Socializing the Materiality of Earthen Structures: The *Chaîne Opératoire* of Construction Practices at the Neolithic Site of Kleitos 2, Greece

Evita Kalogiropoulou, Dimitris Kloukinas & Kostas Kotsakis

This paper describes the chaîne opératoire *of earthen architecture relating to buildings and thermal structures at the Neolithic site of Kleitos 2 in Kozani. It provides a material-based approach to the variable processes involved in construction as a practice of community involvement. The* chaîne opératoire, *adapted based on a refined concept of technology, is employed here as a key analytical tool. This paper tackles questions relating to the social scale of the construction processes concerned, specialization in construction, and the participation and collaboration of the builders. By choosing to focus on a local-scale analysis of a single site, we were able to develop a detailed framework that includes all the steps involved in manufacturing the earthen features, from the decision-making processes to questions of spatial allocation, the acquisition and processing of materials and construction practices, together with their subsequent use and end-life. The aim of this paper is to recognize construction processes as a social event involving cooperation and social performativity, which fosters and reaffirms social interactions, obligations and entanglements, shedding light on the dynamics of the society in question.*

Introduction

Domestic architecture and construction practices are commonly recognized as social enterprises, constituting *loci* and courses of actions that bring people together in various daily or exceptional acts. Architectural construction is, in this sense, a *faire social* that reaffirms social ties and empowers reciprocity through interaction, cooperation and the development of a common memory (Bailey 1996; Hodder 1998; 2013; Ingold 2013; Jones 2007; Kay 2020; Kotsakis 2019; McFadyen 2016; Sparkes & Howell 2003; Tuan 1977; Whittle 1996; Wilk 1983). The built environment encompasses numerous socio-cultural dynamics and underlying structuring principles, metaphors and meanings, which are mobilized through social practice (Benson & Whittle 2007; Eriksen 2016; Kotsakis 1994; Love 2013b; Parker Pearson & Richards 1994b; Rapoport 1969). The act of building, whether of a house or of another type of earthen architecture, involves techniques and constellations of knowledge that are socially acquired and transmitted both within groups and between contiguous communities (Oliver 2006). Different people are employed in different capacities and with different degrees of participation (McFadyen 2016, 57). The manifestation of unity, cooperation, and status during the construction process contributes to the (re)constitution of these social groups (Vellinga 2007, 760). The material character of earthen architecture, however, and the entanglements (*sensu* Hodder 2012) developed in construction processes have drawn little attention in recent archaeological research. Unfolding the successive steps of the building process could shed light on the social dynamics of a given household, group, or community.

Cambridge Archaeological Journal 33:3, 449–475
doi:10.1017/S0959774322000427 Received 3 Oct 2021; Accepted 29 Oct 2022; Revised 4 Oct 2022

In our analysis, we adopt a material-based approach to unravel the variable and intermingled practices integrated in the construction process. To this end, we have chosen to employ the *chaîne opératoire* approach, adapted to the study of earthen architecture of buildings and thermal structures and supported by a refined concept of technology as a socially embedded process of growth and becoming (Dobres & Robb 2000; Fitzjohn 2013; Ingold 2013; Miller 2007; Riede 2006; Schlanger 2005). We emphasize the materiality of construction, which requires technology, cognition and time. We also highlight the cooperation and social performativity involved, rendering this a social event that fosters and reaffirms social relations, obligations and entanglements, and which can reveal the dynamics of a given community. In this respect, the *chaîne opératoire* offers a holistic and multifaceted approach to considering the act of construction, by integrating cognitive processes and decisions, technological applications and social interfaces (Dobres & Robb 2000; Pelegrin *et al*. 1988; Pelmoine & Mayor 2020; Steadman 1996; Ulanowska 2020).

Through the sequential manufacturing practices, we examine various features of the social connotations and human involvement in the spatio-temporal context of a single Neolithic site: Kleitos 2 in Kozani, situated in northwest Greece (Fig. 1). By adopting a local-scale approach, we develop a detailed analytical framework that delves into the intellectual, social and technological steps of the practices involved in the construction of earthen architecture. Buildings and thermal structures are two distinct categories of earthen architecture that shared similar malleable materials and gestures. Although differing remarkably in terms of scale, construction time and effort, they can both be seen as flexible entities encapsulating common social processes, localities and practices, situated within the natural and social surroundings of Neolithic communities (Kay 2020). How did local materials, techniques and builders intertwine? How do the properties of the resources used affect the temporal rhythms of the technological process? Can we identify a degree of standardization or diversity in the various stages of the *chaîne opératoire* of earthen structures? Can we trace reconstruction and maintenance practices and how are these meaningful? Are there indications for the socialities involved, at either the household or communal level? Our analysis endorses a concept of technology as social process that through practice brings people together in a shared act of cooperation and social reciprocity (Dobres & Robb 2005; Ingold 2013; Schlanger 2005).

The *chaîne opératoire*: materiality, prospects and constraints

Coined by Leroi-Gourhan (1943; 1945; 1993), the concept of the *chaîne opératoire* has come a long way and has been adjusted following developments in the research framework. It has served as a powerful analytical tool and a testable framework for materials science (Martinón-Torres 2002, 38), and its contribution to the advancement of our understanding of past societies is well recognized (Riede 2006, 50). The methodology employed is based on a sequential analysis of the gestures, operations and sequences of operations involved in the production, use, maintenance and, ultimately, discarding of artefacts. It aims to trace and reconstruct the tangible and intangible aspects of technology and allows us to understand better the social contexts, actions and forms of cognition required to produce a given object (Dobres 2000). The methodology has been widely employed in the analysis of various categories of material culture, especially in the study of lithic industries and pottery (e.g. Balfet 1973; Cahen & Karlin 1980; Martinón-Torres 2002; Pelegrin *et al*. 1988; Perlès 1987; Schlanger 2005). Nevertheless, it has increasingly been applied to other crafts or even 'non-object' technologies (Miller 2007; Pelmoine & Mayor 2020; Ulanowska 2020). The concept of the *chaîne opératoire* has been introduced to link technical developments with social acts. In practice, however, it has often been restricted to the systematic description of technical processes, while little attention has been paid to the social context of the acts of human interaction and collaboration entailed in the production of a given artefact.

Latest archaeological applications of the *chaîne opératoire* methodology underline its ongoing impact on the study of material remains and iron out the main flaws and anachronisms inevitably associated with it (Lewis & Arntz 2020). It is now commonly accepted that the technological and social processes in the construction of a given artefact are not linear, but interlinked with numerous cultural, social and symbolic developments (Cresswell 1990; Lemonnier 1993; Lucas 2013; Sillar & Tite 2000). Recent studies on material culture and agency-based approaches to technology have allowed for a more comprehensive application of the *chaîne opératoire* that moves beyond functional analyses and further unravels less prominent stages and ramifications of construction (Coupaye 2015; Dobres 2000; Ingold 2013; Knappett 2008; Sillar & Tite 2000). The latest analytical approaches have emphasized the historical socio-contextual dependency, limitations, constraints and

