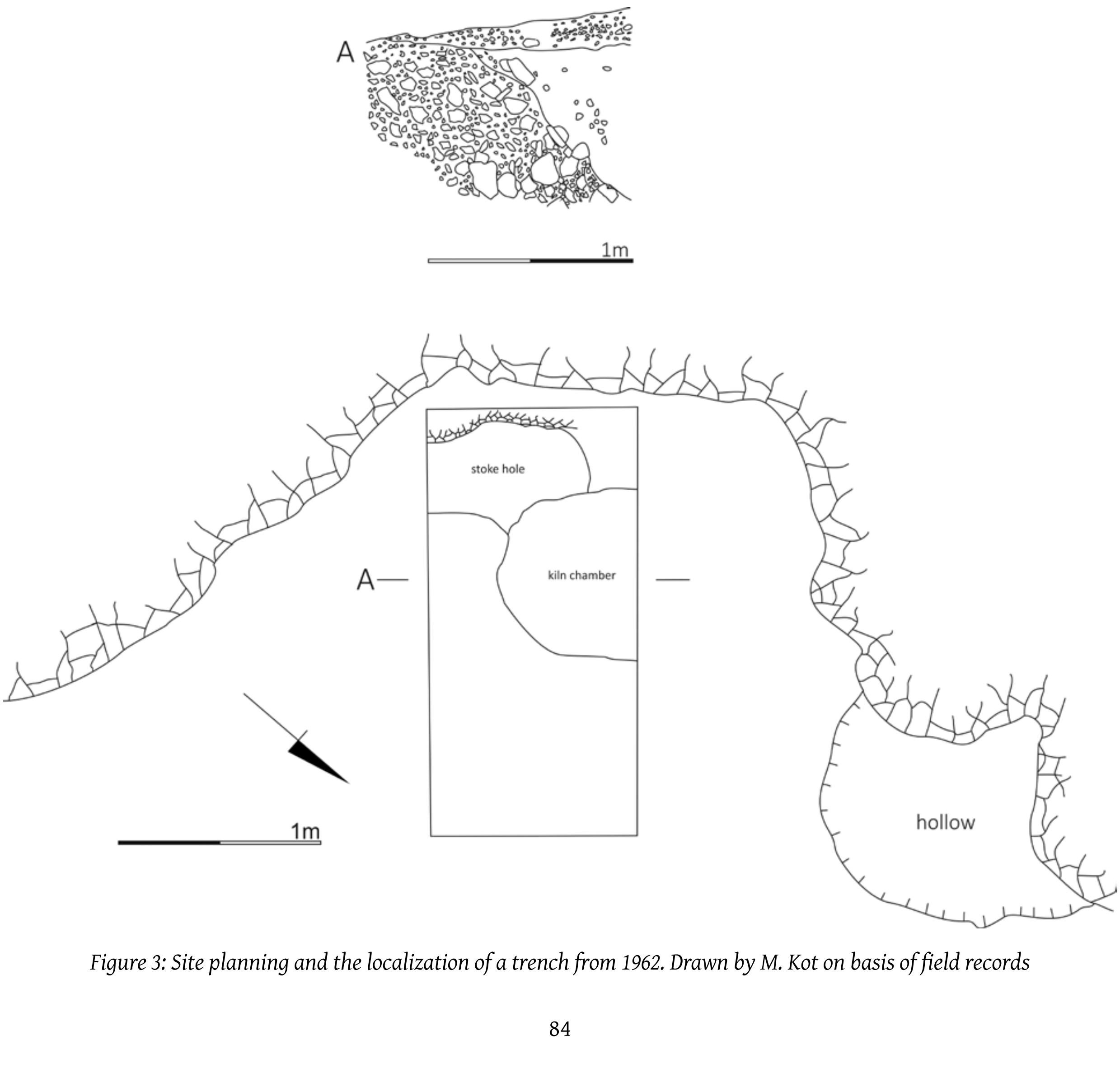

Figure 3: Site planning and the localization of a trench from 1962. Drawn by M. Kot on basis of field records

As is apparent from field records, the archaeological research of 1962 revealed a half of a structure which shall be regarded as round, approximately 1.2 m in diameter and *c* 1 m deep, filled with burned clay. Adjacent to this circular feature, from the south-west there was a smaller and likely elongated structure filled with charcoal. Both structures were located in the north part of the trench, plainly inside the niche of the rock shelter (Figure 3). The main structure, most likely of a round shape, was unearthed *c* 0.6 m from the rock, while the smaller one was evidenced next to it. Regrettably, the lack of a section cut across both structures makes it impossible to comment on their stratigraphic relation (see Figure 3).

The round shape of the main structure as well as the position of the second one form the basis for determining the unearthed archaeological context as a remnant of a pottery kiln. As is evidenced by the fillings of both pits, the main structure – loaded with ceramic debris – may be interpreted as a kiln chamber, while the second one, which was filled with charcoal, represents a stoke hole.

