Journal of Archaeological Science: Reports 49 (2023) 104036

Contents lists available at ScienceDirect

Journal of Archaeological Science: Reports

journal homepage: www.elsevier.com/locate/jasrep

Bronze Age combustion structures of Italian contexts in comparison: Via Ordiere-Solarolo (Ravenna) and Mursia (Pantelleria island). Archaeological, geoarchaeological and experimental data

Alessandro Peinetti [a,b,*], Florencia Debandi [a], Maurizio Cattani [a]

[a] University of Bologna, Department of History and Cultures, Italy
[b] UMR 5140 (CNRS, Univ. Paul Valéry Montpellier 3, MCC), LabEx ARCHIMEDE (programme IA- ANR-11-LABX-0032-01), France

ARTICLE INFO

Keywords:
Bronze Age
Combustion residues
Hearth
Oven
Geoarchaeology
Micromorphology
Experimental archaeology

ABSTRACT

Recent investigations carried out by the University of Bologna at the Bronze Age sites of Via Ordiere (Solarolo – Ravenna province) and Mursia (Pantelleria) discovered several types of fire installations. The paper considers different steps of the research related to the use of fire and cooking practices in domestic contexts using the two settlements for a comparative approach. While in the first case the evidence of firing structures is poorly preserved and requires sampling for micromorphological analysis and complex analysis, the second case of Mursia, thanks to the best preservation of the archaeological deposit, allows to select and reconstruct more easily the features involved in processing and cooking food.

Besides the presentation of the archaeological evidence, the research copes with the methods applied for a combination of results, including an archaeological protocol for documenting fire installations and the geoarchaeological analysis, extended to the comparison with similar features in the literature and with the ethnoarchaeological evidence. A further approach was scheduled experimenting archaeological replica of most common fire installations. Finally, we deal a general understanding of the use of fire with a concept map going in depth with the many questions arisen pointing out the interrelationships among several parts of the process involving fire installations.

1. Introduction: The tangible and intangible elements of domestic fire-related activities

One of the major interests of fire-related structures is that they are at the intersection of several *chaînes opératoires*, concerning not only the processing of products through the use of heat, but also the realization of the structures themselves, the fuel collection or the production of different equipment participating to the use and maintenance of the structures (Cattani et al., 2015b; Peinetti et al., 2020). Looking at domestic hearth, each structure can potentially concern several sets of activities and plays a supporting role for other actions, through the lighting and heating of domestic spaces for example. In addition, the domestic hearth may serve as a social and even symbolic function and different structures may have different status inside the domestic space, with a central or a subsidiary role and different meanings in terms of economic and social functions. These aspects provide different information about consumption and production and are the evidence of the socio-economic organization or the lifestyle of ancient communities (March et al., 2012; Pétrequin and Pétrequin, 1992).

For us, the research on fire-related installations has become the opportunity for a more analytical effort during the excavation in looking for expected items or structural installations related to one of the common daily activity performed by individuals or segments of the community, such as fire management and use. Just to enter in some details, questions as “how was lightened fire”, “how was stored and managed fuel”, “how ash and smoke were disposed” and many others were raised. Actually, most of the actions engaged in the use of fire are invisible in the archaeological record or have left faint traces. They require different strategies in fieldwork or in the collection of samples for laboratory analysis to be documented. They raise questions about how to deal with archaeological evidence to document the choices, gestures and practices related to the use of fire and the managing of fire installations.

This issue is part of a long-term research related to the investigation of Bronze Age settlement pattern in Italy carried out by the University of

* Corresponding author.
E-mail addresses: alessandro.peinetti2@unibo.it (A. Peinetti), florencia.debandi3@unibo.it (F. Debandi), maurizio.cattani@unibo.it (M. Cattani).

https://doi.org/10.1016/j.jasrep.2023.104036
Received 31 August 2022; Received in revised form 26 April 2023; Accepted 29 April 2023
Available online 21 May 2023

Bologna (Cattani and Debandi, 2015). It concerns the investigations on the process of using fire in a domestic context starting from the excavated features. It deals also with different aspects related to the *chaînes opératoires* of realization and use of fire installations or other behaviours related to the use of fire. A starting point of the research has been the drawing of a conceptual map of fire use (Fig. 1) (Cattani, 2019), helping to define the socio-economic organization and cultural peculiarities of the Bronze Age communities. Among the available data, particular effort is devoted to analyse documented structures and tools, environmental and domestic contexts, effects and products of the combustion, as well as complementary purposes in lightning fire.

Inference about the formation processes of the archaeological record requires a dedicated approach, in order to understand the human practices and the transformations of structures. It will consider the cleaning and maintenance processes of the fire installations and the modifications that occur after their abandonment or demolition, which can profoundly transform the original state of structures. Furthermore, different lifestyles and settlement patterns lead to the formation of stratifications and archaeological evidences of various types, among which we can distinguish more or less evident features related to the use of fire. For these reasons, the aim of this paper is to compare the combustion features and the related evidence of two Italian Bronze Age sites, excavated by the University of Bologna (Fig. 2): the settlement of via Ordiere-Solarolo in Northern Italy (Cattani et al., 2019), and the village of Mursia on the island of Pantelleria, south of Sicily (Cattani et al., 2020). The two settlements are almost contemporary, dating in the second quarter of second millennium BC, but belong to distinct regions from an environmental and cultural point of view. This comparative approach deals with highlighting the peculiarities of the two sites, either from the point of view of the strategies adopted on the field and for the results achieved through the archaeological and geoarchaeological analysis of domestic combustion features, supported by experimental archaeology.

2. Geographical and archaeological contexts

2.1. Mursia (Pantelleria – Province of Trapani)

From a geological point of view, Pantelleria is a volcanic island composed of acid magmatic rocks (peralkaline rhyolite and trachyte) and, to a lesser extent, basaltic rocks (Rotolo et al., 2017) (Fig. 3).

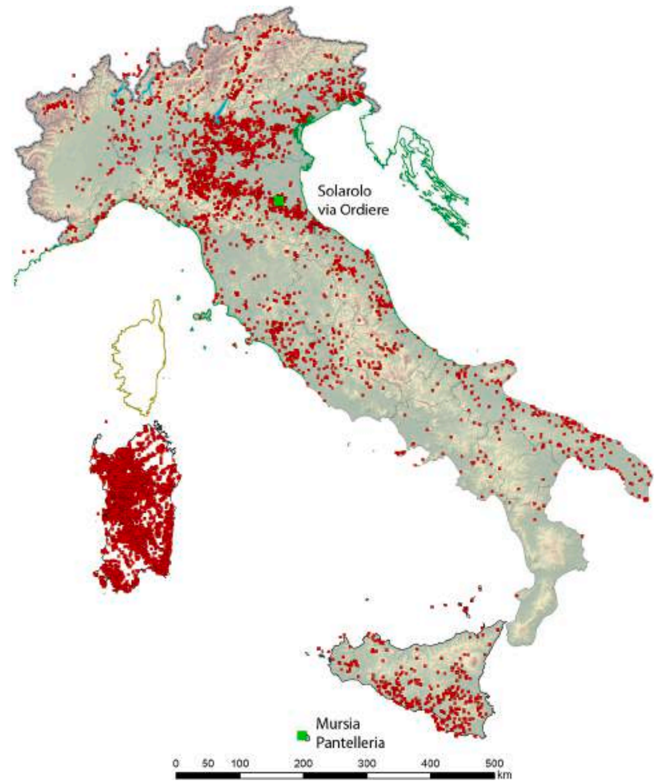

Fig. 2. Location of the two Bronze Age Settlements discussed in this paper: via Ordiere-Solarolo and Mursia (island of Pantelleria).

The settlement of Mursia is located on the north-west coast of the island and occupies a surface area of approximately one hectar. It is densely occupied by dozens of dwellings built with stone, distributed on a flat coastal promontory overlooking the sea. Largely protected by high cliffs, it was defended inland on the slope by a massive fortification wall (Debandi et al., 2021). If the promontory is made of a thick sequence of pyroclastic scoria (tuff basalts) topped by a tabular deposit of Pantelleritic Ignimbrite (Green Tuff), the slope is formed by ryolithic lava deposits (Fig. 4, a).

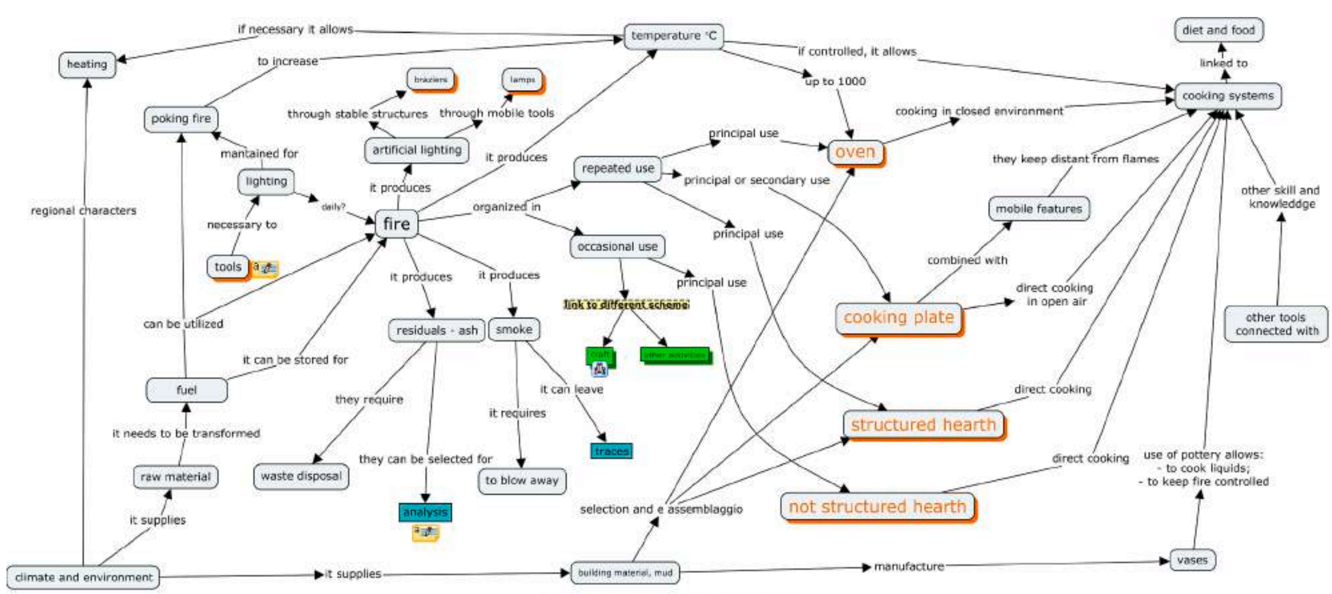

Fig. 1. Concept map of fire and related activities (after Cattani, 2019).

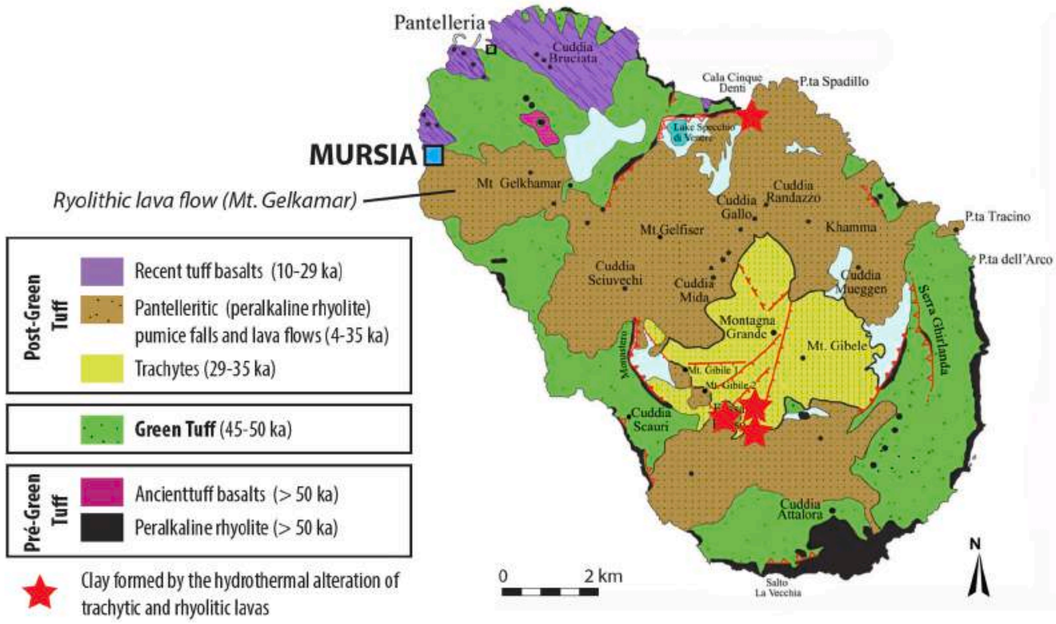

Fig. 3. Geological setting of Pantelleria (after Rotolo et al. 2017) 2-column fitting image.

The occupation dates between the 18th and the 15th centuries BC and the material culture relates to the local Mursia facies, related to a more general Rodì Tindari Vallelunga facies (Cattani, 2016). This long occupation generates a multi-layered, well preserved and complex stratification, characterised by several building renovations. The stone dwellings at the beginning of the occupation are oval elongated sunken buildings (Fig. 4, b-c). In the later phases oval stone dwellings become larger with floor on the outside plane or they have rectangular plan (Fig. 4, b).

The magmatic rocks and the volcanic soils of the island (Andosol type) are both used for building purposes inside the dwellings, even for the realisation of combustion features (Peinetti et al., 2018).

The characterization of the complex evolution of the settlement is facilitated by the exceptional conservation of the stone dwellings and their stratification. The large number and the heterogeneity of fire installations (hearth and ovens) are crucial for the understanding of the use of space inside the settlement.

2.2. Via Ordiere-Solarolo (province of Ravenna)

The settlement of via Ordiere in Solarolo is located in an alluvial plain context in Romagna, today at 40 km west of the Adriatic Sea (about 25 km in the Bronze age), at the top of an ancient alluvial levee formed by the river Santerno (Marabini and Vai, 2020) (Fig. 5, a). The soilscape is composed of alluvial calcareous and hydromorphic soils (temporary waterlogging), developed on sandy loam to silty clay deposits.

The inhabited area was organized in different settlement clusters (Fig. 5, b), located along an ancient river which was probably at a senescent state of activity. The preserved stratigraphy under the ploughing horizon mainly dates to the second phase of the Middle Bronze Age, between the 16th and the 15th centuries BC, while a larger area of 3–4 ha shows continuity till the end of Recent Bronze Age (12th cent. BC). In MBA the material culture shows the presence of pottery types belonging to the Terramare culture associated with others of the Grotta Nuova culture, spread mostly in central Italy (Cattani et al., 2018).

In the main excavation area of the site (sector 1), discussed here, the first occupation phase is characterized by a complex stratification composed by the association and the spatial alternation of two kinds of cultural layers: (1) thick and spatially extended dark layers including large amounts of heterogeneous cultural materials; (2) thinner lenses and heaps of quite homogeneous composition, each one almost exclusively composed of ashes, daub fragments and ceramic material (Fig. 6, a-b). This kind of stratification is typical of "Terramare settlements", spreading in the region during the Middle and Recent Bronze Age (Bernabò Brea et al., 1997). The evidence of dwelling is recognized in the alignment of post-holes, which materialize the presence of pile-dwellings (Fig. 6, c). The second phase is quite different. The eastern and northern parts of the excavated area are occupied by massive tabular silty layers forming earthen platforms, on which the evidence of posts-in-ground dwelling has been recorded (Fig. 6, a, d). The western part shows characteristics more similar to dumping and open areas.