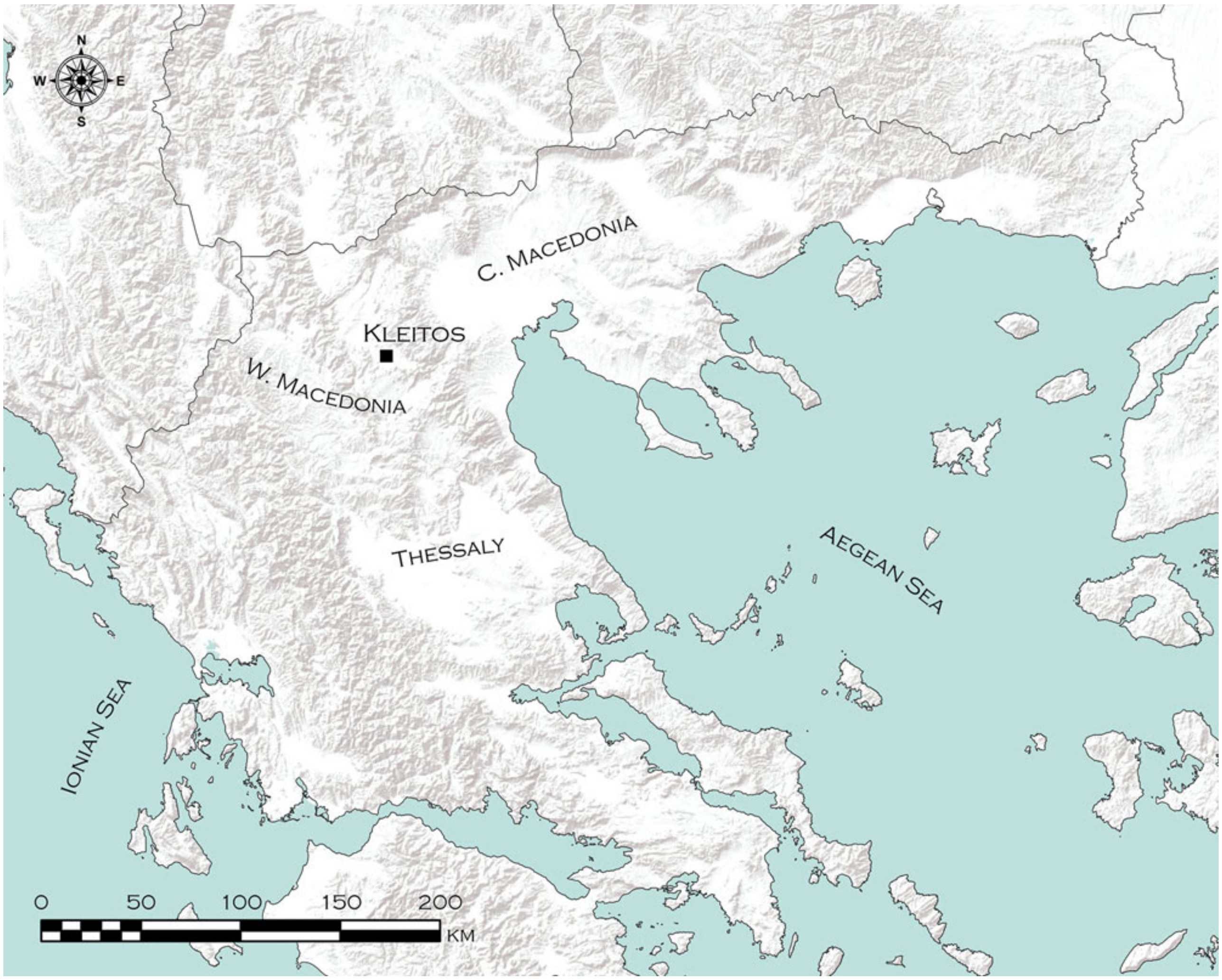


Figure 1. *Map of Greece, showing the location of the Kleitos 2 Neolithic site. (Drawing: J. Donati.)*

possibilities of construction processes (Gell 1998; Knappett 2008; Martinón-Torres 2002, 30; Sillar & Tite 2000, 4; Skibo 2013, 13). The historical development of the *chaîne opératoire* has led to a plethora of approaches addressing questions of society, technology, human agency and tradition. Most recently, an adaptable framework of the *chaîne opératoire* has been proposed that can be manipulated and combined with other complementary methodologies to maximize the information provided (Eriksen 2016; Kay 2020; Lewis & Arntz 2020, 11). For the architectural elements we are examining, we have adapted a more flexible analytical framework for the application of the *chaîne opératoire*, while retaining the fundamental principles of the concept. Given that the sequential order of construction in architectural elements is not straightforward, but a rather intermittent process of various intermingled construction practices, we did not follow a strict sequencing of every task performed. Instead, the different operations and sequences were grouped in more general steps, which refer to the gradual development of the construction project, combined with evidence of the timing, agency, use-life, maintenance and the abandonment of the structure. In doing so, our analysis benefited from the developent of a consistent recording system, comparable with other spatio-temporal contexts. Overall, integrating spatio-temporal data to our analysis enabled us to attribute historical perspective further in the materiality of construction practices.

The *chaîne opératoire* of earthen architecture

In the case of earthen features, including cooking installations and buildings, the concept and methodology associated with the *chaîne opératoire* have occasionally been employed in both archaeological and anthropological case studies (e.g. Pelmoine & Mayor 2020; Prévost-Demarkar 2019). Architectural remains, however, have been more commonly viewed as containers of other artefacts and activities, rather than as technological products or artefacts in themselves. As a result, their technological features have not always been the primary focus in analytical inquiries. This contrasts with the centrality of earthen architecture in the *habitus* of Neolithic southeastern Europe (Souvatzi 2008; Stevanović 1997), and with the impact of earthen architectural remains on the formation of the archaeological record (Lucas 2013). Recent developments in the study of prehistoric architecture, however, have overcome the stale description of form and size, suggesting a rather variable and complex approach for the effect of building making to the formation of shared social traditions through cooperation (Benson & Whittle 2007; Fitzjohn 2013; Kay 2020; Love 2013a, b; McFadyen 2006; 2007; 2016; Uzdurum 2018). To this end, there is a current understanding of prehistoric monuments and architecture as practice rather than as container or object (McFadyen 2016, 59). Inspired by Hill (2003), Leslie McFadyen suggested that the process of construction requires a rich set of interaction and cooperation between people (builders and users) and things (building materials) (McFadyen 2016, 53). Ultimately, she suggested a closer examination of the effect of practice and participation in building making (McFadyen 2016, 55). Contemporary studies of prehistoric architecture approach builders as active agents over resource availability, suggesting that the purposeful selection of material practices is socially informed, complementing the complexity of the construction practice (Love 2013b, 752). The application of a sequential methodology in the analysis of thermal structures, such as hearths, ovens, fire pits, benches and cooking-related portable features, is relatively straightforward. Compared to buildings, thermal structures are smaller constructions that require the procurement of fewer materials, a smaller workforce and less team coordination. When it comes to buildings, however, certain limitations to the strict application of a sequential methodology arise. The construction of a house is a complex project entailing different reductive, transformative and additive processes that cannot always be traced in archaeological records (Kloukinas 2014; McFadyen 2016). They are characterized by their own spatiotemporal frameworks and can be combined in various ways without necessarily changing the end result. The main building materials, including earth and timber, need to be processed according to their own sequence of operations, before being shaped and incorporated into the structure itself (Love 2013a, 270). It may therefore be argued that segmenting all the different processes in a strict sequential order is not always feasible. Further complicating the difficulties presented, buildings should be seen as never-quite-finished patchworks, rather than the result of pre-existing plans (Fitzjohn 2013; Ingold 2013; Kay 2020). This leaves little room for ideal reconstructions. Even so, the 'checklist' aspect of the *chaîne opératoire* methodology (Gosselain 2017) is important for tracking technological evidence and thus enabling comparative approaches at different scales of analysis in time and space: the spatial scale as for the occupation of a structure is space, the different requirements of raw materials needed, the varied scale of interaction, reciprocity and collaboration, the scale of time required for the construction of a feature and the unequal ways in which people worked together (McFadyen 2016, 57). What is important is to identify 'meaningful observation units' (Balfet 1973, 12), whether they are operations, sequences, or phases.

The case study

Two neighbouring Late and Final Neolithic dispersed sites, Kleitos 1 and Kleitos 2, were uncovered during large-scale rescue excavation works in the northwestern part of the Kitrini Limni basin in Kozani, northwestern Greece. Archaeological evidence shows that the region was densely populated throughout prehistory (Andreou *et al*. 1996, 568–9; Fotiadis & Hondroyianni-Metoki 1997, 21; Karamitrou-Mentesidi 1987). The two sites cover an area of 2.00 ha and 0.25 ha, respectively, and were excavated almost in their entirety (Ziota *et al*. 2013; Ziota 2014). Kleitos 2 is located *c.* 100 m northeast of the larger Kleitos 1.