Taking into account the 'modern-looking' ceramic waste (see below) and the fact that modern-era pottery kilns as yet are not in the limelight of archaeologists, a search for a benchmark requires to confront the results achieved in the Garncarskie rock shelter with ethnographic evidence. Thanks to the detailed analysis by a mid-20th century ethnographer, Roman Reinfuss, it is not only possible to analyse the relics from Garncarskie, but is feasible to place it in a regional pattern of kiln diversity. In the light of Reinfuss's ethnographic surveys, it was only a simple conical open-topped kiln, which was widespread in the environments of Kraków (*cf.* Moszyński 1967: 364; Reinfuss 1960: 339). Such kilns had a wide flue on the top, and two up to four feeding holes located on the ground level (Figure 4). Although they were usually built on bricks (with the support of internal wooden scaffoldings of crosswise beams leaning up on a cart wheel, which was placed on a vertical post), the most primitive forms might have been built on a thick walled clayed daub. The vast majority of such kilns had a grate that separated vessels from the fuel, but according to Reinfuss the simplest forms not necessarily contained a separate combustion space. The kilns described by aforementioned author had a vertical window in a wall to enable pottery loading, which was closed during the firing process by clay or bricks. The ethnographic sources indicate that vessels were stacked directly on the ground one on the top of another. As regards the simplest types of kilns, a space of *c* 20 cm around the ceramic loading was usually left to supplement a fuel during firing.

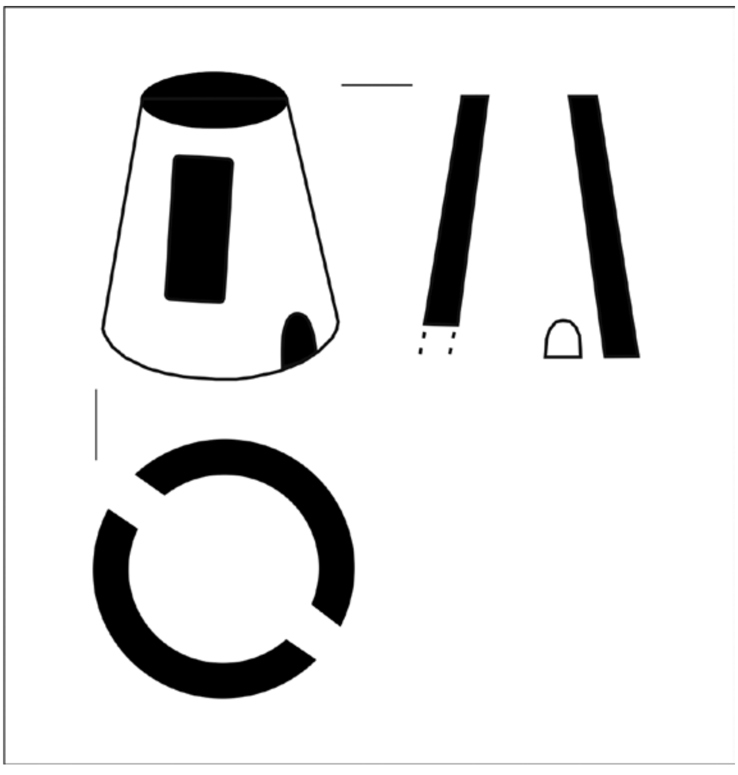

Figure 4: The reconstruction of the pottery kiln from the Garncarskie rock shelter. After Reinfuss 1960: 335, Plate 1, modified.

These conical open-topped kilns reached average height of 2.5-3 m (Reinfuss 1960: 330-332, 334-335, Fig. 1). A good example of these basic forms described by Reinfuss is the kiln deposited before 1939 in the Museum of Kraków Land in Kraków (Figure 5).

The analysis of a structure unearthed in Ojców points to the fact that the kiln from the rock shelter most likely represented one of the simplest

Figure 5: A kiln made of bricks deposited in the Ethnographic Museum in Kraków; before 1939. After National Digital Archive.

forms pictured above (Figures 4 and 5). It might have contained a single firing chamber, although the presence of a grate cannot be excluded. The kiln was rounded in shape and had approximately 1.2-1.4 m in diameter. Unfortunately, due to the state of its preservation during fieldwork it is not possible to draw any conclusions about the wall constructions. The lack of bricks suggests that it was built of daub, but it may as well be presumed that after the kiln was abandoned its walls were completely dismantled for building materials.

An interesting point is that the kiln was not placed on the ground level, but it was dug down *c* 1 m from the original ground surface. As Reinfuss reports, this process was desirable to fire the vessels not only in oxidizing, but also in reducing atmosphere (Reinfuss 1960: 331). It is worth mentioning that reducing firing was confirmed in examining the ceramic assemblage from the site (see below).