The case of Via Ordiere is representative of a stratification with very poor evidence of fire installations preserved *in situ*, while on the contrary an abundant amount of burnt earth, ashy and charcoal-rich layers suggest that combustion activities were carried out frequently. It corresponds therefore to a challenge in looking for and documenting traces of the firing process with the help of different disciplines.

3. Approaches and methods

The research carried out concerns the combustion features in a broad sense: any kind of combustion residue assemblages that are part of the archaeological record (Leroi-Gourhan, 1973). In our case, this concerns mainly domestic fire installations that can be classified as "structured hearths" and ovens, realised mainly with stone and earthen materials, but also evidences of combustion residues in secondary position (e.g. dumping) that carry indirect information on practices related to the use of fire in a domestic environment.

3.1. Archaeology, geoarchaeology and experimental archaeology

On one side, the archaeological analysis adopted for this study is holistic. It encompasses the formal analysis of the fire-related structures, the stratigraphic analysis of the structure itself and its archaeological context, but also the functional analysis of archaeological materials associated with the structures (see Section 3.2). These classic archaeological approaches are used on both sites, Mursia and Via Ordiere, to classify and analyse all the evidence connected to fire-related structures and combustion features. On the other side, geoarchaeology and experimental archaeology were chosen among the most operational

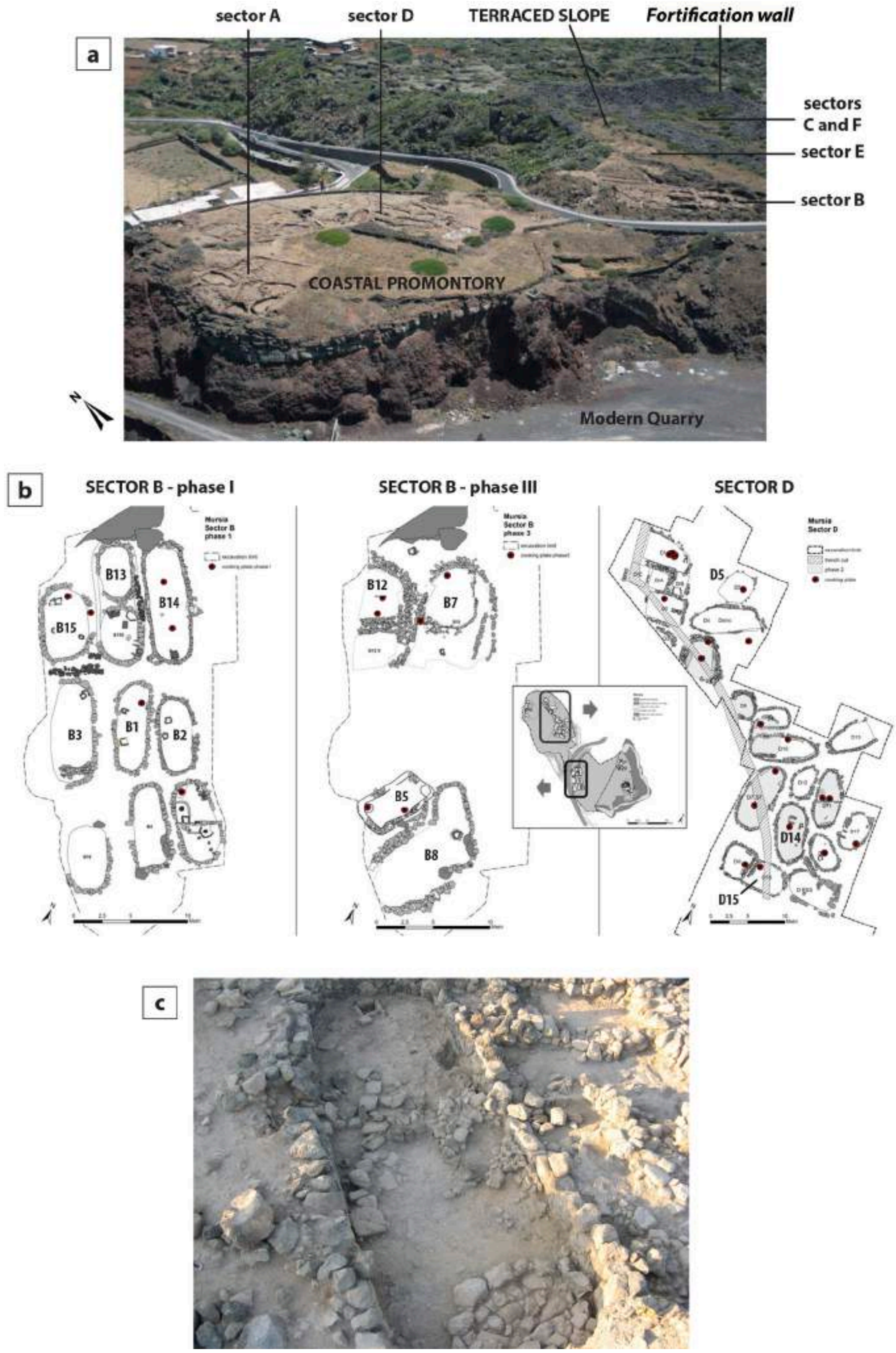

Fig. 4. The settlement of Mursia: (a) aerial view of the site and its organisation; (b) plan of sectors B (phase I and III) and D, with buildings cited in the text; (c) sunken building of the first occupation phase (hut B14, sector B).

disciplines that can contribute to archaeological research on combustion features. The results of research from other disciplines, such as archaeobotany and archaeozoology are not discussed here.

From a geoarchaeological point of view, the research on combustion features is integrated into a larger project that aims to specify in detail the formation processes and then the use of space within the sites (Peinetti, 2021). On both sites, the geoarchaeological research is based on microstratigraphic analysis (soil micromorphology). After the stratigraphic characterisation on the field, a protocol of systematic spatial and vertical sampling for soil micromorphology is realised. This kind of approach allows to define the composition, the depositional and post-depositional history of combustion features, but also to characterise the occupation surfaces associated with them. The sampling strategy for micromorphology (sampling of oriented and undisturbed blocks of sediments, Courty et al., 1989) varies according to the characteristic of each site. In Via Ordiere-Solarolo the sampling is done on large stratigraphic sections at the borders or transversals to the excavation area, or on stratigraphic sections that cross archaeological features (pits, combustion features, ash heaps…). At the site of Mursia, the density of structures within the stone buildings and the narrowness of unbuilt space leaves no opportunity to maintain large stratigraphic sections during excavation, as this practice would not allow a proper reading of the stratification. Then, the micromorphological sampling is done on smaller stratigraphic sections crossing parts of archaeological features, or on small stratigraphic columns left regularly in place during excavation.

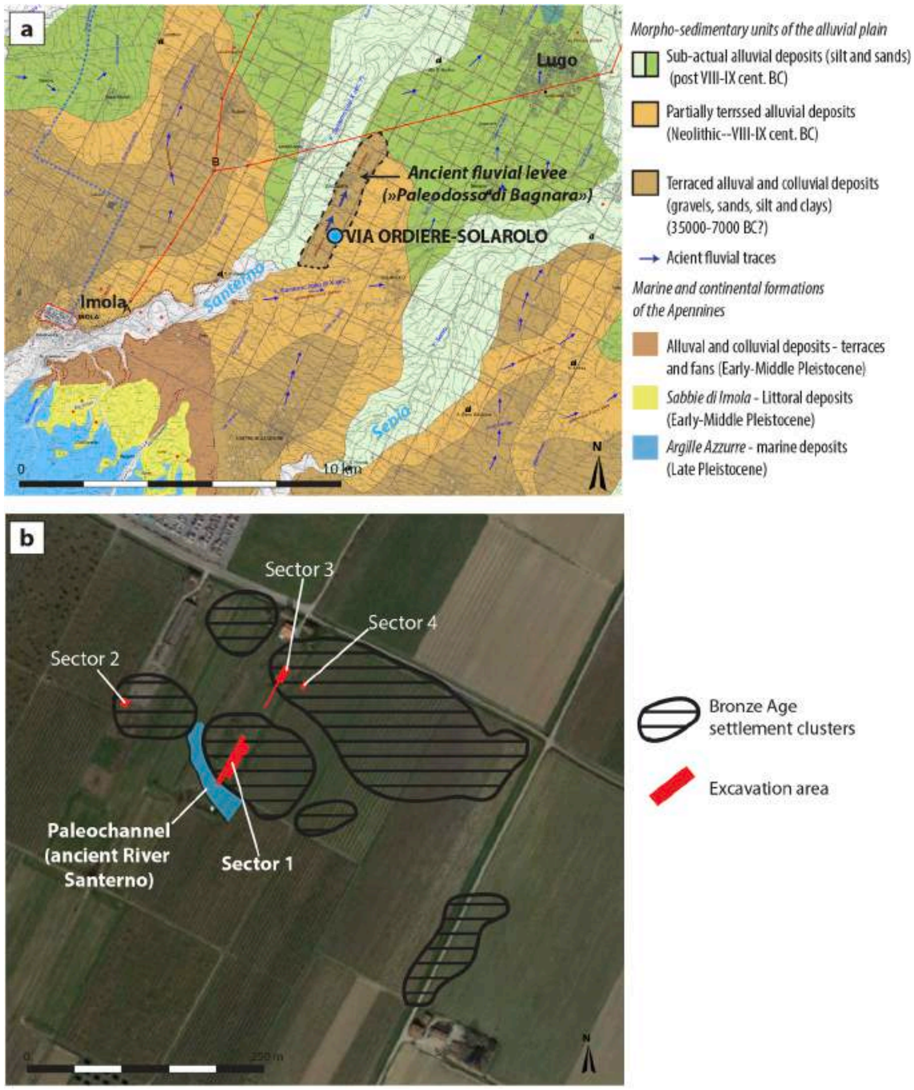

Fig. 5. Bronze Age settlement of Via Ordiere – Solarolo: (a) geographical/geological setting (geological map after Marabini and Vai (2020)); (b) layout of the village and location of excavation areas.

Thin sections are made from micromorphological samples. The thin sections analysis is based on the methods of description and interpretation developed by micromorphology, especially when adapted to archaeological contexts (Bullock et al., 1985; Cammas and Wattez, 2009; Courty et al., 1989; Macphail and Goldberg, 2018; Nicosia and Stoops, 2017; Stoops et al., 2010). This approach leads to the identification of microstratigraphic units (MSUs) and then to the description of their micromorphological properties under the polarising microscope. The set of identified sedimentary signatures allows to qualify the sedimentary organisation of each of the microstratigraphic units. These different sedimentary organisations, called micro-facies, are the expression of the interaction of natural and cultural agents, mostly related to different human activities and the specific sedimentary environment (Cammas et al., 1996; Courty, 2001; Wattez et al., 1998).

Thirty thin sections from the site of Mursia were studied. Among them, 6 thin sections directly concern fire structures and 3 thin sections document the formation processes of occupation surfaces close to fire installations. At Via Ordiere, 32 thin sections were studied and 2 of them concern earthen hearths, while 11 thin sections document waste heaps partially or exclusively composed of combustion residues. This paper presents a synthesis of the results of micromorphological analysis on combustion features of both sites (see Peinetti, 2021 for a full presentation of results).

Finally, experimental archaeology carried out on experimental replicas of Bronze Age earthen constructed hearts and ovens stress the understanding of the realization, the functioning and the weathering/decaying of these fire-related structures. The experimental protocol adopted to control and record the different variables related to the construction, use, and abandonment of the structures is inspired by the protocol proposed for experiments related to burnt earthen architecture (Peinetti et al., 2017), adapted to the analysis of combustion structures (Peinetti et al., 2020).

Two experimental earthen-made domed ovens and seven experimental earthen constructed flat hearts were realised, used and left to decay between 2012 and 2020. Each structure couldn't be used daily or on a regular basis, but at least five to twenty times on a time lapse of one or two years before the abandonment of the structure (Peinetti et al., 2020). The other experimented variables concern essentially the kind of processing food (bread, unleavened bread or meat) and the kind of cooking activity and associated tools (foods cooked in direct contact with heated surfaces or using of cooking lids, spits, andirons and cooking vessels). In one case, the functioning temperatures of an oven were measured with thermocouples (Cattani et al., 2015b). The use wear traces and the decaying processes after the abandonment of structures have been regularly documented (Peinetti et al., 2020).

Then, the synergy of data from archaeological, geoarchaeological

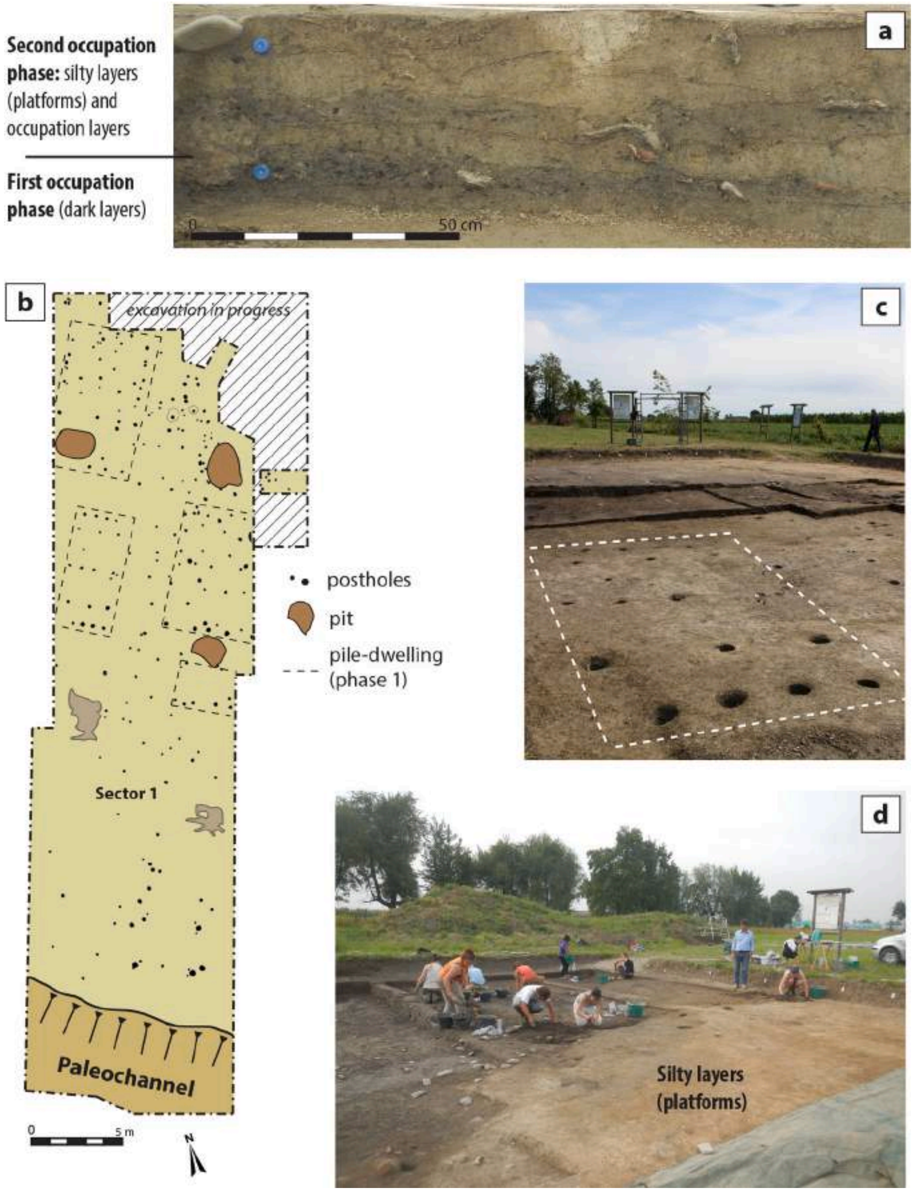

Fig. 6. Bronze Age settlement of Via Ordiere – Solarolo, sector 1: (a) eastern section showing the stratification; (b) plan of sector 1 during the first occupation phase; (c) postholes materialising a pile-dwelling house; (d) silty platforms of the second occupation phase.

and experimental archaeological analysis helps to characterize the fire-related structures throughout typological, technological and functional points of view in their context.