The Neolithic settlement was situated on a low mound with a northwest–southeast orientation (Hondroyianni-Metoki 2011; Ziota *et al*. 2013, 71). The remains of at least four buildings, nine clay-based thermal structures, pits and cobble-paved areas were unearthed during excavations on site (Fig. 2). Buildings 1, 2, 3 and 4 were preserved as concentrations of fire-hardened clay rubble, *in situ* wall sections, floors and clay surfaces. The spatial allocation of the buildings was loose, with wide open-air intervals between them.

Geomorphological investigations suggest that Kleitos 2 was developed on an alluvial terrace

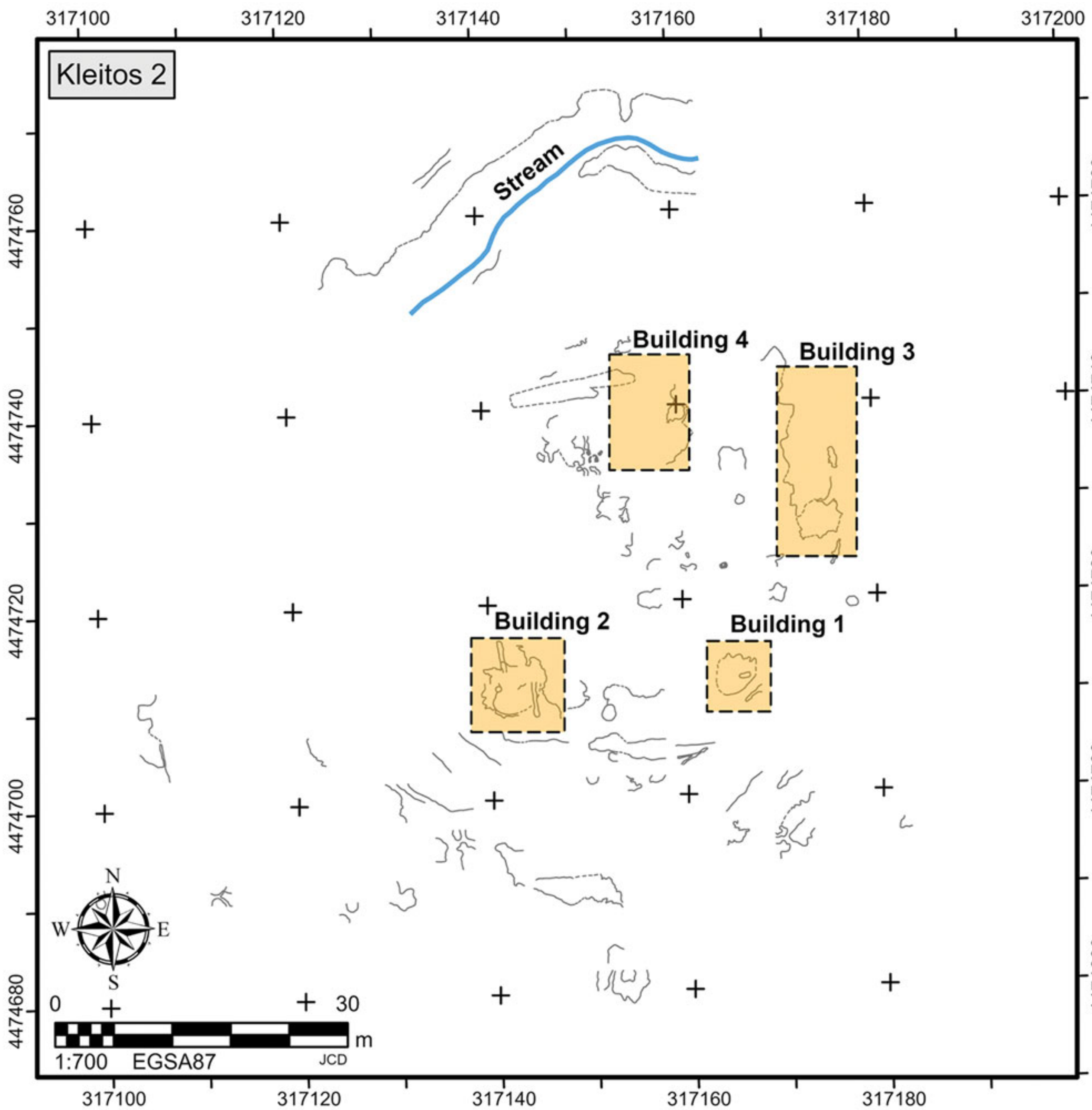


Figure 2. *Plan of the building distributions at the Kleitos 2 site. (Drawing: J. Donati.)*

formed during stream flooding (Ziota 2014, 329). Excavations on site identified the course of three streambeds, which separated the two Neolithic sites and demarcated the eastern area of Kleitos 2 (Ziota *et al*. 2013, 59). During the Neolithic, the landscape at the Kitrini Limni basin was incised by shallow streams and gullies, while parts of it were probably covered by stagnant or slowly running waters forming marshy areas (Fotiadis *et al*. 2019). The relationship between the inhabitants and this complex wetland environment is reflected in the earthworks of Kleitos 1 and other possible waterworks, such as the retaining wall uncovered at Kleitos 2, immediately to the south of the north streambed (Ziota *et al*. 2013, 76). Charcoal analyses (Ntinou 2014) show that the surrounding landscape of the two sites was covered by an array of riparian species, such as ash (*Fraxinus* sp.), elm (*Ulmus* sp.), willow/poplar (*Salix*/*Populus*), and extensive reed stands. Sub-mediterranean to sub-continental mixed oak

(*Quercus* sp.), oriental hornbeam forests and alluvial hardwood forests have been also identified (Marinova & Ntinou 2017, table 4; Ntinou 2014, table 2). It has been supported (Bottema 1982) that the mountains surrounding the basin were covered by coniferous woodlands. This is, however, based on palynological investigations of a number of lakes to the north of the Kitrini Limni basin.

Our analysis focuses on two buildings, namely Buildings 3 and 4, and the assemblage of nine thermal structures uncovered at the site (Fig. 3). The two buildings were selected mainly based on their sufficient preservation status due to conflagration and collapse that protected the archaeological material and provided us with the opportunity to have a sufficient overview of building technology. Building 3 preserves three successive construction Phases A, B and C, indicating a minimum of three different habitation periods (Chondrou 2020, 287; Kalogiropoulou & Ziota 2021). For Building 3, the analysis of architectural remains derives from the earliest and better-preserved Phase C. Building 3 stands out on account of its outstanding concentration of six *in situ* and well-preserved clay-based cooking-related features and the preservation of large quantities of stored products (Ziota *et al*. 2013, 76; Valamoti & Stylianakou 2015, 67). Building 4, on the other hand, is identified by a fire-hardened daub spread but contains no *in situ* cooking-related features. A single hearth is recorded in the deposits of Building 2, placed at the core of the building, while the remaining two hearths were found outdoors as single features (Table 1). Buildings 1 and 4 were empty of *in situ* cooking-related facilities.

How were earthen structures constructed? A six-step analytical framework

In order to tackle the limitations of a traditional technological analysis of earthen structures, we are proposing a schematic framework informed by the effects of time, space and human interaction on the construction practices. The developed step-by-step outline integrates decision-making processes, spatial allocation and form, material acquisition, material processing, details of the manufacturing practices, use and function and elements of the end-life of earthen features (Fig. 4).

Step 1. Form and spatial allocation

Regarding the initial stages of the *chaîne opératoire* of earthen structures, the built form and spatial allocation of the structures are significant aspects of the planning and manufacturing process. Both involve multifactorial decisions based on social interaction, community rules and traditions, technological and topographical constraints and cultural perceptions. Form, however, develops dynamically over time, which adds a transformative quality to cultural products. Rather than deriving from a fully preconceived plan, form largely results from the builders' experiences with different materials, terrains, subsoils and weather conditions (Ingold 2013).

The selection of the construction site set the sequential order for various ground-preparation and building practices. The clearance of vegetation, flattening of hilly spots and the levelling of previously inhabited or demolished areas were prerequisite steps that preceded the construction of earthen features (Kalogiropoulou & Ziota 2021). Evidence from Kleitos 2 indicates that the Neolithic inhabitants carried out some sort of levelling practices which seems to have involved layering a substratum. Building 4 was erected on top of a layer with a relatively high content of natural yellowish clay marl, while comparable layers were identified both between the successive phases of Building 3 and beneath the use surface from its earliest phase (Ziota *et al*. 2013, 73).