The small structure adjoined to the main firing chamber we dare to interpret as a pit dug around a feeding hole for fuel supply, which was located in the lowest part of the kiln. In this case the position of the feeding hole, from two sides surrounded by rock walls, was certainly not by chance. The opening was protected both from wind blows and other atmospheric conditions. Needless to say, preventing the unexpected wind blows was necessary in order to control the temperature of firing (Czechowski 1918: 64; Hołubowicz 1950: 224-225). It would also appear that a strong point in favour of our interpretation is a specific character of erosion of the rock - only at the back of the potential feeding hole, the rock bears traces of overheating.[1] (Figure 10)

The question to answer is the construction of the unexcavated part of the kiln. Usually, pottery kilns of this type had two up to four feeding holes located symmetrically around it. This was due to balanced fuel supply and to keeping proper temperature all over the kiln (Czechowski 1918: 64). If the kiln had four holes, two of them should have been excavated and shall be visible on the field drawings. As long as there was only one found, it is possible to draw the conclusion that there were only two feeding holes, located on the opposite sides of the kiln (Figure 6). This seems to be explained due to the ergonomics. As the kiln was situated only 0.6 m from the rocks there was not enough space for a simple foot passing, not to mention wood delivery for firing. Moreover, in the place of expected third or fourth feeding hole, the rock bears no traces of overheating.

[1] The overheated rock was noticed and determined by Maciej Krajcarz, a geologist from the Institute of Geological Sciences, Polish Academy of Sciences.

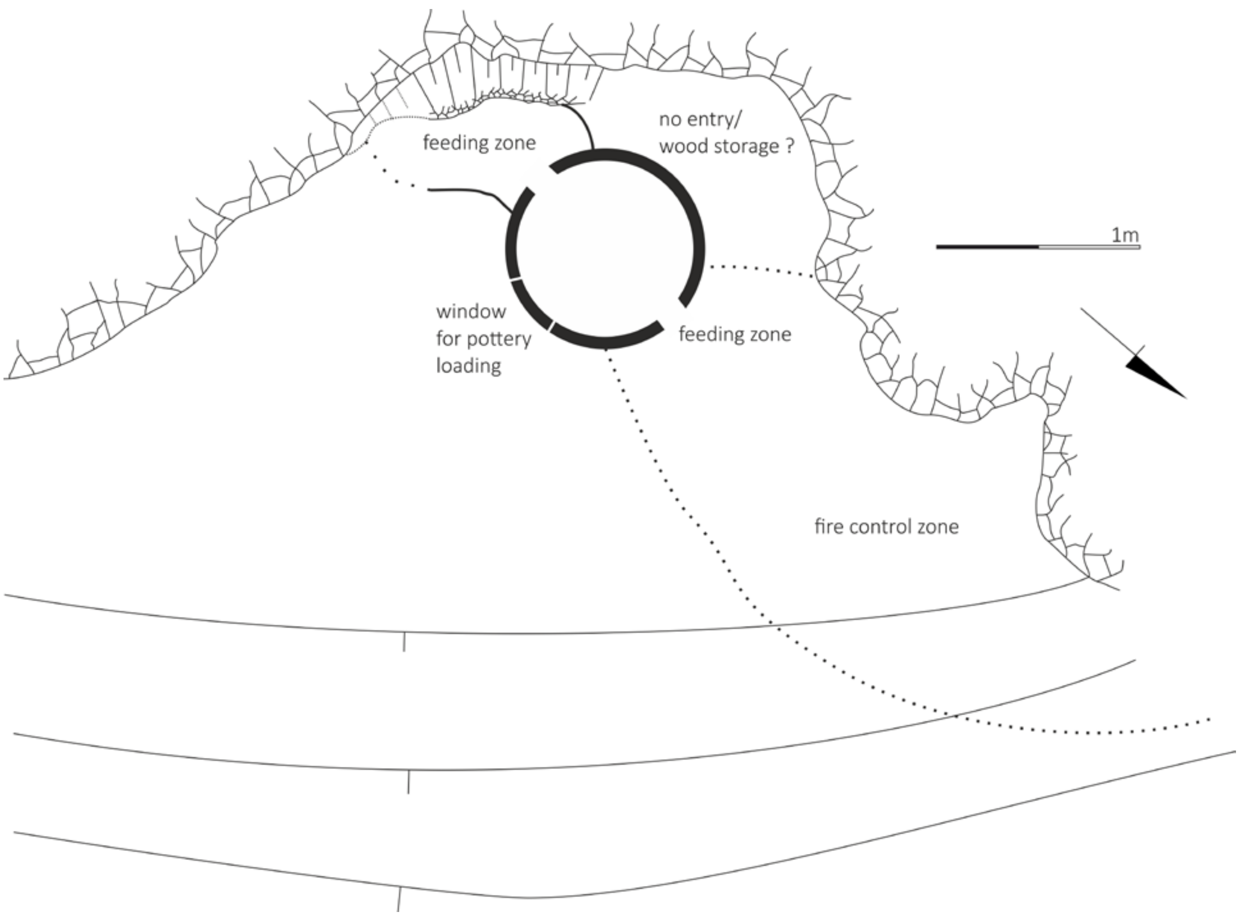

Figure 6: The reconstruction of the kiln within site planning. Drawn by M. Kot.