3.2. *Typological, technological and functional analysis*

First of all, the typological approach is used to classify the different types of structures found during the field activities in terms of shape, size and articulation (e.g. Balossi Restelli, 2015; Cavulli, 2008; Cazzella and Recchia, 2008; Costa et al., 2019; Frère-Sautot, 2003; Gascó, 2003; Peinetti et al., 2019; Prévost-Dermarkar, 2002).

The technological analysis is used to document the choice of construction materials for the structures, their preparation and the techniques used for their installation. This approach is particularly developed for earthen fire-related structures (hearths and ovens realised with earthen materials). The first step consists of a macroscopic characterization of raw materials and technological markers (Peinetti, 2016). Then, soil micromorphology is a powerful tool which can be used to characterize the whole *chaîne opératoire* of construction of earthen fire installations (Bassetti and Degasperi, 2002; Germain-Vallée et al., 2011; Peinetti et al., 2018). In this case, the principles of interpretation are borrowed from the technological analysis of earthen architectures and daub fragments in micromorphology (e.g. Cammas, 2018; Friesem et al., 2017; Karkanas, 2019; Onfray, 2012; Wattez, 2003).

The functional analysis is developed through the observation of use wear traces on structures and their combustion assemblage (e.g. Conati Barbaro et al., 2021; Costa et al., 2019; D'Oronzo, 2019; Gascó, 2003), but also the analyses of artifacts that were used in association with hearths (e.g. Balossi Restelli, 2015; Cazzella and Recchia, 2009; Debandi and Magrì, 2021) or the micromorphological characterisation of combustion residues (Braadbaart et al., 2012; Canti, 2003; Villagran et al., 2011; Wattez, 1988, 1992). Moreover, the stratigraphic and micro-stratigraphic record of fire-related structures highlights their life history in deep and enabling the inference on formation processes related to their use and abandonment (Aldeias et al., 2016; Mallol et al., 2017; Matarazzo et al., 2017; Mentzer, 2014; Wattez, 1996, 2004).

The typological, technological and functional aspects, although analysed separately through different disciplines, are closely interrelated (e.g. the shape is partly representative of functional aspects and technological constraints related to the construction and use of the structure). The contextual analysis of fire-related structures opens the perspective to analyse the diachronic evolution inside the life of the settlements, the variability of the combustion features and the use of space in relation to the fire-related activities (Cavulli, 2008; Cazzella and Recchia, 2008; Degasperi, 2019). All these approaches are mutually supportive. Finally, the analysis of fire installations could help to define socio-economic structures and tell us something about the size or the organisation of the social groups using them.

4. Results

Four examples that show the results of different analytical approaches and allow addressing different issues related to the interpretation of combustion structures have been selected, according to specific problems posed by the two sites of Mursia and Via Ordiere. They address, in the case of Mursia, the issues of the complementarity and evolution of fire installation and their equipment within the same site, but also the techniques for building and using these structures. In the case of Via Ordiere, they treat of the characterizations of domestic combustion activities through the analysis of waste residual, or through the analysis of use and decaying processes of installations, when hearths and ovens are poorly visible or preserved.

4.1. *Mursia: The typo-functional variability of fire installations*

The excellent preservation of the built space in Mursia allows illustrating in detail the structured fire installations of the site, classified in four main types (Fig. 7): the hearth made of four vertical stone slabs ("lithic *cist*"); the stone oven; the hearth built with a stone slab laying horizontally and, finally, the clay hearth (Debandi et al., 2019).

The most recurrent structure is the so-called "lithic *cist*". The four stone slabs are placed vertically to form a rectangular case of small size, from 25 to 60 cm of side length (Fig. 7, a). This kind of structure is systematically anchored in a pit, with slabs originally protruding 15–30 cm above the floor level. The slabs are gradually covered on the sides by successive layers of floor resurfacing. This shows that the same lithic *cist* was used for a long time and reused during several life stages of the same building. The stone chosen for the construction of these structures is

Fig. 7. Mursia: main types of fire installations of the site: (a) lithic *cist*, associated to postholes (hut B14); (b) stone oven (hut B15, phase 2, courtyard); (c) hearth built with a stone slab laying horizontally on the floor (hut B14); (d) clay hearth with slightly concave surface and sub-vertical smoothed edges (hut D15); (e) clay hearth with slightly concave surface and rounded smoothed edges (hut B12); (f) clay hearth with flat surface (room F1, excavation of the clay surface in progress).

mostly the Pantelleritic Ignimbrite, suitable for making slabs due to its oriented fabric. This kind of installation was used to manage the fire in a confined environment, allowing it to control the combustion and prevent it from spreading and causing fire spreading. The structure may have served to produce embers or heating and lighting the house. It is also possible that was directly used for processing food (e.g. smoking products, arranging cooking vessels above the embers or using the hot walls of the slabs to bake flatbread). Its use as fire installation is attested by the infill layers, made of ash and charcoal, but also by traces of thermal alteration and soot on the slabs.

The bottom of these hearths was regularly cleaned and raked out. This was confirmed by the discovery of a small shovel made of a cattle bone scapula (Fig. 8, a), bearing rubbing marks at its end, found in the hut B14 next to a lithic *cist*. In one case (hut B13 south), a lithic lid with a handle was also found near a lithic *cist*. It was used to cap the structure and perhaps to conserve heat inside (Magri, 2015). Another main aspect to investigate is also the way to manage the smoke inside the buildings. In the hut B14, for example, four post holes around the hearth (Fig. 7, a) suggest the presence of a kind of hood or a chimney (Debandi, 2015). This wooden structure could also be used to suspend some equipment above the hearth, maybe related to food processing.

Generally, one lithic *cist* is present in each building or room. However, in some cases up to three lithic *cists* are present (Debandi et al., 2019). Even if the most of these structures are placed indoor, some examples of hearths made in external courtyard areas are also known, for example in the zone occupied by the hut B13 (Magri, 2015). The occurrences of lithic *cist* characterize the whole lifespan of the site (Table 1). Effectively, this hearth constructed with four stone slabs is a very diagnostic architectural feature of Mursia, comparable with some hearts recovered in Haghia Photinì and Kommos in Crete (Palio, 2001). This element confirms the close relations between Pantelleria and the Mediterranean, already visible in the material culture of the site. Similar structures are also known in Southern Italy, e.g., at Coppa Nevigata or at the Bronze Age settlements of Eolie Islands (Cazzella and Recchia, 2008).

The stone oven seems to be a kind of variant of the lithic *cist*. In this case five or more vertically slabs form a circular structure, with an outer diameter of about 1–1.20 m (Fig. 7, b). The presence of a lateral opening would also suggest the presence of a possible vault-covering, although no trace of the latter was clearly found. The materials used to realise the perimeter of this kind of oven are both Pantelleritic Ignimbrite and effusive rhyolitic lavas. Only two occurrences from sectors B and F allow documenting this kind of installation, always placed in external area dated to the middle and last phases of the site. The absence of strong thermal alterations and the relatively small size suggest a domestic use of these structures, related to food preparation.

The open hearths made of an ignimbrite slab placed horizontally on the floor are typical of the first occupation phase (Fig. 7, c; Table 1). They always take place in close proximity to the lithic *cist* (Fig. 8, b). This association suggest that the use of the two structures was complementary. The main function of the earth constructed with four stone slabs could be the managing of the fire and the production of embers. Then, the embers were moved on the open hearth, where most of the cooking activities were carried out. The horizontal slabs are rectangular, trapezoidal, oval or more rarely circular, with sizes ranging from 40 to 80 cm, and they are often covered by a thin earthen plaster (at most 1 cm thick), reddened by the impact of fire.

During the life of the village, the clay hearths (also called “cooking plate” to translate the Italian term *piastra di cottura*) gradually replace the hearths made with a horizontal stone slab (Table 1). The foundations of these new structures are made of carefully juxtaposed ryolithic pebbles collected in a coastal environment, lapilli or potsherds, placed on the floor of the buildings. The top and the edges of this low foundation platform is covered by a clay coating, 1 to 3 cm thick, carefully smoothed on the surface (Fig. 7, d-f). The regularity and homogeneity of the thermal alteration on the surfaces suggest that consolidation of the clay layer had occurred during the setting up of the structure and that is not merely due to its simple use. These hearths are generally sub-circular, with diameters varying from 60 to 150 cm. The most widespread model have a slightly concave surface and sub-vertical smoothed edges (Fig. 7, d-e), even if in the last occupation phases (e.g. in the room F1, Fig. 7, f) some clay hearth are characterised by a flat surface that

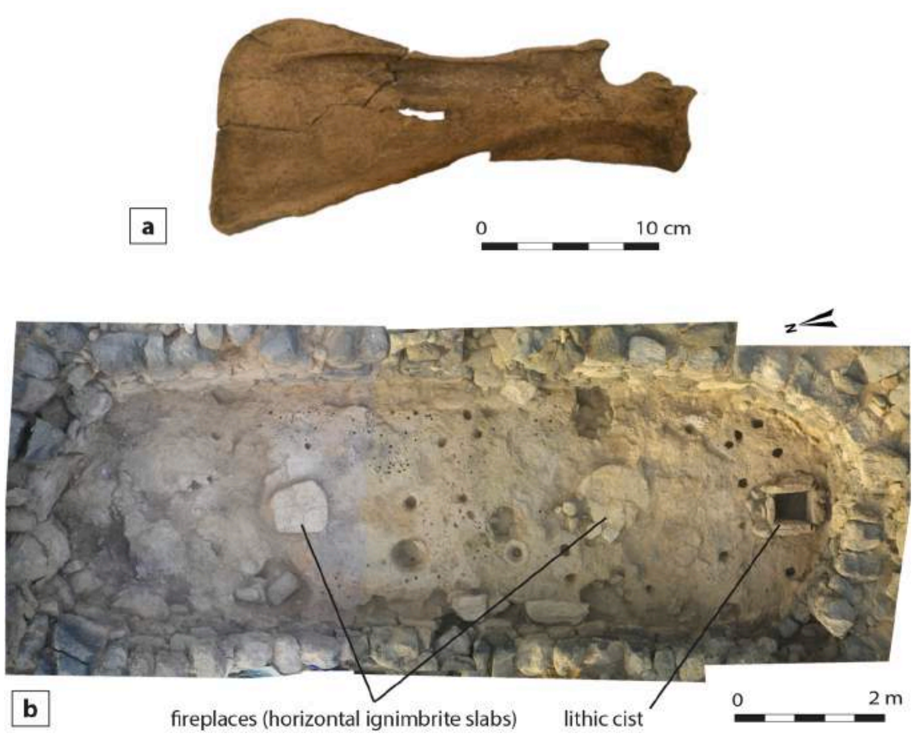

Fig. 8. (a) Shovel made of a cow bone scapula; (b) zenithal view of Hut B14, showing the association between lithic *cists*and two hearths built with a stone slab laying horizontally on the floor.

Table 1
Mursia: presence of different kind of fire installation in a selected sample of built spaces from different occupation phases of the village.

	Hut/Area (and eventual building phase)	Built surface (m^2)	Number of fire installation in each built space			
			Lithic *cist*	Stone oven	Stone hearth (horizontal slab)	Clay hearth / Cooking plate
Macro phase I	B1 (phase 1)	18	2			
	B1 (phase 2)	18	1		1	
	B2	15	2			
	B3	28	1			
	B13 South	17	1			1
	B14 (phase 1)	31	1		2	
	B14 (phase 3)	31	1			
	B15 (phase 1)	20	1/double			
	D7	29	1		1	
	D14	23	1			1
	D16	11	1			1
	D17	13,5				1
Macro phase II-III	Area Nord sector B (courtyard)	–	1			
	B15 (phase 2) (courtyard?)	20		1		1
	D15	16				1
	DIII	12				1
Macro phase III (before abandonment)	B5	12				2
	B7	17				1
	B8	45	1			
	B10	48	1			
	B12	23				2
	E2	15				2
	E3	48				1
	F1	10	1			2
	F3 (courtyard?)	N.D.		1		

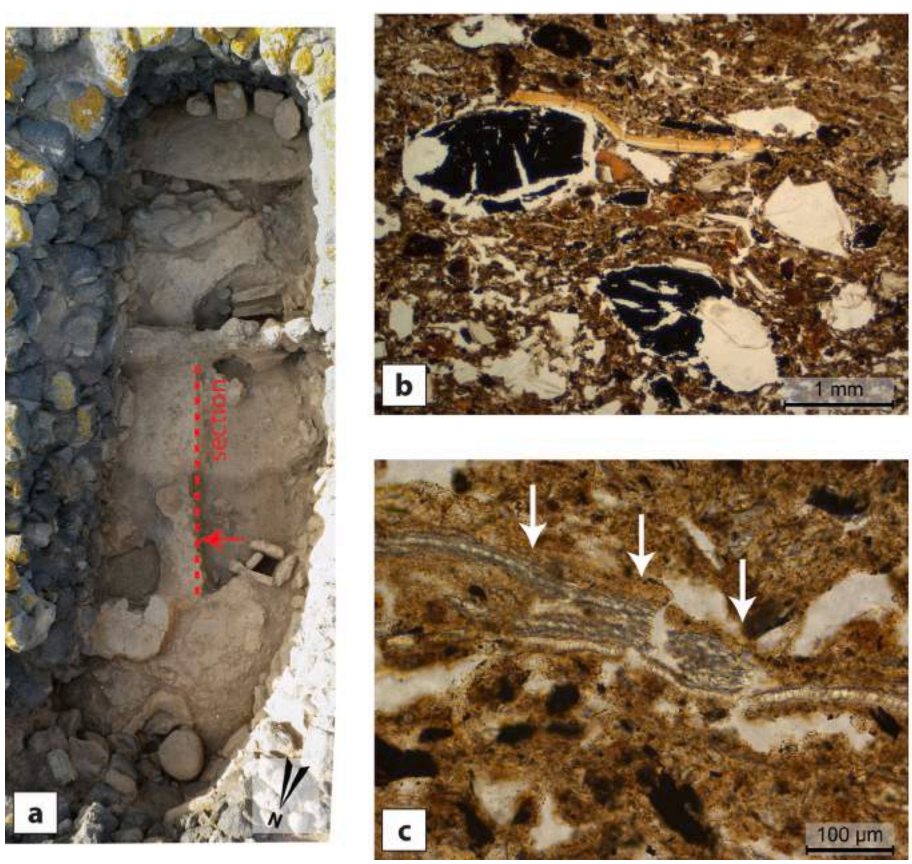

Fig. 9. Micromorphological analysis of domestic sequences of the hut B1: (a) location of the micromorphological sample documenting domestic floors in the vicinity of a lithic *cist*; (b) occupation surface with trampled micro-charcoals, charred cereal grains and heated fishscales and bone fragments; (c) occupation surface with interconnected phytoliths (arrows).

slopes gently towards the edge (Cattani et al., 2015b; Debandi et al., 2019). With regard to the location of these hearths, they are often leaning against a wall inside the buildings. They can be associated with lithic *cist* or be the only fire installation within a room (Table 1). In some buildings belonging to the middle and last occupation phases of the village, as in huts B5, E2 and F1, two clay hearths can be used simultaneously in the same space. Given the small size of these buildings (less than 15 m^2), the presence of several clay hearths suggests a specialised use of the space as kitchen area. This hypothesis is supported by the presence of other equipment dedicated to food processing, such as mortars and cooking vessel abandoned *in situ*.