For Neolithic builders, orientation was another significant component of the decision-making process. This was based on natural elements, such as the sun/sunlight and the direction of the prevailing winds; on cultural proxies, like other structures, yards, and plot areas; and on symbolic connotations and cosmic references (Gillespie 2000, 137–8; Parker Pearson & Richards 1994a, 15–17). Socio-cultural influences, including the proximity of and affiliation to other social units, also play a crucial role in the location and orientation of buildings and associated structures.

At Kleitos 2, both buildings under study were detached and followed a roughly rectilinear ground plan, as well as a similar north–south orientation. The dimensions of Building 3 during Phase C are estimated to be 11×5 m, covering an area of about 55 sq. m. The interior space was probably partitioned off with post-frame features and two walls made of 'compacted clay', which appear to screen the northern and southern ends of the building (Ziota *et al.* 2013, 73–5). Building 4 is the northernmost building of the settlement and was uncovered 10 m to the northwest of Building 3. Its remains, which cover an area of approximately 90 sq. m, reflect a larger rectilinear structure estimated to be 12.50 × 7.00 m, with a single building phase.

The diverse assemblage of clay-based cooking-related structures found in Kleitos 2 is grouped into

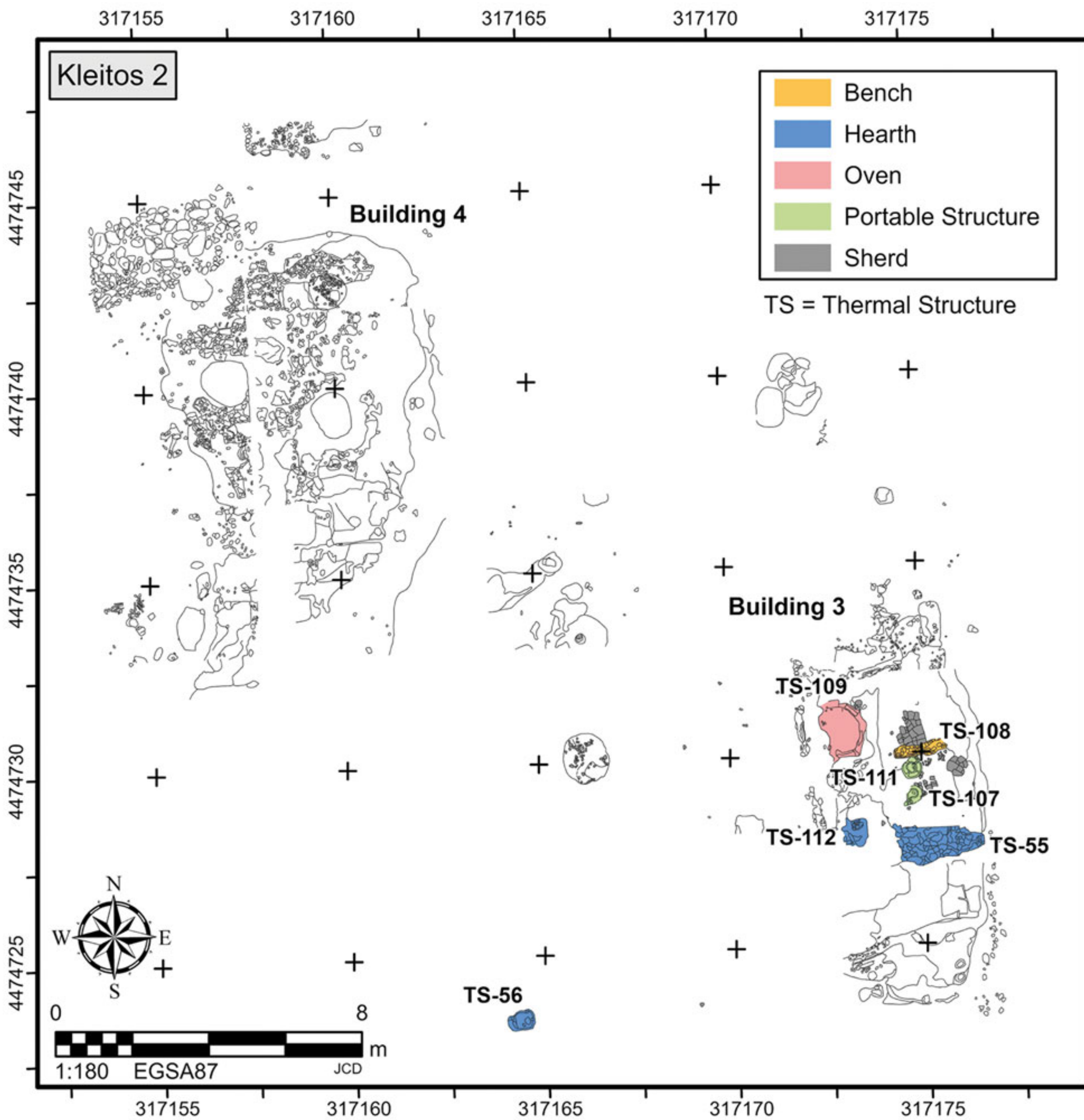


Figure 3. *Plan of Buildings 3 and 4 with thermal structures. (Drawing: J. Donati, © Ephorate of Antiquities of Kozani, Hellenic Ministry of Culture and Sports.)*

four categories: a single oven, hearths, food preparation benches and portable features (Table 1). Five horseshoe-shaped hearths—T.S. 55, T.S. 60, T.S. 112, T.S. 56 and T.S. 79—constitute the dominant category of this assemblage, indicating preferences for open-fire cooking practices, such as grilling, boiling, smoking and roasting (Atalay & Hastorf 2006; Kalogiropoulou in press; Uzdurum 2018; Valamoti 2011). The two structurally unique and spatially adjacent portable structures T.S. 107 and T.S. 111 make up the second category identified in the settlement. Additionally, a single oven T.S. 109 and one bench T.S. 108 were also found in Kleitos 2. The size of these structures varies, ranging from small (e.g. T.S. 112, 0.40 × 0.40 m) to average (e.g. T.S. 56, 0.75 × 0.50 m) and large (e.g. T.S. 55, 2.30 × 1.10 m). Their preservation ranges from average to good; however, all the features bear evidence of their

Table 1. *List of nine thermal structures at Kleitos 2 Neolithic site in Kozani.*

ID	Space	Type	Shape	Preserved size (m)	Orientation	Construction techniques	Function
55	Building 3	hearth	irregular/ horseshoe shape	2.30 × 1.10 × 0.04	W	smoothed heating surface organic inclusions reconstruction works (>4) low walls twig underlay above ground	
60	Building 2	hearth	horseshoe shape	0.74 × 0.83 × 0.19	W	smoothed heating surface pebbled underlay low perimetric walls above ground	grilling roasting boiling smoking
109	Building 3	oven	horseshoe shape	1.55 × 1.20 × 0.15	N	smoothed heating surface organic inclusions reconstruction works (>4) low perimetric wall pebbled underlay	
112	Building 3	hearth	square	0.40 × 0.40	W	smoothed heating surface low wall organic inclusions underlay: yellowish clay floor above ground	
56	outdoors	hearth with perforated vault	horseshoe shape	0.75 × 0.50 × 0.13	W	smoothed heating surface pebbles & sparse organic inclusions perforated heating floor (hole 0.16 m) 2 cavities on top surface low perimetric wall underlay: shallow pit filled with rubble adjacent yellowish clay floor above ground sheltered (?)	
59	outdoors	hearth	horseshoe shape	0.95 × 0.76 × 0.13	W	smoothed heating surface low walls inner clay case pebbled underlay above ground sheltered (?)	grilling roasting boiling smoking cinder
111	Building 3	portable structure	circular	⌀0.49* × ⌀0.25** 0.18***	–	curved discoid clay lower plate cylindrical clay tube organic inclusions lower part replastering (>4) coiling technique	smoking
107	Building 3	portable structure	circular	⌀0.41* × ⌀0.23** 0.12***	–	curved discoid clay lower plate cylindrical clay tube organic inclusions lower part replastering (>4) coiling technique placed on layer of joining sherds	
108	Building 3	bench	rectangular	1.25 × 0.33 × 0.15	W	smoothed upper surface organic inclusions reconstruction works (>7) large potsherds for sidewalls pebbled and twig underlay above ground	food preparation domestic work