As has already been argued, the kiln from Garncarskie rock shelter most likely had only two feeding holes. The excavated one was placed directly behind the rock and protected the inner part of the kiln from wind. Taking into account the fact that fuel loading shall be balanced to keep a proper temperature of firing, the most appropriate localization of the second feeding hole shall be the NEE part of the kiln (which faces the valley), thus the opposite to the first one. Worth mentioning is that in the place of assumed feeding hole there is still a small hollow, approximately 1 m in diameter. Whether it corresponds with feeding hole, it is hard to assess. From the point of view of the ergonomics it could have remained efficient as long as it was located on the slope along the rock, which in this place turns slightly to the north.

What is more, in pottery kilns of such a size the firing process takes usually 10-15 hours of constant work at which a potter uses to sit in front of the feeding zone in order to control the firing temperature. With this in mind, it seems that the location of the excavated feeding zone is rather inconvenient. In front of the hole there is only *c* 0.5-0.7 m of space between the kiln and the rock. Given the high temperature near the kiln, the back of this feeding hole could not have served as a place for sitting and looking at the fire. In search for such a space needed for a constant fire control, a point we need to return to is the assumed second feeding hole, located on the slope. This fits perfectly with a place from which the potter could have had an eye for firing. Moreover, if one takes into consideration the placing of feeding zone *c* 1 m below the surface of the rock shelter, the preparation of the elongated pit along the rock and facing down the slope would have been the best solution to have a glance on the fire without necessity of constant bending and crouching.

The last problem which requires reconstruction is a window for pottery loading (Figures 4-5). If one takes into consideration the effectiveness of the loading process and the location of the kiln, the most probable place for it would be in the SE part of the rock wall just in between the two feeding zones (Figure 6).

The interesting issue is the reason for location of the kiln in the rock shelter. Pottery kilns were usually placed in separate buildings with opening roofs or outdoor. In this case the potter decided to use a rock shelter, which has its pros and cons. Not to mention the fact that it gave a natural shelter, the site and its rocky surroundings had an impact on the moisture conditions, which had a great influence on both drying of pottery and firing process. What was probably the most important reason is, however, a perfect wind protection by the rock wall. As long as the rock shelter has an eastern exposition it protected from the most frequent western winds. What is more, the kiln was located exactly beneath the almost vertical rock fissure with eastern inclination, which was a perfect natural flue (Figure 10), still providing a rain protection due to its slight inclination.

Although the archaeological excavations carried out in 1962 were supposed to yield a large amount of pottery fragments, the collection of the University in Warsaw, which holds the assemblage from Garncarskie, is preserved only by 55 ceramic sherds, including remains of barely 24 modern-era vessels.[2] Such a small number of artefacts contradicts both the reports on a 'huge amount' of pottery fragments considered a waste (Chmielewski 1988: 13) or 'dozens' of ceramic pieces found in the inside of the kiln (Madeyska 1988: 162). Modern-era pottery finds from the site deposited in Warsaw with no exception represent diagnostic parts of vessels, which leads to the conclusion that this is only a selection of finds from the 1962 fieldwork. Moreover, a surface survey undertaken in the rock shelter recently by one of the authors brought to light nine non-characteristic pieces of pottery, which suggests that this supposition holds true.

Thus, as regards modern-era finds, in total there are 33 pieces of pottery left for the formal and technological analysis. Examining pottery sources, the pieces have been classified into 25 units, theoretically identical with different vessels. The assemblage consists of 12 pots, 2 bowls, 1 lid and 10 unspecified vessels (Figure 7).

The analysis of these artefacts gives an insight into the technology of their production. The vast majority of them was produced of iron-rich clays, frequently occurring in the nearby (18 vessels). The surfaces of these finds are pale red, red or even brick red in colour. On the other hand the assemblage holds seven vessels made of the so-called white kaolinite clay, characterized by creamy or even white surfaces. The presence of these finds in the assemblage associated with pottery production is surprising, giving the fact that in this part of the region deposits of white loamy clays have not yet been identified (see Buko 1990: 51-52, 79, Fig. 21).

In most cases the fabric of the pottery assemblage included slightly coarse vessels tempered with fine-grained sand (roughly 0.1-0.2 mm) in smaller quantities. The quantity of sand and the admixture of different tempers formed the basis for determining types of fabric. Examining the sources, five essential fabric groups of ceramic paste have been distinguished: 1) slightly coarse vessels with low quantity of sandy temper (11 vessels); 2) slightly coarse vessels with low quantity of sandy temper and with low quantity of limestone temper, occasionally large in size (two vessels) (Figure 8); 3) slightly coarse vessels with low quantity of sandy temper and chamotte (nine vessels); 4) slightly coarse vessels with low quantity of sandy temper, chamotte and with low quantity of gravel (one vessel); and 5) well levigated fabric, fairly fine, occasionally with sparse inclusions of sandy grit (two vessels).

[2] The assemblage from the rock shelter contains also 30 non-diagnostic pieces of pottery, which can be attributed to the Neolithic and a small piece of medieval pottery (a belly fragment). There is no doubt that these finds reflect an earlier human activity than functioning as a kiln site.