The contextual analysis of all domestic fire installations shows a strong typo-functional variability, with the coexistence of different types of structures suggesting a functional complementarity between them, as well as a typological evolution over time. While these installations are polyfunctional and complementary, it is, however, difficult to determine the exact type of products processed because of the intense cleaning of their surfaces. In this regard, the microstratigraphy of associated occupation surfaces can help defining their functional context, through the characterization of trampled micro-residues lost during cleaning activities of hearths and, more generally, the use of space (nature and rhythms of activities). For example, occupation surfaces located next to a lithic *cist* in the hut B1 of Mursia (Fig. 9, a) are characterised by sub-horizontal fissures and an oriented distribution of the coarse fraction parallel to the surface, documenting high trampling. The activity residues of micrometric to millimetre size are abundant and refer to the integration of combustion residues in the activity surface: 10–20% of micro-charcoals; 2–5% of fishscales and bone fragments only partially altered by fire; two isolated charred cereal grain (Fig. 9, b). The nature and the amount of micro-residues confirms the domestic use of this space, devoted to food processing and consumption activities (see also Debandi et al., 2021; Peinetti, 2021). It shows the range of eaten foods, although those of vegetal origin remain underrepresented. These micro-residues are associated with lenses of interconnected or partially fragmented phytolits, interpreted as remains of mats (Matthews et al., 1997) attesting sitting areas around the fire installations (Fig. 9, c). This set of evidence materializes the internal organization of the building and the practices associated with the gathering of the family unit during meal consumption.

4.2. Mursia: Technological and functional aspects of cooking plates

Cooking plates constitute one of the characteristics and most common structural elements within Mursia buildings (Debandi et al., 2019). However, it is possible to note some variability in their morphologies and construction techniques through preliminary analysis of six cooking plates from different building and occupation phases of the village (Tables 2-3). The strongest variability is in the materials selected for foundation construction: potsherds or lithic elements (stone, pebbles, gravels and pyroclastic scoria from deposits outcropping in the vicinity of the site), assembled in very different ways and with different associations. On the contrary, the earthen surface is always made with clayey materials, but the percentage of mineral inclusions varies (fine to coarse sands, 10 to 30% on average). In the case of a cooking plate from hut D14 the distribution of sands is clearly bimodal, suggesting a possible addition of the coarser fraction. The micromorphological analysis of two cooking plates from sector F shows that the surface is built with reddish clay material (Fig. 10), containing alkalin feldspath, quartz, clinopyroxenes, aenigmatite and aegirine (Peinetti, 2021). These raw materials come from deposits of so-called “red clays”, formed by the hydrothermal alteration of trachytic and rhyolitic lavas and available in geological formations located 5 to 8 km from the site (Montana et al., 2007) (Fig. 3).

The sedimentary structure of the earthen surfaces appears to be quite massive when clay was carefully mixed or more granular, even if formed by strongly coalescent aggregates, when the mixing process of the sediments has been less thorough (Peinetti, 2016). The sub-horizontal porosity indicates a strong compaction of mixed sediments during the manufacturing of the earthen surface. The addition of vegetal temper is not clearly attested, except in a border of one cooking plate from sector D, which bears clear imprints of grass fibers (Table 2).

Another element of variability is the size of the plates, but also the shape of the surfaces, although those with a slightly concave surface are far more numerous. This slightly concave surface could have a functional purpose, aimed for example at better containing embers and thus heat within the structure. On the other hand, cooking plates with a flat surface and slightly inclined edges could facilitate the evacuation of embers towards the outside of the hotplate, offering different possibilities for managing the combustion process and thus the cooking of food. The micromorphological analysis of a cooking plate from room F1, belonging to the second type, characterised by a flat surface, highlights

Table 2
Mursia, sector D: main typological and technological characteristics of cooking plates from the earlier and middle phases of the village.

			Location of earthen cooking plates (Huts)			
			Sector D	D15	D14	D5
Earthen cooking plate (characteristics)	***Typology***	***Shape***	Sub-circular, slightly concave surface, sub-vertical edges	Sub-circular, slightly concave surface, sub-vertical edges	Oval with one side leaning against a vertical slab, slightly concave surface, edge of the west side more raised, vertical edges	Sub-circular, slightly concave surface, sub-vertical edges
		Size	120 cm	106 cm	100 × 130 cm	110 cm
	Foundation layer		Mix of lapilli, sub-angular gravels and pebbles (6–8 cm size)	Outer curb: ryolithic stones (6–7 cm size). Centre: mixed pumice and lapilli.	Outer curb: ryolithic stones (8–20 cm size), Centre: gravel, lapilli and rare potsherds.	Mix of lapilli and sub-angular gravels
	Earthen surface coating	***Thickness***	1–2 cm	1–3 cm	0.5 – 1 cm	1–2 cm
		Texture	Clayey, 15% coarse sand, 10% medium sand	Clayey, 10% coarse sand, 10% medium sand	Clayey, 20% coarse sand, 15% fine sand	Clayey, 5–10% coarse sand, 20% medium-fine sand
		Sedimentary structure	Dense granular, massive near the surface	Massive, horizontal fissures	Massive, horizontal fissures	Dense granular, massive near the surface
		Vegetal inclusion	Occasional impression of elongated fine fibers (2–5 mm)	No	Impression of chaff (only on the west border)	No
		Color	2.5YR 4/8	5YR5/8	2.5YR 5/8	5YR5/6

Table 3
Mursia, sector B and F: main typological and technological characteristics of cooking plates from the later phases of the village.

			Location of earthen cooking plates (Huts)	
			B12	F1 (US 24)
Earthen cooking plate (characteristics)	***Typology***	***Shape***	Sub-circular, slightly concave surface, sub-vertical edges	Sub-trapezoidal with rounded corners, flat surface at the center that slopes gently towards the edge. Poor edge preservation
		Size	75 cm	80 × 120 cm
	Foundation layer		Potsherds and pebbles (4–5 cm size)	Potsherds, pebbles (4–5 cm size) and sub-angular gravels
	Earthen surface coating	***Thickness***	1.5 – 2.5 cm	1–2 cm
		Texture	Clayey, 5% coarse sand, 20% fine-medium sand	Clayey, 10% coarse sand, 15% fine-medium sand
		Sedimentary structure	Dense granular, massive near the surface	Massive, horizontal fissures
		Vegetal inclusion	No	No
		Color	5YR5/6	5YR5/8

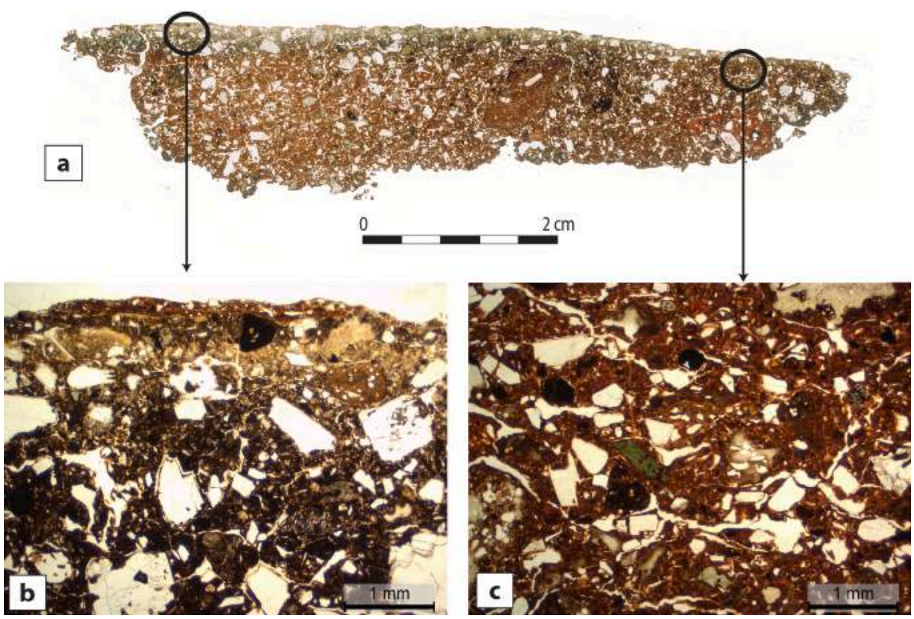

Fig. 10. Cooking plate (US 42) of the room F1: (a) thin section scan of the micromorphological sample from the clay surface; (b) grey-brown clay fraction at the centre of the hearth; (c) reddish-brown clay fraction moving outwards of the hearth.

some functional aspects. Thermal alteration impacts most intensely on the upper 5 mm of the surface coating, where the clay component shows a total loss of birefringence (T = 500–600 °C, see Wattez, 1992). Lateral variations in the expression of the combustion medium are however observable on the surface. In plane polarized light, the clay fraction appears grey-brown towards the center of the hearth (semi-reducing conditions), while moving outwards it is red to reddish-brown (oxidising to semi-oxidising conditions) (Fig. 10, b-c). This variation could be casual and related to the complex repeated use cycles of the hearth, which impact the surface differently, or it could reflect patterns in fuel management. The rather semi-reducing environment recorded towards the center of the hearth can indeed be explained by a recurrent positioning reserved for embers contained between andirons, limiting the oxygenation of this zone of the hearth's operating surface.

These types of variations, linked to the use of specific equipment in the management of fire and cooking activities, are observable through experiments conducted on cooking plates (Cattani et al., 2015b; Peinetti et al., 2020): the repeated use of andirons, systematically positioned in the same location, produced chromatic variability of the surfaces after several cooking cycles. Another interesting case of chromatic variability of the surfaces is observed on a cooking plate used for bread baking with a ceramic "cooking lid". In this case, the experimental activity was concentrated on one day, with several baking cycles. One month later, a circular area with very little alteration was still observed at the location of the cooking lid, surrounded by a crown characterised by blackish to reddish spots where the fuel was placed (Fig. 11,a-b).

Although food could be cooked in direct contact with the heated surface of the cooking plate, andirons used as supports for cooking vessels above the embers and cooking lids are extremely common in Mursia (Cattani et al., 2015b; Debandi and Magrì, 2021) (Fig. 11, c). Their recurrent use can therefore leave traces on the cooking plates, although long use and recurring cleaning can make these traces scarcely visible.

4.3. Via Ordiere-Solarolo: Documenting domestic fire-related activities from refuse disposal associated to pile-dwelling houses

Concerning the site of via Ordiere, there is no evidence of fire installations preserved *in situ* during the first occupation phases (around 1550–1500 BC). This is due to the fact that most of the hearths and ovens were probably located above the wooden floor of pile-dwelling houses and that the few hearths outside the dwellings left ephemeral traces.

Nevertheless, the micromorphological analysis of the thick dark layers associated to the pile-dwellings of the first occupation phase

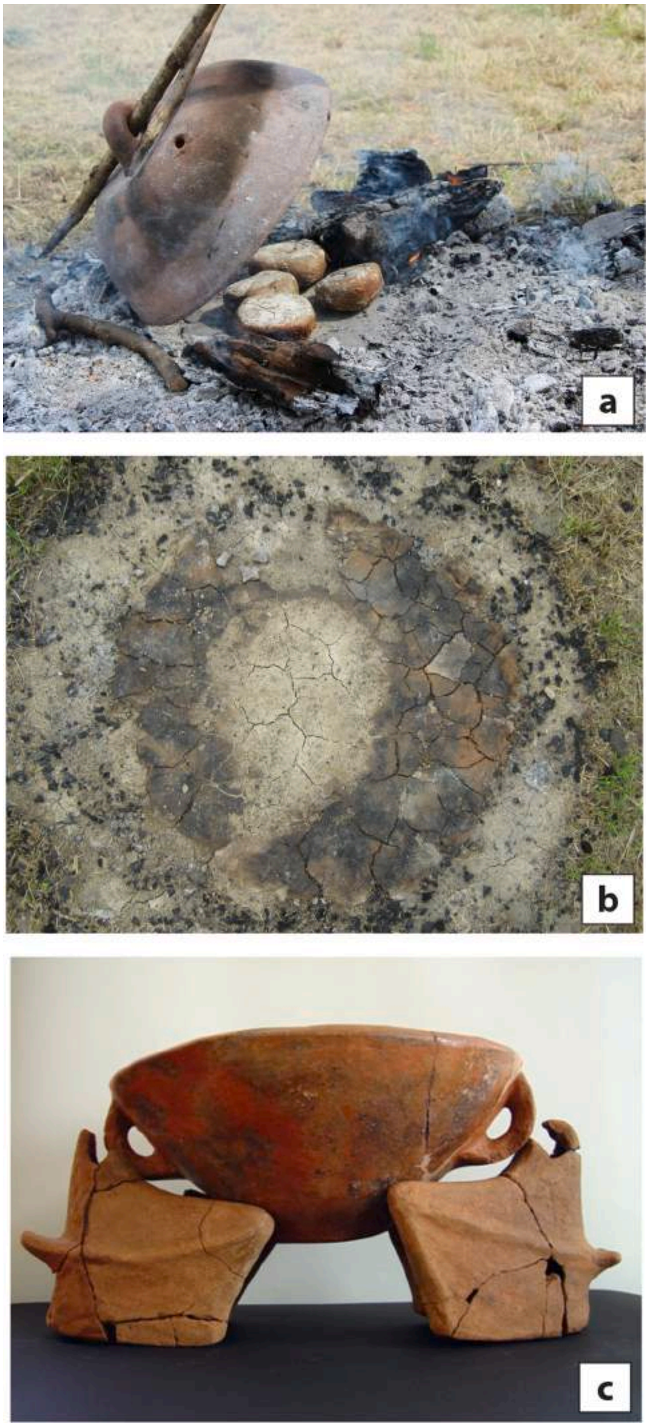

Fig. 11. (a) Experimental use of a cooking bell to bake bread; (b) black and red halo leaved on the earthen surface of a cooking plate by the repeated use of a cooking bell (1 month after the food processing); (c) andirons and cooking vessel found in Mursia. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

shows that they are the results of regular waste dumping and, to a lesser extent, of backfills and mechanical redistribution of domestic refuses (Peinetti, 2021). A diversification in waste management has been observed through micro-facies analysis: if some waste areas are characterised by heterogeneous domestic waste or by the accumulation of organic matter alone, other areas are especially reserved for products from the cleaning of domestic hearths and ovens (Fig. 12). These last micro-facies are organised in a rather bedded way. They are clusters of lenses made up mainly of residues from activities related to the use of fire, which materialise areas of accumulation of residues strictly related to the cleaning of domestic and culinary fireplaces.

Each bed, identified as a microstratigraphic unit with homogeneous and continuous characteristics, corresponds to a single cleaning (or to a series of cleanings) of hearths made up of constituents of the same nature. Among the micro-facies dominated by combustion residues, further distinctions can be made on the basis of their composition (Table 4):

- Micro-facies composed of heterogeneous combustion residues;
- Micro-facies dominated by burnt earth fragments;
- Micro-facies characterised by the presence of charred chaff;
- Micro-facies dominated by ash.