*circular round plate (lower part); ** cylindrical clay tube (top part); *** height of clay tube; ⌀ diameter

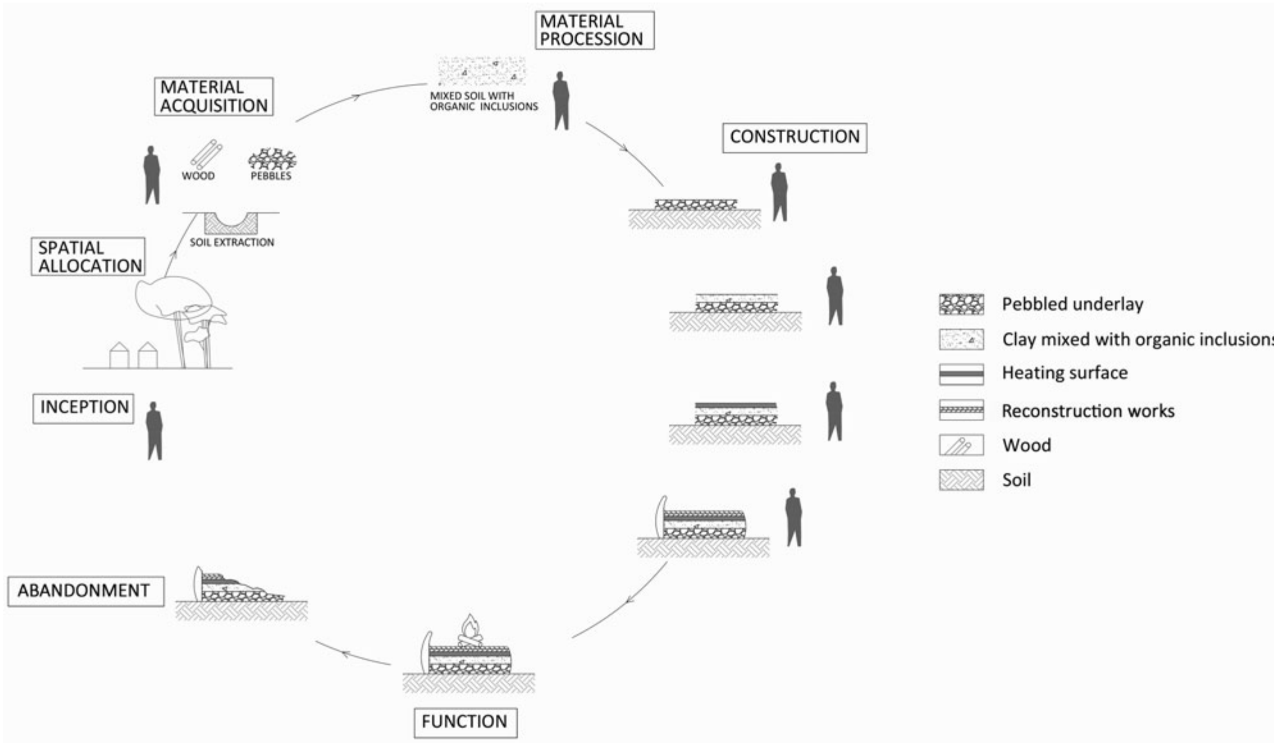


Figure 4. *The* chaîne opératoire *of construction practices of earthen architecture. (Drawing: K. Roumelioti.)*

form and provide details as to their construction techniques.

Thermal structures were mainly placed indoors, with a typical orientation along the west–east axis. In contrast, hearth T.S. 56 is recorded at the open-air space between Building 3 and 4, while hearth T.S. 59 was found at the northern area of the settlement, distant from other structures. A single hearth, T.S. 60, is recorded in the deposits of Building 2, placed at the core of the building, which underlines the centrality of daily routines and practices for the Neolithic inhabitants. On the contrary, a large assemblage of six thermal structures (T.S. 55, T.S. 109, T.S. 112, T.S. 111, T.S. 107, T.S. 108) was found in Building 3, forming a designated, diverse kitchen space (Fig. 5). The spatial distribution of the structures covered the northern part of Building 3, leaving the southern half empty of cooking installations. This suggests that it was used for a different purpose, possibly being marked out as a sleeping or gathering area (Kalogiropoulou & Ziota 2021; Uzdurum 2018). Spatially, the six structures were arranged in close proximity and interdependency with one another, allowing for a collaborative arrangement of simultaneous, diverse cooking and eating practices. The large oven T.S. 109 was constructed in the northwestern area of Building 3. In addition, the Neolithic builders constructed another considerably smaller hearth 112, 2.00 m to the south, while hearth 55 formed another cooking space 2.00 m southeastwards of that one. At the centre of this designated kitchen space, and within easy reach of all three hearths, two portable features—T.S. 107 and T.S. 111—were placed next to each other, demonstrating that advanced food preparation and cooking practices took place at the core of the assemblage. Adjacent to T.S. 111, a rectangular auxiliary bench set the northern boundaries of this complex kitchen space.

Steps 2 and 3. Material acquisition and processing

The step relating to the acquisition of materials is closely linked with knowledge of the properties of the selected natural resources and the degree of standardization of construction practices. The recurrent use of certain categories of raw materials, which were systematically introduced during designated steps of the building process in Kleitos 2, reflects a certain consistency in the construction of both buildings and thermal structures. In addition, the processing of the materials required human intervention in order to transform the raw materials into cultural products. This entailed the implementation of knowledge, skills and traditions.