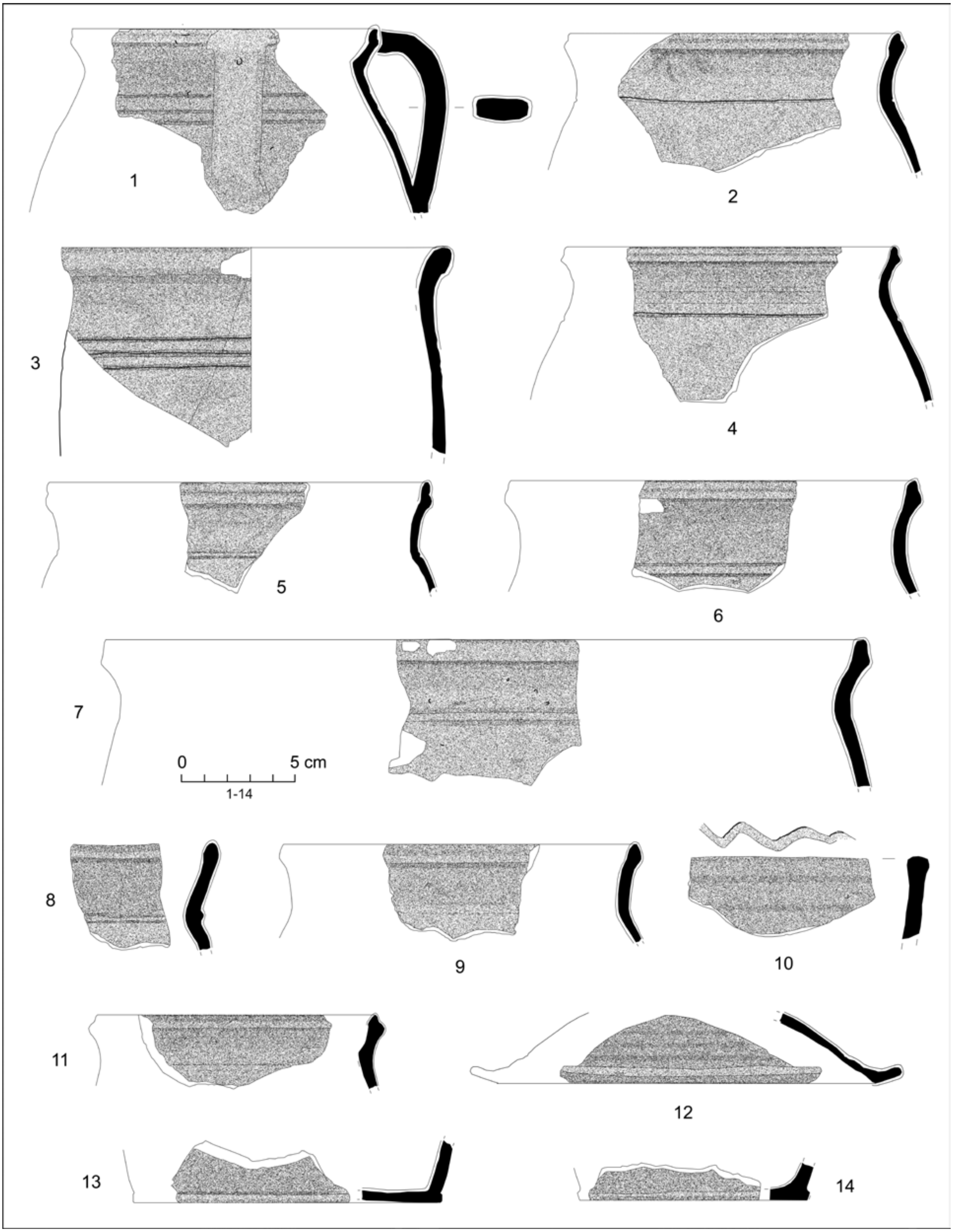

Figure 7: Pottery assemblage from the Garncarskie rock shelter in Ojców. Drawn by M. Wojenka.