The micro-facies composed of heterogeneous combustion residues are particularly made up of aggregates of wood and herbaceous ashes (prismatic calcite pseudomorphs, silica remains of grass fragments, see Canti, 2003; Canti and Brochier, 2017; Wattez, 1988, 1992), charred plant tissues and charcoals of millimetre or more rarely close to centimetre size (Fig. 13, a-c). They seem to correspond to regular cleaning of hearths. The occasional inclusion of small fragments of burnt earth, close to a millimetre in size, is the result of the rake out of the earthen surfaces of the hearths during the cleaning process. The rare fragments of burnt bone attest to cooking activities of meat (Fig. 13, c).

The micro-facies dominated by burnt earth fragments (Fig. 13, d) mark particular moments in the history of the accumulations and are probably linked to *ad hoc* maintenance activities of the hearths (Schiffer, 1987), for example the partial dismantling and repair of the hearth and ovens or their replacement with new installations. The presence of coarse daub fragments (0.5–1 cm in cross-section or more), showing a variable degree of thermal alteration, characterises these micro-facies. The ash and micro-charcoal mixed with these residues are partly the result of the filling of the interstices between the coarser, weakly accommodated daub fragments.

The micro-facies characterised by chaff remains show an abundance of weakly charred *Gramineae* husk and steams (20–40%), associated with occasional charred cereal grain remains (Fig. 13, e-f). These residues are mixed with wood ash (30–50%) and rarer fragments of silica remains of grass (Fig. 13, g). Such an assemblage could be the result of a simple combustion, using herbaceous material as fuel in association with wood. However, each type of constituent shows a different degree of thermal alteration, in a fairly systematic way, with an assemblage of bimodal character. In fact, the woody species are characterised by complete incineration at temperatures between 450° and 700° (wood ashes with grey crystalline, lumpy white crystalline or cryptocrystalline fabrics with high birefringence, see Wattez, 1988, 1992), whereas the wood charcoal (T = 300–350° C, Wattez, 1992) is sporadic or absent. On the other hand, the remains of grass husks are characterised by a mostly incomplete carbonisation process, which attests to temperatures equal to or lower than 300° C (Wattez, 1992; Nicosia and Canti, 2017). Siliceous slags, corresponding to high temperature melted grasses (Canti and Brochier, 2017), are occasional (Fig. 13, g). Such recurrences suggest that these micro-facies may be the result of the cleaning of a fire installation after a specific activity. The most likely hypothesis is the roasting and drying of cereal grains to separate them from their husks, using wood as fuel. During this operation, the cereal products to be processed are not placed in direct contact with the fire and are moderately to slightly altered by the heat (weakly charred chaff). The charring of some grains can be seen as an accidental phenomenon in the process and the presence of silica slags may correspond to the remains of grass that has occasionally fallen into the fire.

Finally, the ash-dominated micro-facies are composed almost exclusively of crystalline or cryptocrystalline wood ash, mixed with very rare carbonised fibres (Fig. 13, h). They are evidence of the complete combustion of woody species.

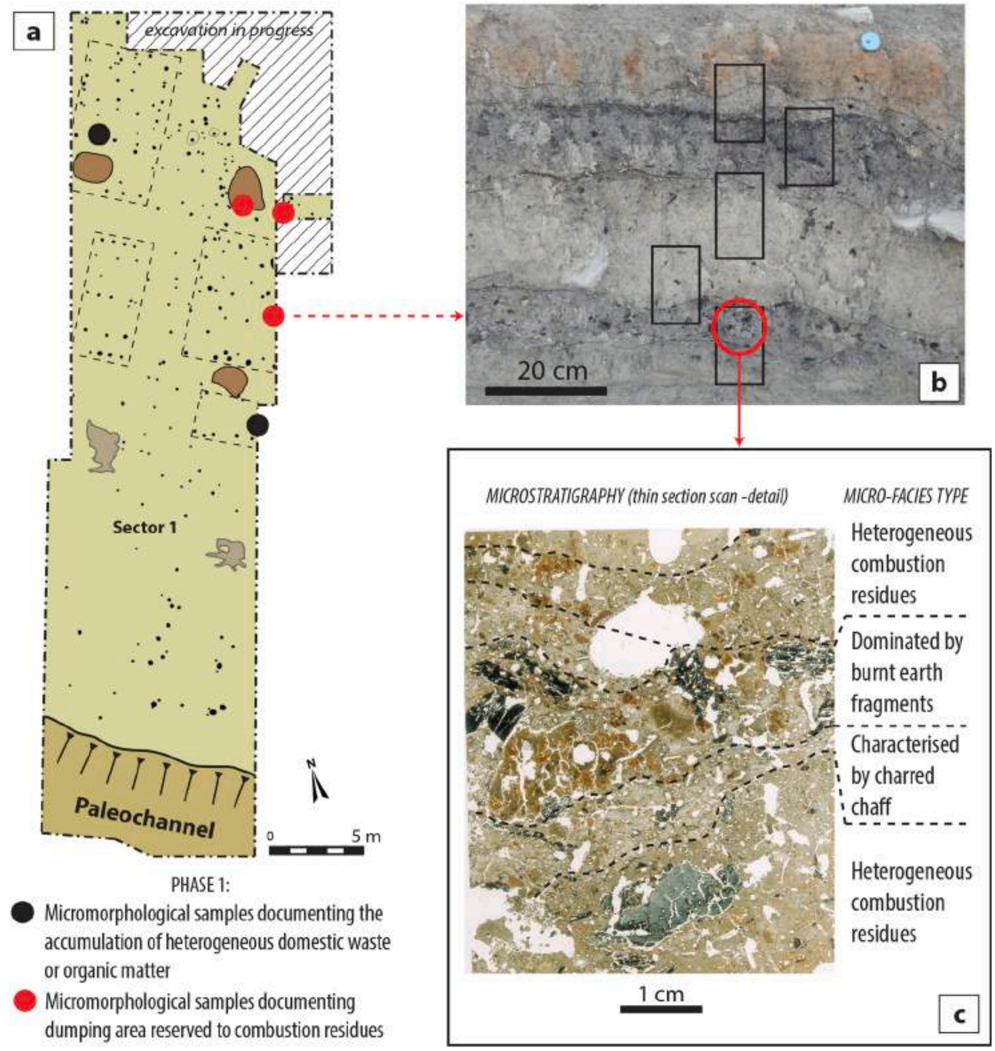

Fig. 12. Microstratigraphic analysis of the dark layers of Via Ordiere (first occupation phase), formed by waste accumulation: (a) location of the samples documenting waste accumulation; (b) stratigraphic section with localisation of micromorphological sample and, at the bottom, the dark layers functioning with pile-dwelling houses; (c) microstratigraphy of accumulation of combustion residues.

Table 4
Constituents of the four types of micro-facies dominated by combustion residues. Key: occasional or very rare, max. 1% (-); rare 2–5% (+); common 5–15% (++); abundant + 20% (+++); dominant + 50% (++++).

	Micro-facies composed of heterogeneous combustion residues	Micro-facies characterised by the presence of charred chaff	Micro-facies dominated by burnt earth fragments	Micro-facies dominated by ash
Wood charcoal	+++	−/+	++/+++	−/+
Wood ashes (crystalline fabric)	++/+++	+++	+/++	+++/++++
Wood ashes (cryptocrystalline fabric)	++	++	+/++	+++/++++
Charred / weakly charred chaff	-/+	+++	–	–
Charred cereal grains	-/+	+	–	–
Silica slag and silica remains of plant fragments	+/++	+	-/+	+
Burnt earth fragments	+/++	−/+	++++	-/+
Burnt bone	+	–	-/+	-/+

These different types of micro-facies dominated by combustion residues reflect the different uses of domestic fire (fuel, products processed) and the management of fireplaces in a context where the fire installations themselves are not directly known. Just some constructed floor fragments, found in the waste accumulations, show the traces of fire and an ashy crust formed by repeated combustions and cleanings of the structure, suggesting that these fragments were part of structured flat hearth, built with earthen materials. They are made with a mix of silty and sandy loam sediments, poorly homogenized and heavily beaten to create a smooth surface (Peinetti et al., 2018). Their surface is sometimes characterised by the presence of a blackish to orange-brown residue, similar to meat cooking residues observed during experiments (Peinetti et al., 2020).

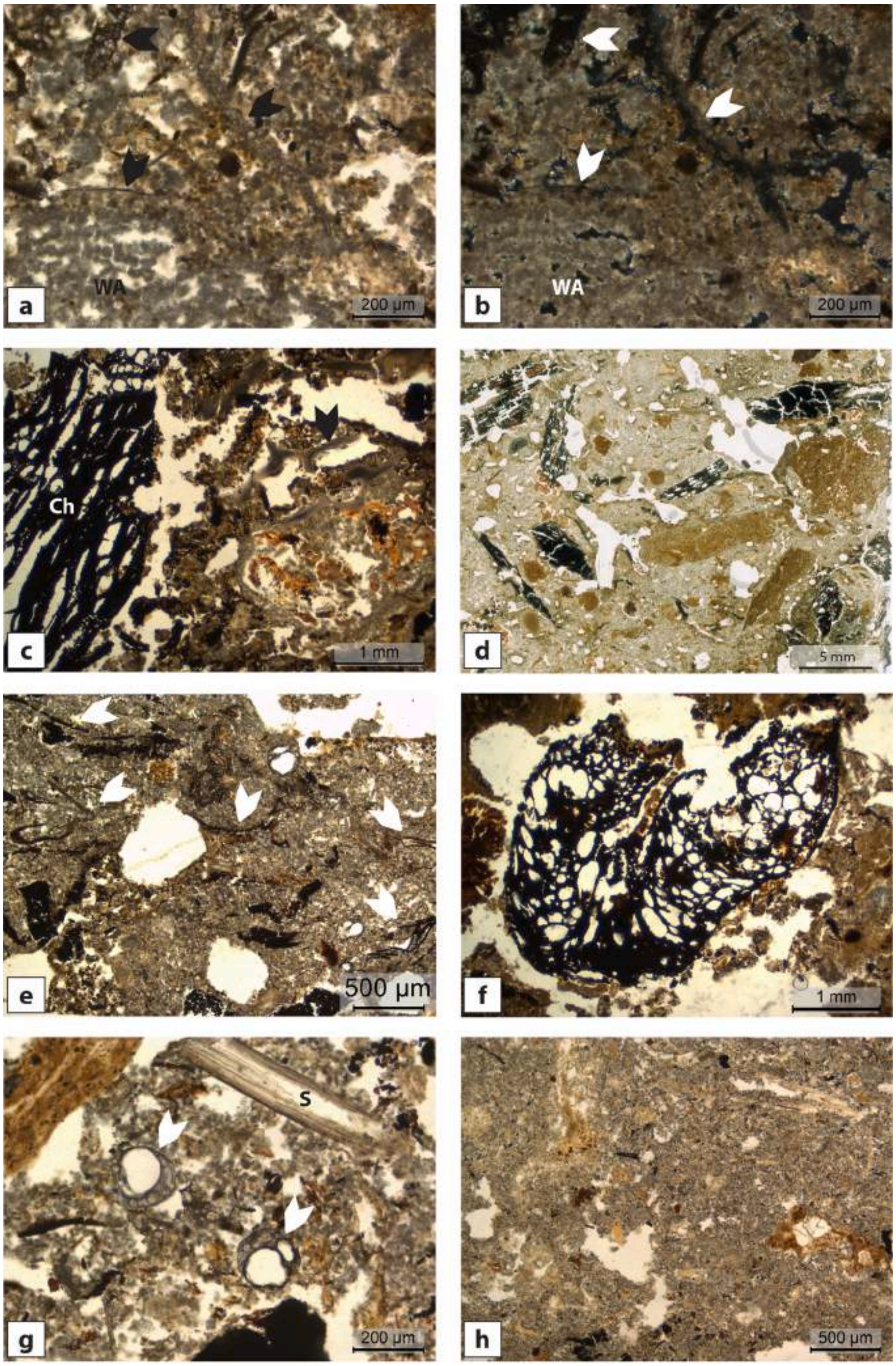

Fig. 13. Constituents of different sub-type of micro-facies documenting the accumulation of combustion residues: (a-b) aggregates of wooden ashes (WA) associated with amorphous silica remains of plant fragments (arrows), dark in PPL; (c) charcoal (Ch) and heated bone fragment (arrow); (d) micro-facies dominated by burnt earth fragments, embedded in a ashy groundmass with charcoals; (e) micro-facies characterised by the presence of charred chaff (arrows); (f) charred cereal grain; (g) silica slags and silica remains of grass steam fragment; (h) wood ashes with crystalline fabric.

4.4. Via Ordiere-Solarolo: Different kind of earthen firing structures and experimental focus on earthen ovens

In later occupation phases of the sector 1 of Via Ordiere (around 1500–1450 BCE), two kinds of fire installations take place on the earthen platforms occupied by dwellings with ground-floor. The first are structured hearths made with a thin layer of earth, without foundations, circular in shape, flat in the centre and slightly convex towards the edges (Fig. 14, a-b). Carefully mixed clayey sediments are regularly used to make them, instead of all other earthen building materials which are of loamy texture. The inclusion of blackish vegetal fragments observed in thin section, 50–200 µm of size and altered by fire, suggest that clay sediments were extracted from settling deposits of swampy environment.

The remains of a combustion structure (US 448), interpreted as an oven, were also found inside a dwelling with earthen floors, next to a cooking plate (Fig. 14, c). It is a shallow oval-shaped pit, 1.5 to 1.7 m of length and 1.2 m large, characterized by traces of thermal alteration on the walls. The filling is composed by charcoal remains and few pottery fragments, covered with partially fired sediments of loamy texture. The latter were interpreted on the field as the degradation of the oven vault. Associated to this feature are a thin layer of ash, a layer of yellow silt interpreted as a floor refurbishing and few post holes, that seem to encircle an inner zone of the dwelling. Next to the fire installation, a thick reddish layer has been interpreted as the dumping of combustion residues or the result of its partial demolition. The set of deposits