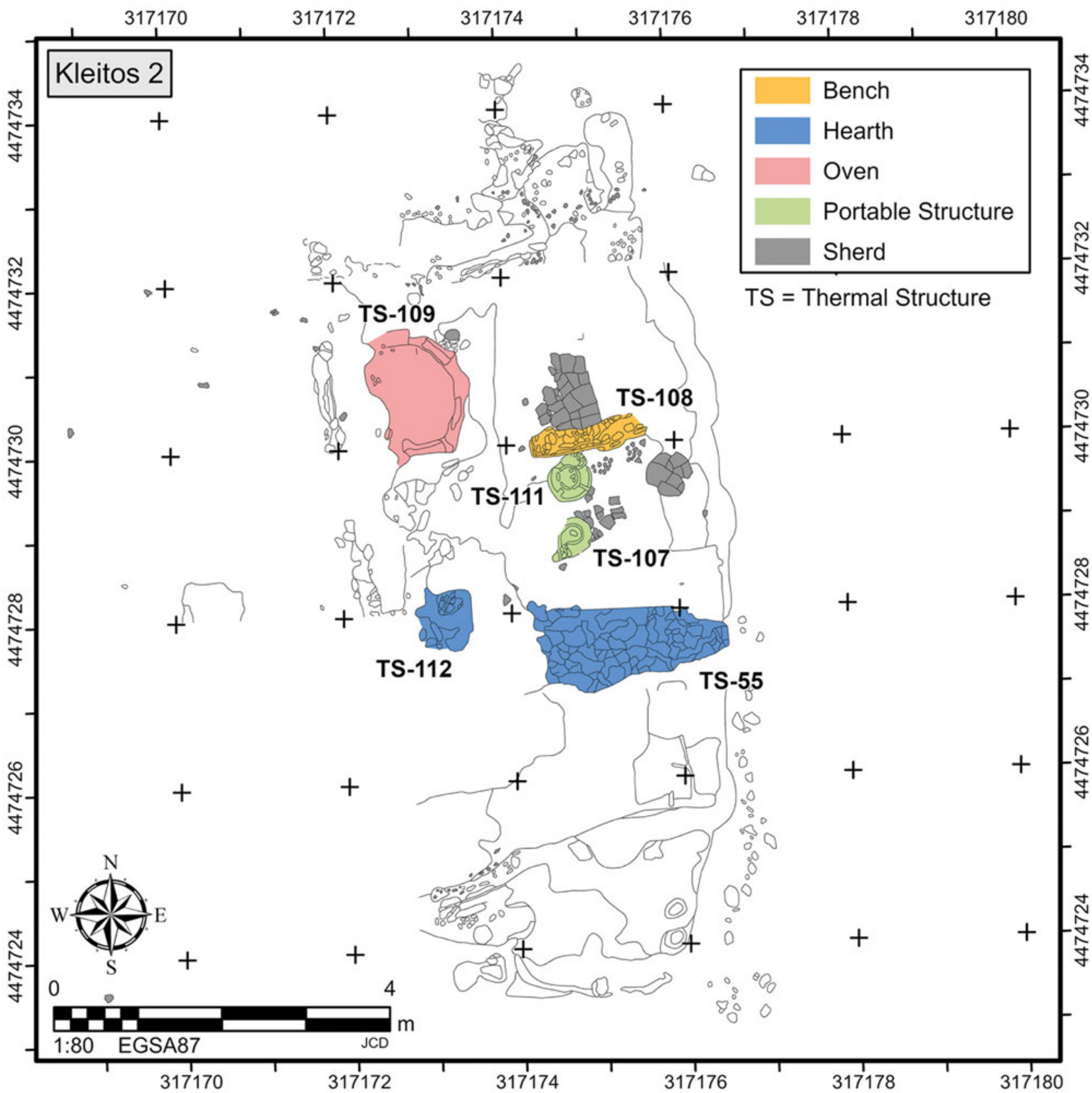


Figure 5. *Spatial distributions of thermal structures in Building 3 (Drawing: J. Donati, © Ephorate of Antiquities of Kozani, Hellenic Ministry of Culture and Sports.)*

At the Neolithic site of Kleitos 2, earth, wood and water were the basic elements used for the construction of earthen features. As already noted, water resources were available near the site. Therefore, the procurement and transportation of water was probably not particularly challenging. Water was used to moisten the earth and turn it into malleable daub, as well as to mix it with tempering materials before shaping the earthen structures. As far as the earth used for construction purposes is concerned, the alluvial, clay-rich horizon and the natural clay marl substratum of the site offered suitable resources for both buildings and thermal structures. The excavators argue that certain pits, especially those that were irregular in shape, could have been initially cut for the procurement of earth (Ziota *et al*. 2013, 65). Nearby outcrops may also have been exploited and the material further processed on site. Shapeless accumulations of clay marl were found in different parts of the excavation, often near structures, and were interpreted as raw materials gathered for construction purposes (Ziota *et al*. 2013, 65).

Clayey sediments with occasional inclusions of pebbles and gastropods were preferred for coating the timber support of house walls and roofs, while yellowish clay marl was used for plastering both building surfaces and cooking installations (see also Ziota 2014, 329). Neolithic builders regularly tempered the earth used for construction purposes with organic inclusions such as chopped straw, chaff, reeds or other grass-like materials, which are preserved in daub as round and elongated pseudomorphic voids or as macroscopically visible silicified remains. Apart from tempering materials, the inclusions recorded also comprise pottery sherds, pebbles, bone and chipped stone fragments. Such inclusions attest to the fact that daub was processed within the settlement area and were probably 'tolerated' thanks to their usefulness in the drying process. On the contrary, the thermal structures at Kleitos 2 do not preserve coarse inclusions and demonstrate the use of finer earth materials, containing medium- to small-sized elements, such as finely chopped straw or pebbles and twigs, which were often used as part of the underlay on account of their heat-resistant qualities.

Wood was used for the timber framework of the buildings and occasionally in secondary parts of thermal structures. The acquisition of timber was associated with the availability of natural resources in the area close to the settlement, while processing wood required an autonomous series of treatment processes before being assembled as part of the timber framework. Woodworking operations comprise tree-felling, branch clearing, occasional barking, straightening, chopping, sawing and hollowing. At Kleitos 2, there is little evidence of bark or sapwood having been removed, while sawing is indicated by a number of fragments bearing 'wavy impressions', less abundant than in other sites, probably associated with advanced know-how, labour invested or preference for other techniques.

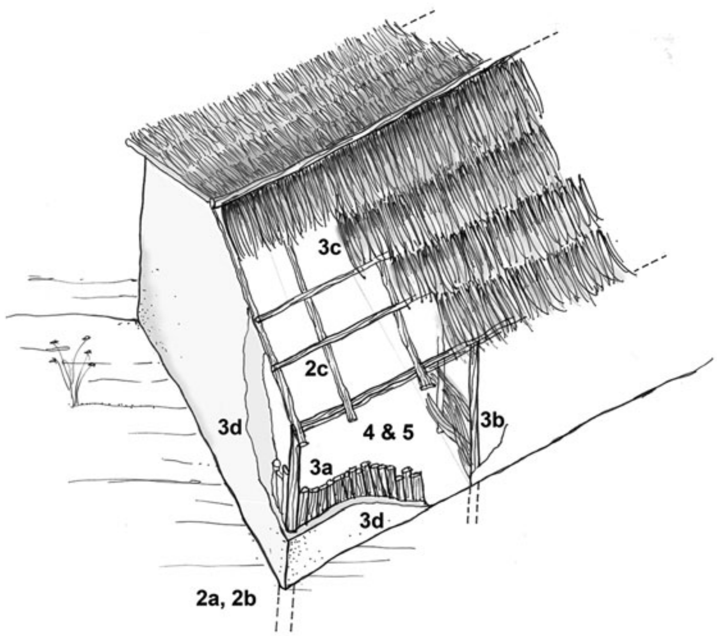
In terms of the tree species exploited, a charcoal analysis of the Kleitos assemblage (Ntinou 2014) supports a range of options. Thanks to its durability and availability, oak would have been suitable for constructing the main load-bearing and framing elements. Coniferous species, such as black pine and juniper, would also have been suitable choices for similar purposes (Marinova & Ntinou 2017, 8; Ntinou 2014, 412). Other species found in the nearby deciduous oak and riparian woodlands could have been used for constructing the walls and roofs. Less sizeable elements were made of saplings or the shoots of various tree species. Wattle frames (e.g. for partition walls) require long stems, such as hazel rods, willow withies and viburnum branches. Finally, the gathering of reeds is indicated by the presence of numerous impressions on daub and by their preservation in silicified form on-site. They were probably gathered with the aid of sickles or sickle blades from reed stands found in the nearby stream courses and wetland areas. The gathering and assembling of reed bundles would have been a demanding, time-consuming activity involving considerable quantities of plant material (Bakels 1978, 90; Fitzjohn 2013, 635).

The quantity or volume of the resources used during the building process is difficult to estimate, as it presupposes an accurate reconstruction of the building dimensions and the techniques applied. In addition, the approximation of the person-hours of work without an adequate knowledge of the organization of production offers solely a sense of scale. In any case, estimations that are commonly based on ideal models (Fitzjohn 2013; Love 2013a; Shaffer 1983) confirm that large quantities of building and tempering materials were required to erect a single building. The same stands for the buildings of Kleitos 2, where a minimum of 15–20 cubic metres of construction earth, several thousand litres of water and several cubic metres of timber and other plant resources were used for the construction of the exterior walls alone. Even if these materials were easily accessible at a short distance, the participation of a more or less extensive group of people would have been necessary for their acquisition, transportation and processing.

Step 4. Construction

Buildings (Fig. 6): ground preparation was followed by the construction of the foundations and the erection of the main framework. The techniques applied seem to adhere to the basic principles of earthfast architecture, which involve transferring all vertical loads to the ground. The rarity of post-holes may reflect the restricted number of load-bearing elements used. Although the preservation of elements belonging to the roof frame is extremely rare in Neolithic Greece (but see Chourmouziadis 1971), the roofs are commonly thought to have been either gabled or hipped, with adequate overhanging eaves to protect the walls from rainwater. Tentative reconstructions are primarily based on clay house models and parallels from vernacular architectural records. In the case of Kleitos 2, a clay house model with triangular narrow walls (Fig. 7) supports the construction of

https://doi.org/10.1017/S0959774322000427 Published online by Cambridge University Press



1. Material acquisition & processing
Tree felling, branch removal, barking, splitting, seasoning
Coppicing(?), wattle gathering
Reed harvesting, fixing reeds into bundles
Earth digging, paddling with water, tempering with vegetal tempers
Cordage making

2. Ground preparation & setting of the timber frame
2a. Ground levelling, layering of a sandy marly substratum
2b. Sinking the load-bearing posts
2c. Setting of the roof frame (tie-beams, rafters etc.)