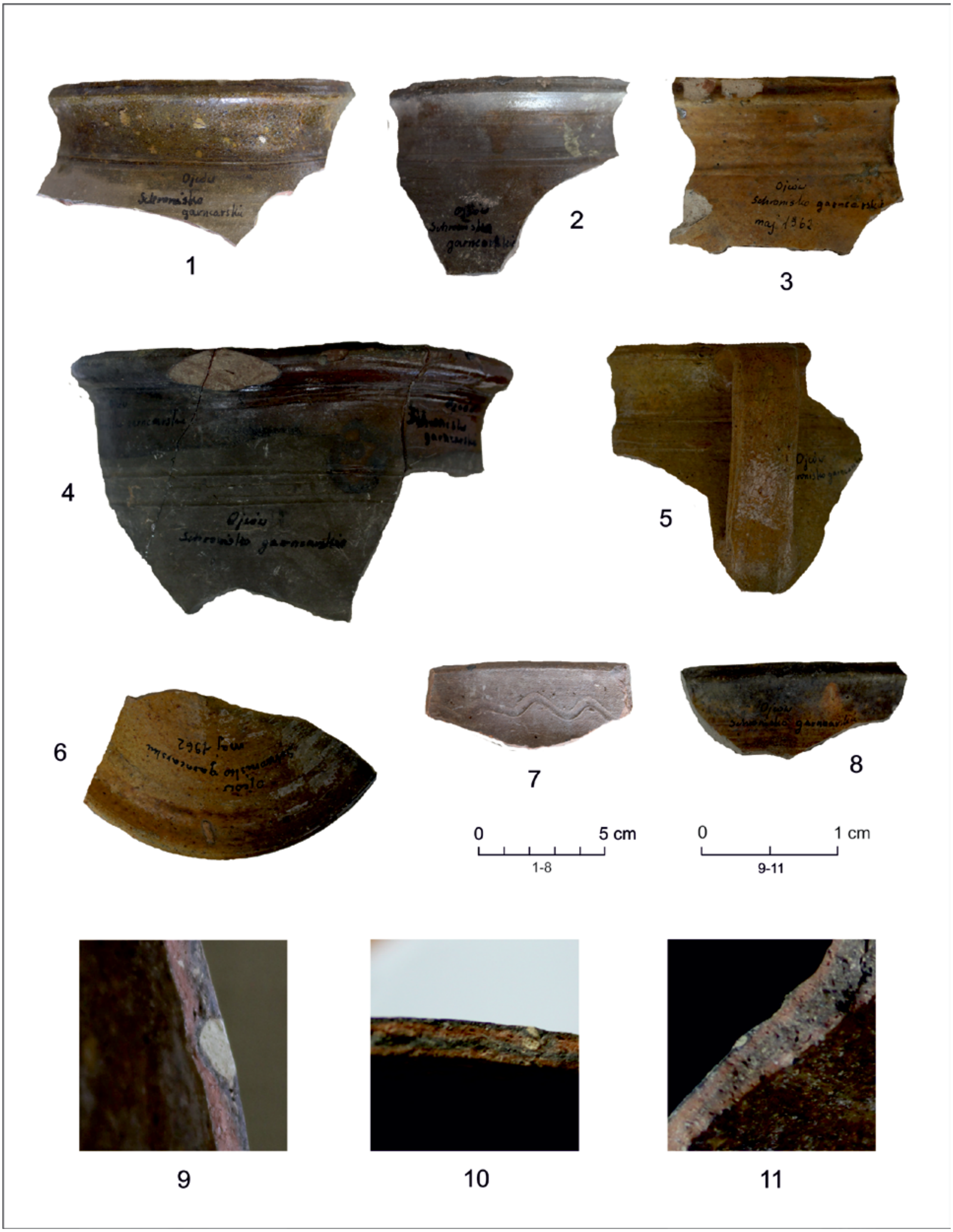

Figure 8: Pottery assemblage from the Garncarskie rock shelter in Ojców. Photo by M. Wojenka.

Although due to the fact that the analysed group of ceramics includes units which were likely to have been broken in the kiln and later they were secondarily burnt out (what might have made difficult to draw certain conclusions on the technology of firing), examining the thin-sections of vessels leads to the point that the wares were fired both in oxidizing (15 units) and reducing (8 units) kiln atmosphere. In case of two vessels, one can assume uneven firing conditions. The thin sections of vessels were one-coloured (19), bicoloured (1) and three-coloured (5 wares). Noteworthy are the vessels of three-coloured thin-sections (20% of assemblage), with grey inner and brownish-red external parts (Figure 8.10-11). Such effect appears to have resulted from inaccurate insulation of the kiln at the final stages of reducing firing or from a decreased temperature (Niegoda 1999: 158-159). The latter possibility is rather unlikely due to the fact that surfaces of all the wares from Garncarskie are very hard; at any rate, in both cases this startling trait does not speak well of the potter's craft level.

The hardness of wares and the use of reducing kiln atmosphere is a premise which suggests a high temperature of firing, at least of around 600°C. It is assumed that in case of the so-called 'folk pottery' the temperature of firing reaches 920°C (Fryś-Pietraszkowa 1988: 99; Niegoda 1999: 159).

The decoration of wares from Garncarskie rock shelter is rather poor. It is limited to stripes of engraved horizontal lines (Figure 7.1-5) or shallow horizontal grooves (Figure 7.6-7). In one case a vessel was ornamented with engraved wavy horizontal line (Figure 7.10).

The vast majority of vessels were covered with a glaze (19 wares), predominantly yellow (Figure 8.3, 5-6), brown in various hues (Figure 8.2, 4, 8) and green in colour. These are glazed inside and out (Figure 7), although it is worthwhile noting that some of the wares are covered only on one side. In particular this has to be applied to vessels fired in reducing atmosphere (Figure 7.3-5, 11). In this instance glaze not necessarily served a functional role, since wares fired in reducing atmosphere were hard enough to prevent seeping the liquids through their walls. It does not concern the rims from the examined assemblage. Whether wares are fired in reducing or oxidizing atmosphere, the rims are commonly glazed on both sides (Figure 7.1-9, 11).