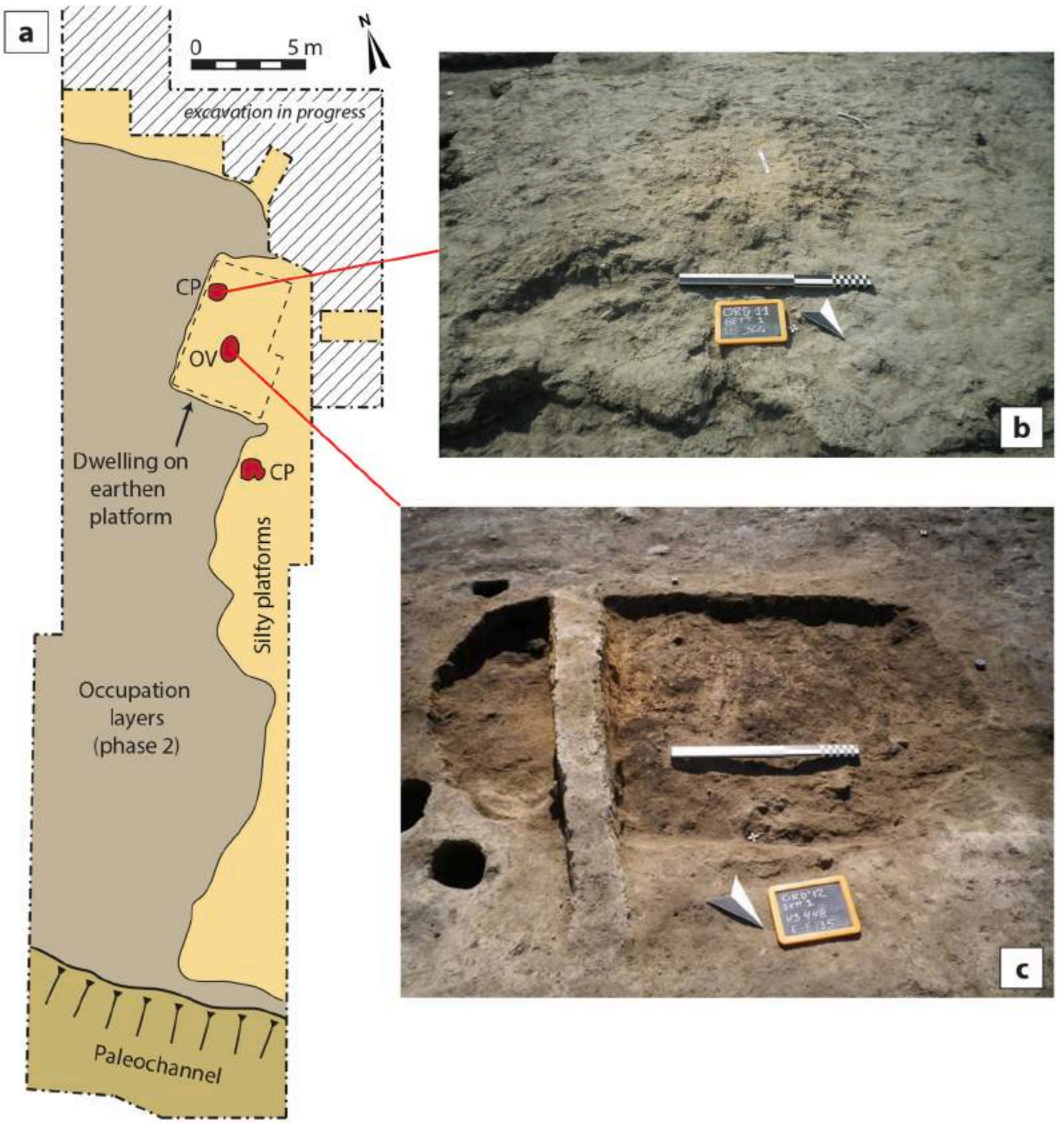

Fig. 14. Via Ordiere – Solarolo: (a) plan of the second occupation phase, with location of the cooking plates and a oven built on earthen silty platforms; (b) floor of a silty platform and flat cooking platform with poorly preserved edges; (c) shallow oval-shaped pit with charcoal lenses, interpreted as the base of an oven.

associated with the shallow pit structure thus supports the hypothesis that it may be an oven, although the functional traces remain faint due to the transformations that followed its degradation or demolition. Despite the poor preservation, the most suitable interpretation is that of an oven for domestic use. In order to test if the low thermal alteration of sediments coming from an oven dome is compatible with what has been observed on the field, but also to test the building techniques and functioning of such structures, a series of experiments was carried out (Peinetti et al., 2020).

A first experimental project was carried out based on the model of a well-preserved oval oven found at the Early Bronze Age village of Nola-Croce del Papa near Naples, in the building n. 3 (Albore Livadie et al., 2005; Albore Livadie and Vecchio, 2020). This earthen domed oven is one of the best-preserved examples of the Italian Bronze Age, because the village have been buried by a pyroclastic flow. In this case, the dome is still preserved on a height of 60 cm, without chimney. The oval plan has a length of 98 cm. Although this oven is smaller in size than the one at Via Ordiere, it therefore constitutes an excellent starting point for the development of an experiment focusing on use and decay processes of such structures. Then, an experimental replica of the Nola's oven was made, reproducing the morphological characteristics of the starting model (Cattani et al., 2015b).

The oval-shaped experimental oven was equipped with potsherd foundation and earthen firing surface and vault. The walls and vault were assembled by direct shaping, mounting overlapping bands of daub thick 3 to 5 cm (Fig. 15). The bands were prepared from moderately homogenized silty sediments to which short straw fibers was added, then assembled and overlapped when the earth was still in a plastic state. The oven has no chimney but has been fitted with a sort of cupel at the top, attested at Nola and whose function is still doubtful. After his drying, the oven was repetitively used to bake bread over three years (Fig. 15, c-d). During the process of heating the oven and baking the bread, the temperatures were measured at different points in the structure, both inside and outside (Fig. 16). At the beginning, the fire raises temperatures up to 400 °C in the vicinity of the point of combustion. After removing fuel residues and temperature reaching less than 250 °C, the oven is ready to bake bread. On the other hand, the control of the heat is more difficult when the embers are left inside the oven during the baking process. Bread baking is generally completed in 20 min. The experiment show that the cooking surface slowly releases the accumulated heat and maintains a constant temperature (200 to 150 °C) throughout the whole cooking process (Fig. 16). After abandonment, the slow degradation of the oven led to the formation of an accumulation of sediment bearing little evidence of thermal alteration

Fig. 15. Experimental oven, made after the archaeological model of Nola-Croce del Papa: (a) direct shaping of the vault (May 2015); (b) closed oven in use; (c) end of baking with embers on the bottom of the oven; (d) oven after three cycles of baking, notice the brown traces on the surface dues to the bread processing; (e) oven in April 2018, abandoned for a year and heavily damaged by moist; (f) oven in September 2018, six months after removal of its protective shelter.

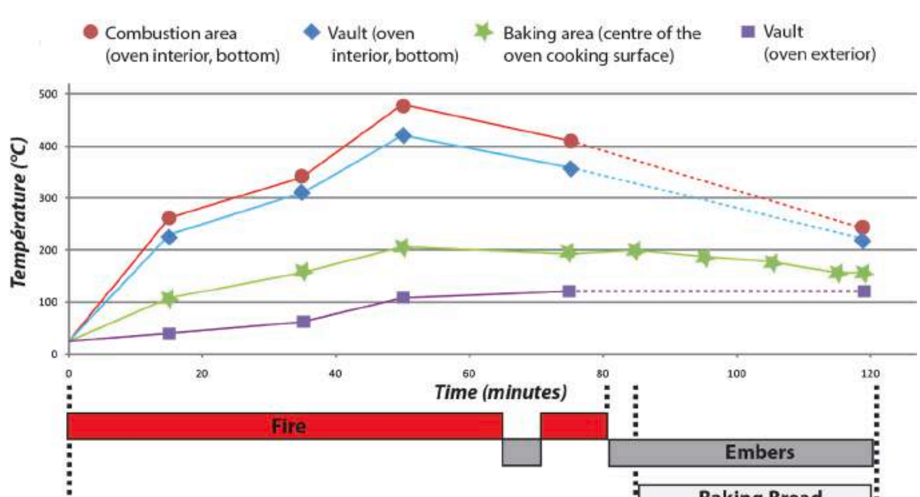

Fig. 16. Temperatures in different parts of the oven, measured with a thermocouple during a baking process (embers leaved inside the oven).

(Fig. 15, e-f).The low thermal alteration of sediments coming from the decaying of the oven dome is compatible with what has been observed on the field, during the excavation of the hypothetic oven of Via Ordiere.

5. Discussion

The approach toward a definition of fire installations during the Bronze Age started from the field observations and made immediately clear that, to proceed in the comprehension of use of fire, a large variability of traces should have been recognized as well as it was necessary to refer to interdisciplinary methods of research and wide comparison.

The analysis of the structures includes following steps of the research: the first is a collection of comparisons of similar features found in archaeological and contemporary contexts; a latter approach through ethnographical observations and physical definition of heat and air circulation helps defining characters of the structure and, finally, the experimental replication allows to enter in detail in the process from the construction to the use. More information could come from similar experiments carried out recently with scientific protocols (Conati Barbaro et al., 2021; Đuričić, 2014; Prévost-Dermarkar, 2003; Thér, 2004).

The Bronze Age earthen ovens recorded in the literature (e.g. Peinetti et al., 2019) have circular or more often oval plan. Occurrences of rectangular or square base are less represented. Most of the structures were built above a foundation made of pottery shards or small pebbles. The size varies from usual 80 × 60 cm to 150 × 100 cm in few occurrences (Cattani et al., 2015b). When preserved, walls were made of earthen materials, sometimes implemented a wooden frame (Degasperi, 2019, p. 192). The best Bronze Age example found at Nola-Croce del Papa near Naples (Albore Livadie et al., 2005; Albore Livadie and Vecchio, 2020) clearly suggests a domestic daily use for food preparation, heating the dwelling and arranging fire available for further purposes (lightning). The oven recognized at the site of Via Ordiere have a quite classical oval shape, but his size (1.5 to 1.7 m of length and 1.2 m large) is slightly larger than the average dimensions attested for the Neolithic and Bronze Age domed oven in Italian domestic contexts. This size suggests that the oven could be used to process a larger amount of food than usual, perhaps related to serve beyond a single family. In Mursia, no domed earthen ovens were clearly recognized. Oven-like functions may have been conducted in the few sunken stone ovens found at the site and, more extensively, with the use of cooking lids used for baking bread above the clay hearth surfaces (*infra*).

Addressing the operating principles of reaching and maintaining heat, useful for cooking food, allows to check the construction details of the ancient ovens and to reproduce the models to be applied in the experimental phase, especially in relation to the parts usually lacking in the archaeological documentation (walls, vault, chimney or vents, hatch of the entrance). Cooking food in an earthen oven is mainly based on the characteristic of earth as building material, suitable to store heat and release it slowly, using the conduction, convection and radiation mechanisms (Fig. 17). The thermal operation of the oven is based on reaching the heat inside the structure (up to 500° or more) with fuel and maintaining as much as possible the temperature level sufficient for cooking (bread ca. 200-250°, other food 80-150°). The most effective process in maintaining temperature is the transmission by direct radiation from the surfaces of the internal walls of the previously heated oven. Even if the oven is opened to add or remove food with a consequent lowering of the temperature, the amount of heat transferred by radiation still ensures the ability to cook for long time or to draw the heat on adding fuel. Despite the capacity of the air to accumulate heat is limited, the continuous movement of the convection currents helps to keep the cooking temperature uniform in the whole oven. The closing of the oven by means of a special door preserves the humid environment inside, extracting the water from the foods inserted for cooking and keeping it inside the structure. The humidity present in the oven allows cooking at high temperatures and in shorter times, without the risk of burning or drying the food. According to the structure found at Nola-Croce del Papa, without chimney, this type of oven confirms the attention to avoid leakage of heat and maintain temperature inside the structure with air circulation and way out of smoke guaranteed by the mouth. The location of the oven inside a dwelling will protect the structure from weathering, but at the same time needs to take care of smoke circulation. This requirement suggests finding additional structures like chimney or a different partition of the roof.

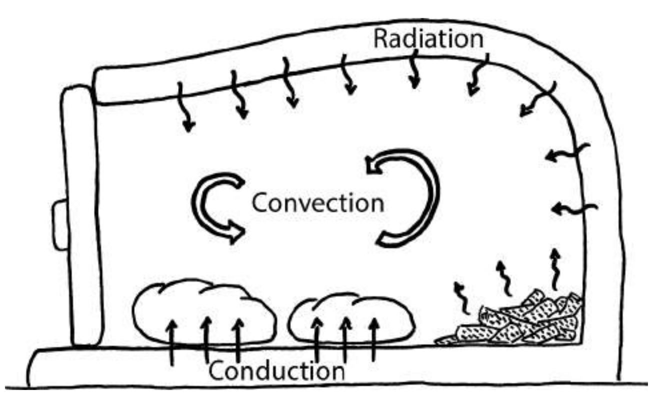

Fig. 17. Heating Operations inside the oven (after Denzer, 2007).

Concerning cooking plates made of earthen material on the same level of the floor, in many cases they suggest using fire for cooking on open air. The arrangement of smooth surface and the size of these features (from 50 to 150 cm) are related to cooking food by contact with the heated surface (Gascó, 2002) through the conduction of heat by the earthen surface of the plate (Fig. 18, a). They could have been used with living flame burning fuel or with charcoal prepared in other structures and moved at the maximum heating output. The processing of food on a cooking plate could use different techniques beyond cooking in contact with the surface (Cattani et al., 2015b; D'Oronzo, 2019), also in association with cooking vessels such as cooking lids (Fig. 18, b).

These types of structures are configured as multifunctional installations, serving as hearths for the domestic space and for cooking food. They lend themselves to different cooking techniques and associations with different cooking tools, as well documented in Mursia. All the structures identified at Mursia or Via Ordiere have the same average size than in other Italian contexts (Cattani et al., 2015b). The variability lies in the location within the settlement and, to a lesser extent, in the shape of the surfaces, which may be flat, slightly convex, or slightly concave. As we have seen, the morphology of the surface could have a functional purpose, related in particular to the management of embers and heat (see Section 4.1 and 4.2).

Apart from the motivation of the use of fire, often shared among different populations, technological choices in building and shaping structures could be used to distinguish cultural traditions, as well as the addition of mobile objects clarify the differences among regions in the final purpose of the process of combustion. The examples of Mursia and Via Ordiere highlight such different traditions in Italian Peninsula. One of the major differences is the use of andirons to support cooking vessels in Mursia (Debandi and Magrì, 2021), whereas at Via Ordiere they are absent. The extensive use of cooking lids and flat pans in Mursia, diffused in Bronze Age contexts of Southern Italy (Cattani et al., 2015a, 2021), is another peculiarity of the site if compared to Via Ordiere, when a domed oven likely used for baking bread is attested. Even if cooking plates are attested on both sites, the other fire structures associated to them (e.g. lithic *cist*, ovens) and the differences of cooking vessels involved in the use of fire installations suggest differences in managing the fire and in cooking activities.

Furthermore, the variability of evidence concerns not only different regional space, but it could also point out changes in the social structure or in the technological choices. Cross-referencing archaeological and geoarchaeological data allows to delineate what are the similarities and

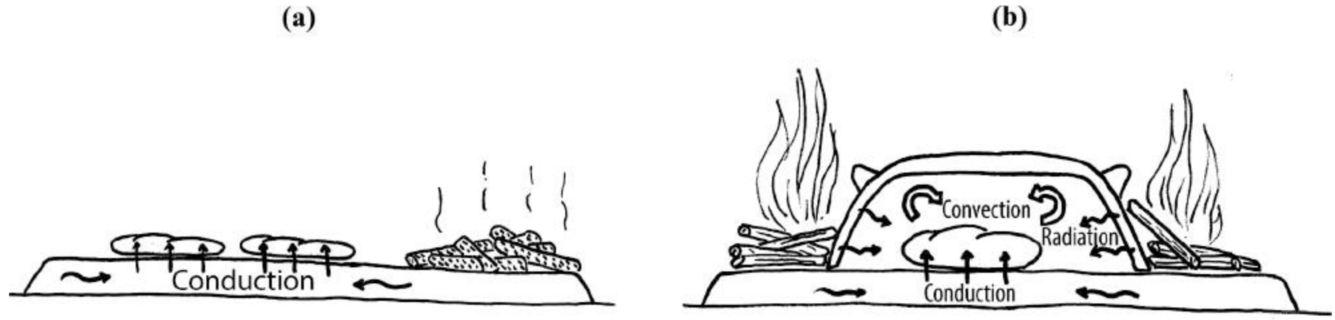

Fig. 18. Heating Operations of the cooking platforms: (a) used to cook food by contact with the heated surface; (b) using a cooking bell.

specificities of each site.

With regard to construction techniques, the fire installations of Via Ordiere and Mursia are built with local materials generally sourced from the direct vicinity of the village. The raw materials are assembled in different ways to create combustion structures of various types. A choice of clay materials is often reserved for the realisation of cooking plates, although fragments of hearths set on constructed floors made with a mix of loam and sandy raw materials are known at Via Ordiere. The peculiarity of the Mursia cooking plates is that they are made from clays quarried several kilometers from the site, but this aspect should also be considered with regard to the sourcing of the same raw material for pottery production.