3. Screening of the timber frame
3a. Setting of the timber support of exterior walls (closely set round and splt timbers)
3b. Weaving of wattles around staves for partitions
3c. Fixing of reed bundles for the screening of the roof and/or the ceiling
3d. Daubing of timber supports with successive layers of mud plaster

4. Floor construction
Trampling, clay plastering

5. Construction of interior features

Figure 6. *Plan summarizing the main operations associated with house constructions. (Drawing: D. Kloukinas, A. Marda-Stypsianou.)*

gabled roofs. Their basic frame could have been set by joining the vertical posts to tie beams.

Once the timber framework was in place, the builders had to screen the walls, the partitions and the roof. The macroscopic study of fire-hardened superstructural material indicates that the main walling technique involved a timber support coated with successive layers of the earth used for construction purposes (Fig. 8a, b). Thin poles, split or halved timbers and thin branches were closely set to create a compact wall screen. Impressions of round poles indicate a mean diameter ranging from 0.04 m to 0.08 m. The use of split timbers in place of round ones is reflected by a number of wavy impressions, while thin branches measuring approximately 0.02–0.03 m in diameter were possibly used to fill in the interstices between the more sizeable elements. Rare samples bear thin parallel lines (wood rays) which follow the direction of the round impression. They suggest that the people involved in woodworking occasionally removed the bark, probably to speed up the drying process and to protect the timber against insects and decay.

The exact technique by which the timber support was fixed is elusive. Evidence from sites including Dikili Tash (Martinez 2001), Sosandra (Georgiadou 2015) and Avgi (Kloukinas 2014; Stratouli *et al*. 2020) indicate that Neolithic builders probably used horizontally placed split poles, transverses and cordage to deal with horizontal movements (Kloukinas 2017; in press). In the case of Kleitos 2, they probably did not sink these timbers deep into the soil, as reflected by the absence of stake-holes at the building's perimeter (Ziota *et al.* 2013, 73). On the contrary, the timbers may have rested on the ground, on a wooden foot in the form of a sleeper beam (see Efstratiou 2002, 248), or inside narrow trenches. The latter could be supported for Building 4, where a narrow foundation trench was uncovered along the eastern boundary of the rubble area (Ziota *et al*. 2013, 73).

The screening of the wall frame was followed by the daubing and plastering of wall surfaces (Fig. 9a–c). The builders coated one or both sides of the timber support with successive layers of 'plant-tempered earth', which were probably left to half-dry before the next layer was laid. This may be supported by the fact that, in most cases, the different layers were separated during conflagration and collapse. Daub fragments of the first layer are commonly about 0.08–0.10 m thick and ceramified. Their incidental inclusions comprise a few pebbles and gastropods, pointing to the alluvial/lacustrine environment of the site. The second layer is generally thinner, about 0.06 m, and yellowish in colour, probably due to the natural clay marl. The wall surfaces were finished with a thin layer measuring around 0.008–0.015 m thick and pinkish/yellowish plaster. Evidence of wall decoration in the form of painted or relief/grooved designs, which have been identified at Kleitos 1 (Ziota *et al*. 2013, 75), are missing from Kleitos 2. The thickness of the wall is estimated at approximately 0.20–0.25 m, although this could be increased considerably if the coating of both sides is postulated.

The construction of internal partitions seems to have been carried out using different techniques. In the case of Building 4, a number of well-preserved fragments with thin, round impressions, *c*. 0.015–0.025 m in diameter, reflect the application of the *wattle-and-daub* technique (Fig. 8c, d), which has often been attributed to partition walls (Kloukinas 2017; in press; Prévost-Demarkar 2019). The Neolithic builders wove pliant branches or reeds around vertical posts or staves in order to form a dense support with no need of further fixings. Following this, they plastered the timber support on both sides with plant-tempered earth. Evidence for the possible application of this technique in the case of Building 3 is restricted to a couple of poorly preserved fragments. The internal partitions of Building 3 seem to have followed a 'compacted clay' technique, as indicated by the two parallel, poorly preserved wall sections uncovered.

Moving to the covering of the roof frame (and/or the ceiling?), the information provided derives primarily from the remains of the destruction layer of Building 3. The remains take the form of silicified thatch material and daub fragments with multiple round impressions ranging between *c*. 0.003 m and 0.014 m in diameter (Fig. 10). These dimensions fit well with the stems of the common reed (*Phragmites australis*), which are occasionally preserved *in situ*

Figure 7. *Clay house model with two stories from Kleitos, Late Neolithic. (© Ephorate of Antiquities of Kozani, Hellenic Ministry of Culture and Sports.)*

(Fig. 10a, b). Other round impressions, measuring *c*. 0.02 m in diameter, are occasionally arranged perpendicularly to the reed impressions and could represent thin branches. The available evidence supports the possibility that the Neolithic builders constructed a framework of beams, rafters and purlins, which they later covered with bundles of common reeds. They may also have used leaves of reeds or rushes as light cordage material, as suggested by the occasional preservation of elongated impressions running on top of reed bundles (Fig. 11b). Another hypothesis is that stalks of willow or other species were used instead of cordage, which is also reported ethnographically (Efstratiou 2002, 266 & fig. 109; Hatzimichali 2010, 208). This could be supported by several leaflet impressions (Fig. 11a, c) that have been tentatively identified (Kloukinas in press) as ash (*Fraxinus* sp.) or willow (*Salix*). Alternatively, their inclusion in the daub could have been accidental. The identification of groups of parallel impressions running diagonally to each other may suggest that the builders placed layers of thatch material in such a way that they partially overlapped. At Kleitos 2, the occasional identification of impressions of reed leaves and inflorescences (Fig. 11a) may suggest that the working group did not invest a lot in their removal before fixing the stems into bundles. Nevertheless, this could also reflect a purposeful practice aimed at maximizing