The collection of pottery from Garncarskie rock shelter holds the vessels which correspond with basic forms of a typical household assemblage (Reinfuss 1955: 30-47). Understandably, the pots prevail there (12 wares; see Figure 7.1-9, 11). Although this group of vessels is represented by forms which differ in size (rim diameters: 110 mm min.; 300 mm max.), most of it is rather medium (rim diameter *c* 130-140 mm; Figure 7.2, 4, 5-6, 9). The necks of pots are usually semicircular in shape (Figure 7.2, 4, 6-7, 11), occasionally slightly elongated, especially in the lower parts of wares (Figure 7.5, 9). It is not absolutely certain whether the bases of vessels depicted on the Figure 8 correspond with cooking pots. In both cases these are marked with footrings (Figure 7.10, 14), their diameters are of *c* 90-120 mm.

Rims of the pots are clearly everted and, in most cases, highly profiled. Particular attention should be drawn to rims with rounded vertical edges and pronounced ridges, frequently occurring within the assemblage (Figure 7.1-2, 4-5, 11) or similar to these, although of 'degenerated' form (Figure 7.6-7). Noteworthy is also a pot with everted, thickened rim (Figure 7.3). Due to the diameter of the belly, the shape of this ware likely harks back to manufactured stoneware vessels (see Fryś-Pietraszkowa 1988: 98).

Bowls are represented by only two parts of simple vertical rims with thickened edges (Figure 7.10; rim diameters of both min. 300 mm). It is likely to assume that these are remains of low truncated cone-shaped bowls, which in households served for eating (Fryś-Pietraszkowa 1988: 99).

Lids are represented by a one find (diameter 140 mm) with raised lip and readable shallow grooves on the outside, made by the fingers as the lid was wheel-turned (Figure 7.12).

Moving on to the chronology of ceramic firing at Garncarskie rock shelter, at first one may need to return to the first written account on the site by Czarnowski. It leaves no doubt that in the early 20th century the household of the potter was already abandoned. The short note of Czarnowski (1911a: 66) is then the *terminus ante quem* for the potter's activity at the site. It is also noteworthy that he did not recognize any element of a potter's infrastructure, which leads to the point that at that moment there was no trace of any building nor the pottery kiln. Since Czarnowski saw 'wild fruit trees at the site', it must have been abandoned much earlier than the turn of the 20th century. Then key for chronological remarks must be the pottery assemblage.

First of all, it needs to be emphasized that ceramic sources from Garncarskie as a whole do not correspond with the so-called 'post-medieval' pottery, and according to the present state of knowledge, they represent 'modern-times' assemblage and are not earlier than *c* 1800 (see Kajzer 1994: 12). Regrettably, it has to be admitted that modern-era pottery sources are beyond the scope of interest of archaeologists and thus, in searching for the affinities by default we are left only with several examples, which in most cases represent pots with rims of rounded vertical edges and pronounced ridges. Without exception, these are broadly dated to the 19th or the early 20th century. Close affinities with wares from Garncarskie were recently found in the nearby Spa-Garden in Ojców as secondary deposits within layers formed after 1863 (Wojenka and Dzięgielewski 2016: 232, Fig. 6.7, 13-15). They are commonly occurring in caves of the area, to mention Borsuka Cave in Radwanowice (Wilczyński *et al.* 2012: 81, Fig. 4.4) or Na Wrzosach Południowa Cave in Wrzosy (Wojenka *et al.* 2017: 174, Fig. 7.2-4). The range of their popularity