Some evidence of floor plasters made from the same red clays is known, although the earthen architecture at the site (wattle and daub, constructed floors,…) is mostly made from the silty-sandy volcanic soils sourced in the village area (Peinetti et al., 2018). The selection of red clays highlights a precise choice of raw materials, as it implies more effort to make the cooking plates. This choice could be made to ensure better thermal performance of the structure, although aesthetic needs may have contributed to this choice. A greater variability of structures in terms of type and raw material assemblage is also attested in Mursia. This fact may be partly attributable to the environmental context of the site, which offers different types of stone materials that contribute, along with earthen materials, to the development of different structures.

In contrast, the low variability in Via Ordiere must be put into a different perspective because of the small number of structures preserved *in situ*. However, the analysis of sedimentation dynamics related to the degradation of structures or the dumping of combustion residues makes it possible to partially reconstruct fire-related activities at the site.

In perspective, the detailed recording of technological variables related to the construction of structures allows to delineate local building habits, specific to a given geographic and cultural area, but also to identify different practices among households.

Concerning the socio-economical organisation of households and communities, the analysis of the combustion structures at Mursia helps identifying the different uses of the buildings and the reconstruction of the domestic activities. From a diachronic point of view, they allow a general interpretation of the changes in the social organisation of the settlement (Cattani and Debandi, 2020). In the first phase, it is possible to observe a high degree of autonomy of the residential structures. Frequently, each hut is equipped with combustion features for food preparation, indicating self-sufficiency and a clear separation among the dwellings. The lithic hearth generally appears inside the hut, generally combined with the cooking plate made of a stone slab. Their location recurs often in a central place, suggesting a homogeneous distribution of heat and light inside the dwelling. In the final phase, the buildings are articulated in more separate spaces, where the huts have larger size and cooking practice has moved to additional structures located next or inside the large dwelling. This phase is evidenced by a more systematic use of earthen hearths (cooking plates) in combination with cooking andirons and large bowls. We hypothesize a different organization of social units made of a larger number of individuals.

At via Ordiere, the size of the oven, dated to the end of the Middle Bronze Age 2, has suggested referring to an extended family or to a shared use by different households, also related to a better exploitation of heat or to different activities in transforming goods (toasting cereals, cooking meat, etc.). Nevertheless, the analysis of waste disposal associated to pile-dwellings of the first occupation phases of the Middle Bronze Age 2 suggest that most of the activities related to food processing and consumption were realised inside each house by family units, rather than a collective or shared basis.

Finally, a high degree of complementarity between fire installations within the same domestic environments can be observed at both sites: cooking plates and ovens at Via Ordiere; lithic *cist* associated with hearths structured in stone or clay at Mursia. This expresses the differentiation in use of structures or their joint participation in *chaînes opératoires* related to food processing, allowing fire and embers to be managed.

The preliminary results presented here stress the need of a protocol of documentation and analysis that could allow the possibility to better compare different archaeological contexts between them, even if the kind of stratification, its preservation and the issues concerning the interpretation of each site are manifold. Such a protocol should include topographical survey with location, plans, sections and possibly 3D models of built spaces with fire installations, as well as the description of technological, formal and taphonomical aspects of all combustion structures. The account of the sedimentary context is also important. The appreciation of the construction, use and abandonment of combustion structures could be deepened by micromorphology (e.g. Germain-Vallée et al., 2011; Matarazzo et al., 2017; Mallol et al., 2017; Mentzer, 2014; Wattez 2004), even if a greater attention has been brought to date to Paleolithic burning structures than to structures of Late Prehistory and Protohistory (see for example Belarte et al., this volume, for applications on Iron Age). The characterisation of the microstratigraphy and micro-residues integrated in occupation surfaces close to fireplaces provides additional data on fire-related activities and management of fire structures (*supra*). The archaeobotanical analysis of different combustion residues (e.g. charcoals, charred seeds, and phytoliths), archaeometry and the analysis of organic residues (e.g. biomolecular analysis) or usewear traces on the fire installations and tools used in association with them are also useful to deal with functional issues related to fire-related activities (e.g. Conati Barbaro et al., 2021; Delhon, 2010; Drieu, 2020; Fiorentino and D'Oronzo, 2010; Forte et al., 2018; Lejay et al. 2019; Picornell-Gelabert et al., 2017). The papers of this special issue of Journal of Archaeological Science: Reports provide a large panel of solutions to build such a protocol based on multi-proxy and multi-scale analysis.

A topological description of the location of combustion structures and their relationship with other archaeological features and materials (inside or outside, proximity, density, etc.) could finally give more significance to a general comprehension of the excavated area.

6. Conclusion

The comparison between the two sites was useful to correlate very well-preserved archaeological deposits (Mursia) with low levels of preservation of structures (Via Ordiere), helping to define a protocol of excavation, sampling and interpretation of fire installations.

During the Bronze Age were widely common both closed oven-type structures and open earthen hearths, often complementary, as it has been documented on both sites and in contemporary settlements, such as at Nola Croce del Papa (Albore Livadie et al., 2005; Albore Livadie and Vecchio, 2020). Even if the preservation of fire installations, like the evidence at Via Ordiere, is poor or partial, it suggests that there was a high degree of autonomy in processing food in each residential structure.

The typological variability of the combustion features at Via Ordiere seems low, while the articulated spatial and diachronic variability at Mursia allow to document social and economic changes within the village.

Furthermore, thanks to the comparison between experimental artefacts and archaeologically documented remains, it is possible to recognise certain markers, in the archaeological record, relating to a specific activity or a particular use of combustion structures (e.g. macroscopic and microscopic analysis of combustion residues, evaluation of firing processes on the basis of colouring or thermal alteration of fire installations). The relationship between technological choices related to the manufacture of the fire installations (e.g. shape, presence of preparation layer) and the mode of use of such structures can also be a marker of their function and their role played within an activity area, a building or a set of spaces inside the settlement. Finally, regular cleaning of the structures also leads to the formation of deposits in secondary position characterised by combustion residues (occupation surfaces and waste accumulations). The detailed study of these residues and the formation of the deposits in which they are contained, for example through microstratigraphic analysis, can be a discriminating element in characterising combustion processes linked to the use of structures for cooking food.

The analysis proposed in this contribution has highlighted, rather than definitive answers, several issues that will require continuous in-depth archaeological research. These lines of investigation also concern the spatial relationships between structures and other elements that make up the settlement forms, in order to deal with economic, social and cultural aspects related to their management.

Future integrations with palaeobotanical data and archaeozoological studies will allow entering in detail about the use of combustion structures and consumption activities in the two villages of Via Ordiere and Mursia. The increase of experiments and micromorphological analyses, as well, can document in greater detail the variability of the construction techniques and deepen the functional interpretation of fire installations.

The research has also been opened to an ontological approach, intended to identify the main components of the structures and the actions relating to the modes of use. This approach starts providing a conceptual model for a better understanding of the archaeological contexts and methods to be applied to field research, with the aim of documenting the various stages of the *chaînes opératoires* linked to the use of fire and the material and immaterial elements that were at the base of fire installations.

CRediT authorship contribution statement

Alessandro Peinetti: Conceptualization, Formal analysis, Methodology, Data curation, Investigation, Writing – original draft, Writing – review & editing. **Florencia Debandi:** Formal analysis, Methodology, Data curation, Writing – original draft. **Maurizio Cattani:** Conceptualization, Formal analysis, Methodology, Data curation, Project administration, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgments

The work of A. Peinetti was supported by LabEx ARCHIMEDE from “Investir L’Avenir” program ANR-11-LABX-0032-01. We would thank Claudio Cavazzuti for the proofread of the final version of the paper.

References

Albore Livadie, C., Vecchio, G., 2020. Nola - Croce del Papa. Un villaggio sepolto dall’eruzione vesuviana delle Pomici di Avellino. Centre Jean Bérard, Napoli.

Albore Livadie, C., Castaldo, E., Castaldo, N., Vecchio, G., 2005. Sur l’architecture des cabanesdu Bronze ancien final de Nola (Naples-Campanie). In: Buchsenschutz, O., Mordant, C. (Eds.), Architectures protohistoriques en Europe Occidentale du Néolithique final à l’âge du Fer (127e Congrès des Sociétés historiques et scientifiques Le travail et les hommes, Nancy, 15–20 avril 2002). CTHS, Paris, pp. 487–512.

Aldeias, V., Dibble, H.L., Sandgathe, D., Goldberg, P., McPherron, S.J.P., 2016. How heat alters underlying deposits and implications for archaeological fire features: a controlled experiment. J. Archaeol. Sci. 67, 64–79.

Balossi Restelli, F., 2015. Hearth and home. Interpreting fire installations at Arslantepe, Eastern Turkey, from the fourth to the beginning of the second millennium BCE. Paléorient 41 (1), 127–151.

Bassetti, M., Degasperi, N., 2002. Lavagnone (BS) – settore B. Osservazioni micromorfologiche su alcuni campioni di concotto. Notizie Archeol. Bergomensi 10, 277–283.

Bernabò Brea, M.A., Cardarelli, A., Cremaschi, M. (Eds.), 1997. Le Terramare. La più antica civiltà padana. Electa, Milano.

Braadbaart, F., Poole, I., Huisman, H.D.J., van Os, B., 2012. Fuel, Fire and Heat: an experimental approach to highlight the potential of studying ash and char remains from archaeological contexts. J. Archaeol. Sci. 39, 836–847.

Bullock, P., Fedoroff, N., Jonguerius, A., Stoops, G., Tursina, T., Babel, U., 1985. Handbook for soil thin section description. Waine Research, Albrighton.

Cammas, C., 2018. Micromorphology of earth building materials: Towards the reconstruction of former technological processes (Protohistoric and Historic Periods). Quat. Int. 483, 160–179.

Cammas, C., Wattez, J., 2009. Approche micromorphologique : Méthodes et applications aux stratigraphies archéologiques. In: Bravard, J.P. (Ed.), La géologie : les sciences de la Terre appliquées à l’archéologie. Errance, Paris, pp. 181–218.

Cammas, C., Wattez, J., Courty, M.-A., 1996. L’enregistrement sédimentaire des modes d’occupation de l’espace. In: Castelletti, L., Cremaschi, M. (Eds.), Paleoecology; Colloquium 3 of XIII International Congress of Prehistoric and Protohistoric Sciences. 3. ABACO, Forlì, pp. 81–86.

Canti, M., 2003. Aspects of chemical and microscopic characteristics of plant ashes found in archaeological soils. Catena 54, 339–361.

Canti, M., Brochier, J.E., 2017. Plant ash. In: Nicosia, C., Stoops, G. (Eds.), Archaeological Soil and Sediment Micromorphology. Wiley, Hoboken, pp. 147–154.

Cattani, M., 2016. Il villaggio dell’età del Bronzo di Mursia (Pantelleria): strategie insediative e aspetti culturali. Scienzedell’Antichità 22 (2), 395–410.

Cattani M., 2019. Digital Atlas of Prehistoric structures: hearths, ovens and fireplaces. In: Peinetti, A., Cattani, M., Debandi, F. (Eds.), Hearths, ovens and kilns from the Neolithic to the Iron Age: Understanding domestic and craft activities through the study of the pyrotechnological features and combustion residues, Abstract Book, Incontri Annuali di Preistoria e Protostoria 6, Bologna 2019, March 29th, Firenze, pp. 87–90.

Cattani, M., Debandi, F., 2015. Analisi di distribuzione delle ceramiche dell’età del Bronzo: il caso dell’Italia centro-settentrionale. Archeol. e Calcolatori 26, 255–264.

Cattani, M., Debandi, F., 2020. Strutture abitative e unità sociali: il caso studio dell’abitato dell’età del Bronzo di Mursia (Pantelleria - TP). In: Negroni Catacchio, N. (ed.), Archeologia dell’abitare. Insediamenti e organizzazione sociale prima della città. Dai monumenti ai comportamenti, Atti del XIV Incontro di Studi Preistoria e Protostoria in Etruria (Valentano, Pitigliano, Manciano, 2018), vol. 1, Centro Studi di Preistoria e Archeologia, Milano, pp. 273–287.

Cattani, M., Debandi, F., Magrì, A., 2015a. La produzione ceramica dell’abitato di Mursia. Proposta di nuova classificazione tipologica dei materiali del settore B. IpoTESI di Preistoria 7 (1), 17–48.

Cattani, M., Debandi, F., Peinetti, A., 2015b. Le strutture di combustione ad uso alimentare nell’età del Bronzo. Dal record archeologico all’archeologia sperimentale. OCNUS 23, 9–43.

Cattani, M., Debandi. F., Tusa, S., 2021. Strutture e oggetti per la preparazione del cibo nell’abitato dell’età del Bronzo di Mursia, Pantelleria (TP). In: Damiani, I., Cazzella, A., Copat V. (Eds.), Preistoria del cibo. L’alimentazione nella preistoria e nella

protostoria, Studi di Preistoria e Protostoria dell'Istituto Italiano di Preistoria e Protostoria 6, Istituto Italiano di Preistoria e Protostoria, Firenze, pp. 475–482.
Cattani, M., Miari, M., Debandi, F., Guerra, L., Peinetti, A., Vaccari, B., Vinci, G., 2018. Gli scavi nell'abitato dell'età del bronzo di via Ordiere - Solarolo (RA). In: M. Bernabò Brea, a cura di, Studi di Preistoria e Protostoria 3,2 Preistoria e Protostoria dell'Emilia Romagna. L'età del Bronzo e del Ferro, Atti XLV Riunione Scientifica dell'Istituto Italiano di Preistoria e Protostoria, Modena, 26-31 ottobre 2010, pp. 523-528.
Cattani, M., Bonazzi, L., Debandi, F., Peinetti, A., 2019. Via Ordiere, Solarolo (RA). Notiziario di Preistoria e Protostoria 2019, 6.I. Italia settentrionale e peninsulare, pp. 10–12.
Cattani, M., Marazzi, M., Tusa, S., 2020. L'abitato di Mursia (Pantelleria) nel quadro delle interazioni nel Mediterraneo durante l'età del Bronzo, in Italia tra Mediterraneo ed Europa: mobilità, interazioni e scambi. Rivista di Scienze Preistoriche, RSIIPP LI, Forlì, 12-15 ottobre 2016, pp. 363–370.
Cavulli, F., 2008. Abitare il Neolitico. Le piu antiche strutture antropiche del Neolitico in Italia Settentrionale. Preistoria Alpina (supplement). Museo Tridentino di Scienze Naturali, Trento.
Cazzella, A., Recchia, G., 2008. A fuoco lento: strutture di combustione nell'abitato dell'età del Bronzo di Coppa Nevigata (Manfredonia - FG), in: Fiorentino G., Magri D., a cura di, Charcoals From The Past - Cultural and PalaeoenvironmentalImplications, Proceedings of the third International Meeting of Anthracology, Cavallino - Lecce (Italy), June 28th - July 1st 2004, BAR International Series 1807, pp. 53–61.
Cazzella, A., Recchia, G., 2009.Sleeping, eating, meeting, working: problems and methods in the study of structures in southern Italy settlements during the Bronze Age. In: Cavulli, F. (Ed.) Defining a Methodological Approach to Interpret Structural Evidence, BAR International Series 2045, pp. 75–81.
Conati Barbaro, C., Forte, V., Muntoni, I.M., Eramo, G., 2021. A multidisciplinary approach to the study of early neolithic pyrotechnological structures. the case study of Portonovo (Marche, Italy). Open Archaeol. 7, 1160–1175.
Costa, A., Cavulli, F., Pedrotti, A., 2019. I focolari, forni e fosse di combustione di Lugo di Grezzana (VR). IpoTESI Di Preistoria 12 (1), 27–48.
Courty, M.-A., 2001. Microfacies Analysis Assisting Archaeological Stratigraphy. In: Goldberg,P., Holliday,V.T, Ferring, C.R. (Eds.), Earth Sciences and Archaeology, Kluwer Academic / Plenum Publishers, New York, pp. 205–239.
Courty, M.A., Goldberg, P., Macphail, R., 1989. Soil, Micromorphology and Archaeology. Cambridge University Press, Cambridge.
Debandi, F., 2015. La capanna B14 dell'abitato dell'età del Bronzo di Mursia (Pantelleria). IpoTESI di Preistoria 7, 71–136.
Debandi, F., Cattani, M., Peinetti, A., 2019. Focolari e piastre di cottura nell'abitato dell'età del Bronzo di Mursia (Pnatelleria, TP). IpoTESI di Preistoria 12, 111–142.
Debandi, F., Magrì A., Peinetti, A., 2021. Stone, Earth and Fire. Living on Pantelleria Island between 1750 and 1450 BC. In: Albertazzi, G., Muti, G., Saggio, A., (Eds.), Islands in Dialogue (ISLANDIA), International Postgraduate Conference in the Prehistory and Protohistory of Mediterranean Islands, Torino, November 14th-16th 2018, Università degli Studi di Torino, pp. 208–229.
Debandi, F., Magrì, A., 2021. Gli alari nell'abitato dell'età del Bronzo di Mursia (Pantelleria): analisi dei modelli e comparazioni tra Sicilia e Mediterraneo orientale. Rivista Sci. Preistoriche LXXI 193–258.
Degasperi, N., 2019. Le strutture di combustione e le strutture accessorie. In: Steffè G., Degasperi N., a cura di, 2019, Il villaggio neolitico di Lugo di Romagna – Fornace Gattelli. Strutture, Ambiente Culture, Origines, IIPP, Firenze, pp. 190–194.
Delhon, C., 2010. Phytoliths and Taphonomy, the Contribution of Experimentation to the Quantification of Phytoliths in Wood Ashes. In: Théry-Parisot, I., Chabal, L., Costamagno, S. (Eds.), The taphonomy of Burned Organic Residues and Combustion Features in Archaeological Contexts, Proceedings of the round table, May 27-29 2008, CEPAM, P@lethnology 2, pp. 93–104.
Denzer, K., 2007. Build Your Own Earth Oven: A Low-cost Wood-Fired Mud Oven, Simple Sour-dough Bread, Perfect Loaves. Hand Print Press, London.
D'Oronzo, C., 2019. Le strutture di combustione: è tutta una questione di relazioni? IpoTESI Di Preistoria 12 (1), 369–390.
Drieu, L., 2020. A pottery biography: considering the entire lifecycle of a pot in organic residue analysis. ArcheoSciences 44 (2), 129–143.
Đuričić, A., 2014. The Construction and Usage of the Neolithic Oven: Experimental Archaeology. In: Vitezović, S., Antonović, A. (Eds.), Archaeotechnology: studying technology from prehistory to the Middle Ages. Beograd, Srpskoarheološkodruštvo, pp. 257–276.
Fiorentino, G., D'Oronzo, C., 2010. An Archaeobotanical and Experimental Approach to Identifying Successive Fire Events in Hearth Structures in the Sanctuary of Apollo in Hierapolis (Turkey). In: Théry-Parisot, I., Chabal, L., Costamagno, S. (Eds.), The taphonomy of Burned Organic Residues and Combustion Features in Archaeological Contexts, Proceedings of the round table, May 27-29 2008, CEPAM, P@lethnology 2, pp. 59–68.
Forte, V., Nunziante Cesaro, S., Medeghini, L., 2018. Cooking traces on Copper Age pottery from central Italy: an integrated approach comprising use wear analysis, spectroscopic analysis and experimental archaeology. J. Archaeol. Sci. Rep. 18, 121–138.
Frère-Sautot, M.-C., 2003. Le feu domestique et ses structures au Néolithique et aux Âges des métaux, Actes du Colloque de Bourg-en-Bresse et Beaune (7-8 octobre 2000), Ed. Mergoil, Montagnac.
Friesem, D., Wattez, J., Onfray, M., 2017. Earth Construction Materials. In: Nicosia, C., Stoops, G. (Eds.), Archaeological Soil and Sediment Micromorphology. Wiley, Hoboken, pp. 99–110.
Gascó, J., 2002. Structures de combustion et préparation des végétaux de la Préhistoire récente et de la Protohistoire en France méditerranéenne, Pains, fours et foyers des temps passés, attestations archéologiques de la cuisson, de l'utilisation et de l'importance des aliments céréaliers en Europe et au Proche-Orient, Écomuséum de Treignes (Belgique), 6-7 octobre 1995. Civilisations, n° 49, 1-2, Dire-Treignes, pp. 285–309.
Gascó, J., 2003. Contribution pour une proposition de vocabulaire des structures de combustion. In: M.-C. Frere-Sautot (Ed.), Le feu domestique et ses structures au Néolithique et aux Âges des métaux, Actes du Colloque de Bourg-en-Bresse et Beaune (7-8 octobre 2000), Ed. Mergoil, Montagnac, pp. 109–125.
Germain-Vallée, C., Prevost-Dermarkar, S., Lespez, L., 2011. Stratégies de prélèvement et de mise en œuvre de la «terre à bâtir» des structures de combustion néolithiques du site de Dikili Tash (Grèce) à partir d'une étude micromorphologique. ArchéoScience 35, 41–63.
Karkanas, P., 2019. Microscopic deformation structures in archaeological contexts. Geoarchaeology 34 (1), 15–29.
Lejay, M., Alexis, M.A., Quénéa, K., Anquetil, C., Bon, F., 2019. The organic signature of an experimental meat-cooking fireplace: The identification of nitrogen compounds and their archaeological potential. Org. Geochem. 138, 103923.
Leroi-Gourhan, A., 1973. Séminaire de 1973 sur les structures d'habitat. Témoins de Combustion Ethnologie préhistoric. Chaire de Préhistoire, Collège de France, Paris.
Macphail, R.I., Goldberg, P., 2018. Applied Soils and Micromorphology in Archaeology. Cambridge University Press, Cambridge.
Magri, A., 2015. La fase tarda dell'abitato di Mursia nell'area nord-ovest del settore B. IpoTESI di Preistoria 7 (1), 137–264.
Mallol, C., Mentzer, S.M., Miller, C.E., 2017. Combustion features. In: Nicosia, C., Stoops, G. (Eds.), Archaeological Soil and Sediment Micromorphology. Wiley, Hoboken, pp. 299–326.
Marabini, S., Vai, G.B., 2020. Carta Geologica della Pianura tra Imola e. Ravenna, Imola, Théodolite Editore.
March, R.J., Lucquin, A., Joly, D., Ferreri, J.C., Muhieddine, M., 2012. Processes of formation and alteration of archaeological fire structures: complexity viewed in the light of experimental approaches. J. Archaeol. Method Theory 21, 1–45.
Matarazzo, T., Berna, F., Goldberg, P., 2017. Micromorphological study of concotto surfaces protected by the avellino eruption in 3945 ± 10 cal. BP at the Early Bronze Age of Afragola Village in Southern Italy. Environ. Archaeol. 22 (2), 1–16.
Matthews, W., French, C.A.I., Lawrence, T., Cutler, D.F., Jones, M.K., 1997. Microstratigraphic traces of site formation processes and human activities. World Archaeology 29 (2), 281–308.
Mentzer, S., 2014. Microarchaeological approaches to the identification and interpretation of combustion features in prehistoric archaeological sites. J. Archaeol. Method Theory 21, 616–668.
Montana, G., Fabbri, B., Santoro, S., Gualtieri, S., Iliopoulos, I., Guiducci, G., Mini, S., 2007. Pantellerian Ware: a comprehensive archaeometric review. Archaeometry 49 (3), 455–481.
Nicosia, C., Canti, M., 2017. Chaff. In: Nicosia, C., Stoops, G. (Eds.), Archaeological Soil and Sediment Micromorphology. Wiley, Hoboken, pp. 137–139.
Nicosia, C., Stoops, G., 2017. Archaeological soil and sediment micromorphology. Wiley, Hoboken.
Onfray, M., 2012. Étude des vestiges de terre crue brûlée de Champ-Durand (Vendée). In: Joussaume, R. (Ed.), L'enceinte néolithique de Champ-Durand à Nieul-sur-l'Autise (Vendée). Association des Publications Chauvinoises, Chauvigny, pp. 599–619.
Palio, O., 2001. Tardo Minoico I: la Casa di HaghiaFotinì. In: Giornate Lincee, I cento anni dello scavo di Festòs, (Roma, 13–14 dicembre 2000). Roma, Accademia Nazionale dei Lincei, pp. 243–272.
Peinetti, A., 2016. L' analisi tecnologica di resti strutturali in terra: variabilità delle tecniche di costruzione e osservazioni in sezione levigata per la caratterizzazione di concotti e conglomerati architettonici. IpoTESI di Preistoria 8, 103–138.
Peinetti, A., 2021, Géoarchéologie du village : variabilité des modes d'occupation de la fin du Néolithique à l'âge du Bronze en Italie et en France méridionale. Implications culturelles, PhD Thesis, Université de Montpellier 3, Università di Bologna.
Peinetti, A., Aprile, G., Caruso, K., Speciale, C., 2017. Looking for a scientific protocol in prehistoric daub experimental project. In: Alonso, R., Canales, D., Baena, J. (Eds.), Playing with the time. Servicio de Publicaciones de la Universidad Autónoma de Madrid, Experimental archeology and the study of the past, pp. 307–312.
Peinetti, A., Boccuccia, P., Cattani, M., Debandi, F., Gabusi, R., Gasparini, D., Guidorzi, G., Magrì, A., Miari, M., Murgia, D., Riccardi, M.P., Tusa, S., Jallot, L., Wattez, J., Lefèvre, D., 2018. Réalisation du second œuvre et d'aménagements domestiques entre l'Énéolithique et l'âge du Bronze en Italie : observations archéologiques et géoarchéologiques. In: de Chazelles, C.-A., Leal, É., Klein A. (Eds.), Terre crue : torchis, techniques de garnissage et de finition, mobilier façonné en terre. Echanges transdisciplinaires sur les constructions en terre crue, 4, Actes de la table-ronde internationale (Lattes, 2016), éd. Espérou, Montpellier, pp. 293–308.
Peinetti, A., Cattani, M., Debandi, F. (Eds.), 2019. Focolari, forni e fornaci tra Neolitico ed età del Ferro. Comprendere le attività domestiche e artigianali attraverso lo studio delle istallazioni pirotecnologiche e dei residui di combustione, Abstract Book Incontri Annuali di Preistoria e Protostoria 6 (Bologna 29 marzo 2019), Firenze, ISBN 978-88-6045-073-9.
Peinetti, A., Debandi, F., Cattani, M., 2020. La contribution de l'archéologie expérimentale à l'étude des installations domestiques en terre destinées à la préparation d'aliments à l'âge du Bronze en Italie : techniques de mise en oeuvre, fonctionnement et processus de degradation. In: Nordez, M., Peche-Quilichini, K., Roscio, M. (Eds.), Aménager, organiser et utiliser les espaces domestiques à l'âge du Bronze : approches expérimentales, Saint-germain-en-Laye, 2 mars 2018, Bulletin APRAB 18, pp. 135–145.
Pétrequin, P., Pétrequin, A.M., 1992. Les rythmes du feu. Terrain 19, 39–48.

Picornell-Gelabert, L., Allué, E., Courty, M.A., 2017. An archaeology of fuels: social and environmental factors in behavioural strategies of multi-resource management. Quat. Int. 431 (A), 2–5.
Prévost-Dermarkar, S., 2002. Les foyers et les fours domestiques en Egée au Néolithique et à l'Age du Bronze. Civilisations 49, 223–237.
Prévost-Dermarkar, S., 2003. Les fours néolithiques de Dikili Tash (Macédoine, Grèce): Une approche expérimentale des techniques de construction des voûtes en terre à bâtir. In: Frère-Sautot, M.-C. (Ed.), Le feu domestique et ses structures au Néolithique et aux Âges des métaux, Actes du Colloque de Bourg-en-Bresse et Beaune (7-8 octobre 2000), Ed. Mergoil, Montagnac, pp. 215–223.
Rotolo, S.G., Agnesi, V., Conoscenti, C., Lanzo, G., 2017. Pantelleria Island (Strait of Sicily): Volcanic History and Geomorphological Landscape. In: Soldati, M., Marchetti, M. (Eds.), Landscapes and Landforms of Italy, pp. 479–487.
Schiffer, M.B., 1987. Formation Processes of the Archaeological Record. University of New Mexico Press, Albuquerque.
Stoops, G., Marcelino, V., Mees, F., 2010. Interpretation of Micromorphological Features of Soils and Regoliths. Elsevier, Amsterdam, Oxford.
Thér, R., 2004. Experimental pottery firing in closed firing devices from the Neolithic – Hallstatt period in Central Europe. EuroREA 1, 35–82.
Villagran, X.S., Balbo, A.L., Madella, M., Vila, A., Estevez, J., 2011. Stratigraphic and spatial variability in shell middens: microfacies identification at the ethnohistoric site Tunel VII (Tierra del Fuego, Argentina). Archaeol. Anthropol. Sci. 3 (4), 357–378.
Wattez, J., 1988. Contribution à la connaissance des foyers préhistoriques par l'étude des cendres. Bull. société préhistorique française, t. 85 (10–12), 352–356.
Wattez, J., 1992. Dynamique de formation des structures de combustion de la fin du Paléolithique au Néolithique moyen. Approche méthodologique et implications. Université de Paris I. PhD Thesis.
Wattez, J., 1996. Modes de formation des structures de combustion: approche méthodologique et implications archéologiques. In: Bar-Yosef, O. (Ed.), The lower and Middle Paleolithic, The study of human behaviour in relation to fire in archaeology : New data and methodologies for understanding Prehistoric Fire Structures, XIII International Congress of Prehistoric and Protohistoric Sciences. 5. ABACO, Forlì, pp. 29–34.
Wattez, J., 2003. Caractérisation micromorphologique des matériaux façonnés en terre crue dans les habitats néolithiques du sud de la France : l'exemple des sites de Jacques Cœur (Montpellier, Hérault), du Jas del Biau (Millau, Aveyron) et de La Capoulière (Mauguio, Hérault). In : de Chazelles, C.A., Klein, A. (Eds.), Échanges transdisciplinaires sur les constructions en terre crue. Actes de la table ronde de Montpellier (17-18 novembre 2001), Ed. Espérou, Montpellier, pp. 21–31.
Wattez, J., 2004. Enregistrement sédimentaire des structures de combustion et fonctionnement de l'espace dans les campements de la fin du Paléolithique : exemples des sites magdaléniens de Monruz (Neuchâtel, Suisse) et d'Étiolles (Soisy-sur- Seine, France) et du site azilien du Closeau (Rueil-Malmaison, Hauts-de-Seine, France). In: Bodu, P., Constantin C. (Eds.), Approches fonctionnelles en préhistoire, XXV[e] Congrès Préhistorique de France (Nanterre novembre 2000), Société préhistorique française (Congrès préhistorique de France, 25), Paris, pp. 225–237.
Wattez, J., Cammas, C., Courty, M.-A., 1998. Marqueurs spatio-temporels des ambiances pédo-climatiques dans les sols archéologiques. Spatio-temporal indicators of environmental settings in archaeological soils, Symposium n°16 « Archivages dans les sols, des changements de leur environnement naturel ou anthropique », 16[e]Congrès Mondial de Science du Sol (Montpellier, 1998), http://natres.psu.ac.th/Link/SoilCongress/fr/entree.htm.