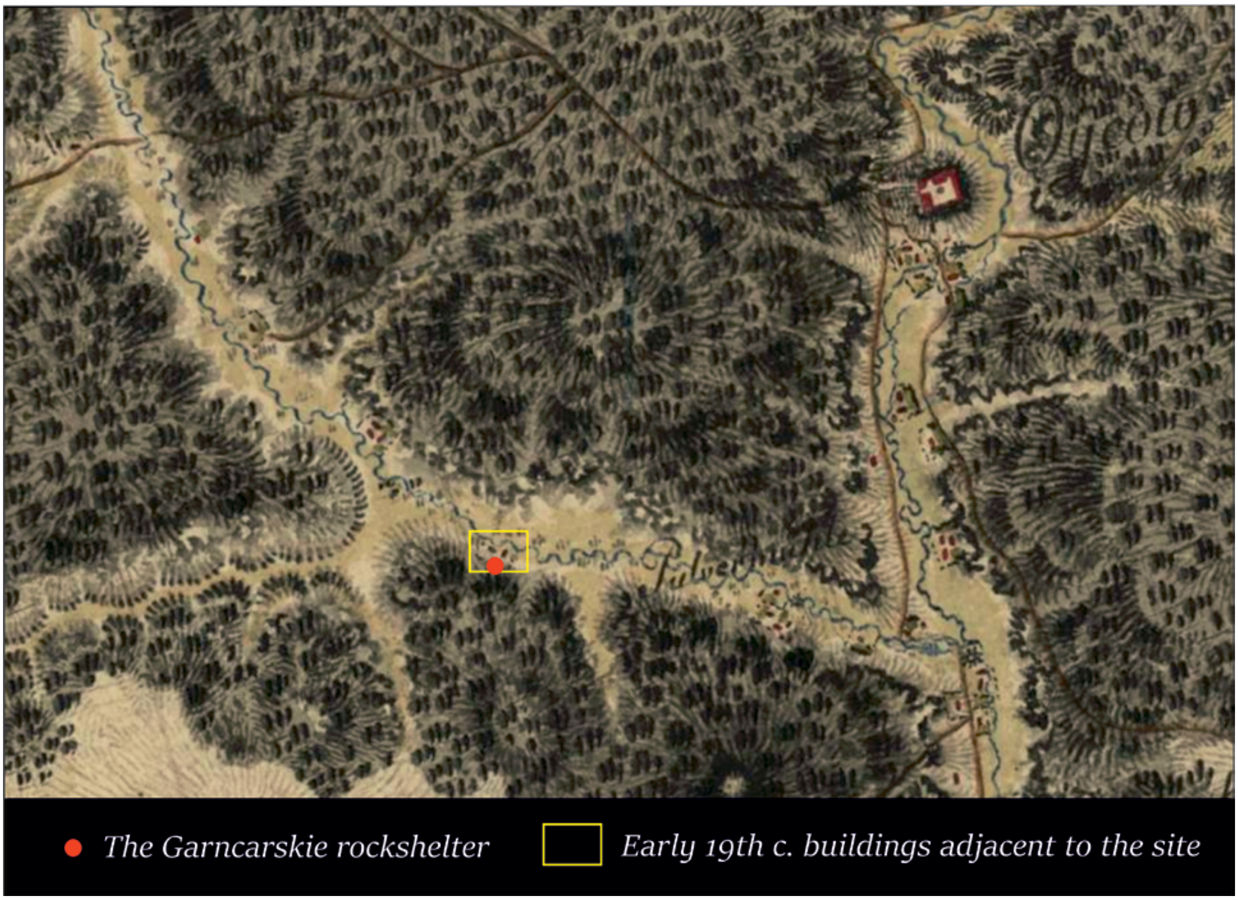

Figure 9: The Garncarskie rock shelter (marked with a red dot) and its surroundings in the early 19th century. A map of Anthony Meyer von Heldensfeld, c 1801-1804. Modified by M. Wojenka after: www.mapire.eu.

for certain was not limited to the southern part of the Polish Jura Chain – in recent years their close affinities were discovered east from Kraków, in Bieżanów (Chudzińska *et al.* 2015: 285, Pl. 17.2-4).

Examining pottery assemblage from Garncarskie in chronological sense worth noting are also the experiences of ethnography. Unfortunately, the serious difficulty there is the manner of publication of the so-called folk pottery sources in the ethnographic literature, where pictures of wares do not include drawings of their sections. As regards ethnographic bibliography, attention should be drawn to a late 19th century cooking pot from Lipnica Murowana, in terms of rim-part morphology similar to the finds from Ojców (Fryś-Pietraszkowa 1988: 103, Fig. 152).

Taking into account the above remarks, we dare to date the potter's workshop at Garncarskie rock shelter to the 19th century, most likely to its second half.

In searching for non-material remains of the potter's activity one may need to refer to the earliest cartographic sources demonstrating the settlement of Ojców. A map which was drawn up in between 1801-1804 by an Austrian military cartographer, Anthony Meyer von Heldensfeld clearly shows plots-of-ground and dwellings in the immediate vicinity of the rock shelter (Figur 9). It is probable that these buildings might have formed a part of the potter's household or – more likely – might have been a property of the potter's ancestors.[3]

Figure 10: Rock fissure in the Garncarskie rock shelter which could be used as a natural flue. Photo by M. Kot.

Since the rock shelter was abandoned, nobody used it for the next century. There are some indications that soon after leaving the site the nearby household might have ceased to exist – a plan of the locality Ojców published in 1907 does not show any buildings in this part of Sąspówka river valley (see Czarnowski 1907: 6).

Examining ceramic assemblage and the remains of the kiln leads to the conclusion that the potter from Sąspówka valley probably was not a high-skilled craftsman. This is evidenced by a number of pottery pieces of not fully successful reducing firing, use of carelessly levigated clay for fabric (see Figure 8.9) and, likely, the lack of bricks or their fragments inside the kiln remains, which suggests that a kiln itself represented more archaic or even primitive type, built on daub.

[3] Regrettably, a search query for the information about potter's identity which was carried out in the archives of the parish church in Smardzowice doomed to failure.

Although probably not necessarily high-skilled, the potter from Ojców was able to benefit greatly from the landscape. As the open-topped kilns for safety reasons usually must have been kept in separate sheds with lifted roof (Reinfuss 1960: 331) or even outdoor (Czechowski 1918: 65), the potter decided to place it inside the rock shelter. Thus he achieved a protection from wind blows, in particular from the most frequent west winds. Moreover, the location of the kiln right down a slightly inclined rock fissure protects ceramic firing from rainfalls (Figure 2).

The Garncarskie rock shelter in Ojców, though seemingly small and inconspicuous, provided interesting and valuable data from a point of view of human-space interaction. Its cultural content allows to consider rocks and rock shelters not only as inanimate part of the landscape, but also as usable and creativity requiring space.

Acknowledgements

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