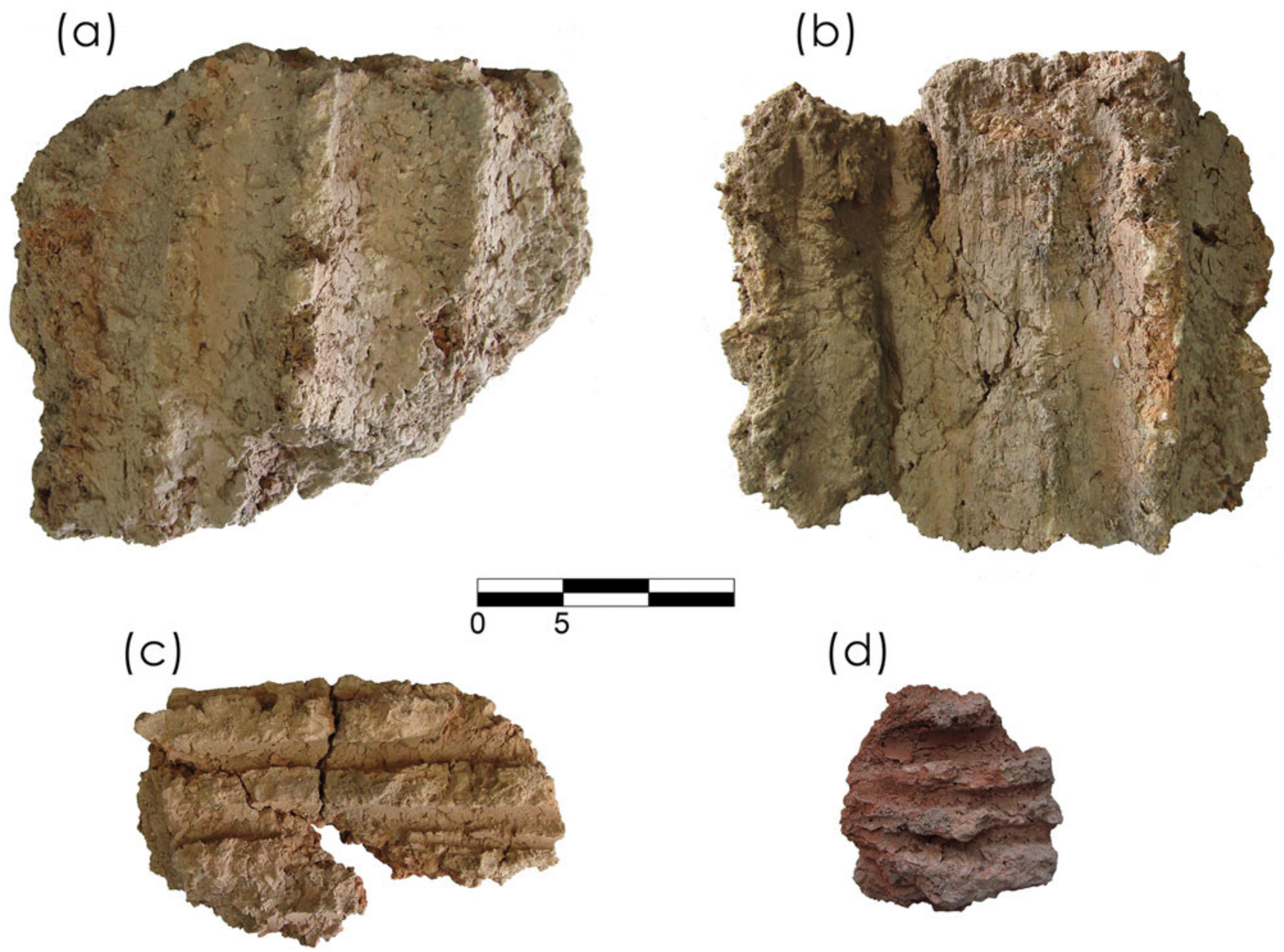


Figure 8. *(a, b) Daub fragments with impressions of thin poles and split timbers and (c, d) woven branches. (Photographs: D. Kloukinas.)*

the volume of the roofing material.[1] After its placement, the thatch was plastered with daub for extra protection against wind and change.

As already noted, the floors of both buildings were laid on top of a substratum with a high content of yellowish clay marl. The floor of Building 4 was sealed by the collapsed superstructural material and was preserved as a thin greyish-black layer. This represents a burnt trampled surface with minor preparation. The earliest floor surface of Building 3 has been described (Ziota *et al*. 2013, 75) as 'clay-made'. It was 0.05–0.07 m in thickness and had been resurfaced at least three times. The latest floor was partially preserved and it is also described as 'consisting of successive layers of clay on top of sherds' (Ziota *et al*. 2013, 73).

Thermal structures: five hearths—55, 60, 112, 56 and 79—constitute the dominant category of the assemblage, indicating preferences for open-fire cooking practices. The hearths demonstrate outstanding homogeneity in terms of the sequence of building techniques applied. They vary in size and shape, as irregular, square and with a horseshoe shape (Fig. 12). Two building techniques are identified in this assemblage.

Technique A involves the initial flattening of the ground and the construction of the underlay directly on top (Fig. 12). At this point Neolithic builders designed the shape of the structure as irregular, horseshoe-shaped or square. Subsequently they set a pebble or twig layer directly on top of the designated flattened area for the construction of the underlay. A yellowish marl has been identified at hearths T.S. 112 and T.S. 56, as part of the underlay construction or as an adjacent plastered floor for cooking preparation practices. The underlay was then covered by a layer of clay mixed with organic inclusions, which formed the heating surface of the structure. At Kleitos 2, the heating surface was simply smoothed, forming a

https://doi.org/10.1017/S0959774322000427 Published online by Cambridge University Press

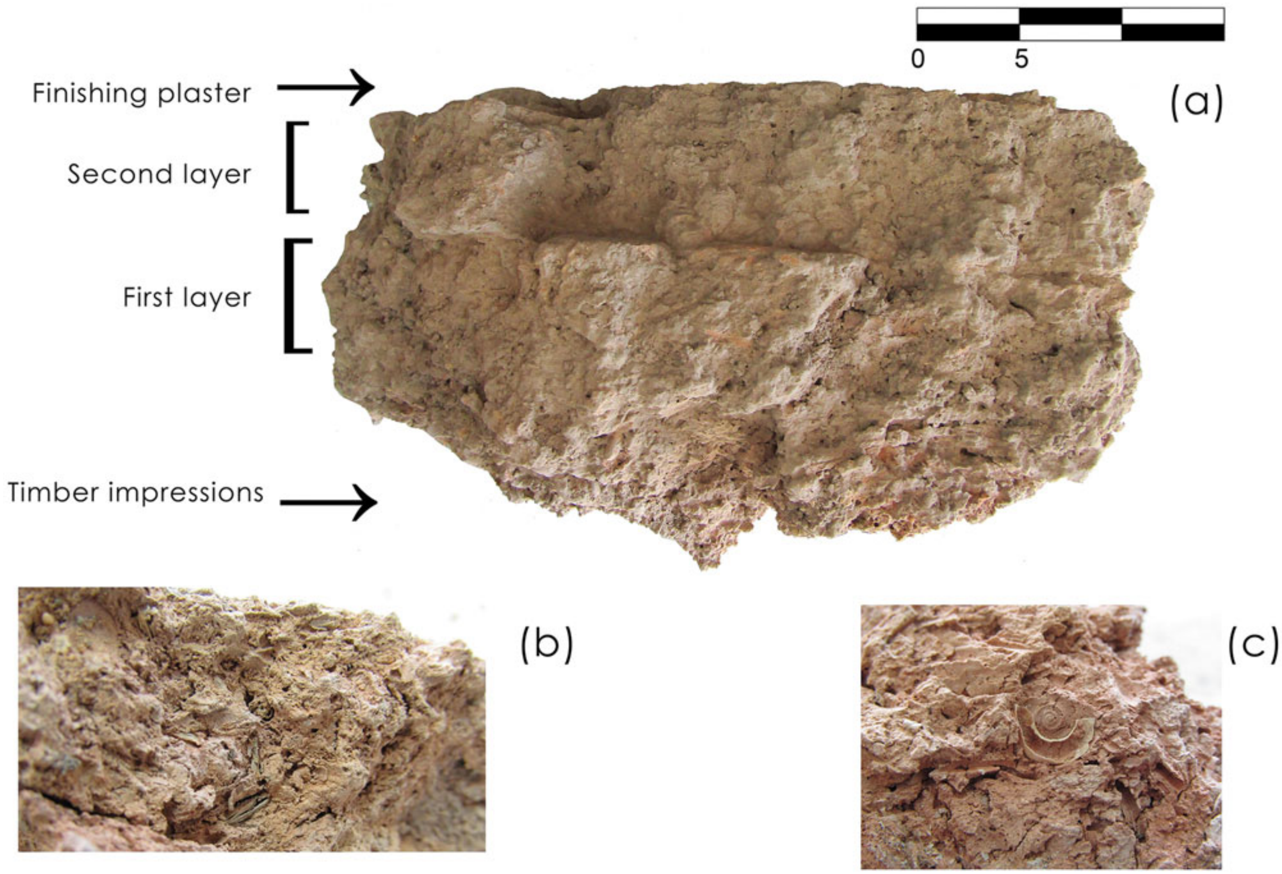


Figure 9. *(a) Daub fragment showing layers of plaster and (b, c) details of fire-hardened daub fragments with macroscopically visible inclusions. (Photographs: D. Kloukinas.)*

flattened, even upper level. A fine-grained clay marl plaster was used to line the side walls of the hearths and was occasionally applied on top of the underlay construction of their heating surfaces (Ziota 2014, 329).

Technique B, on the other hand, is presented at a single feature, T.S. 56, through the digging of a shallow pit with a maximum depth of 0.20 m, filled with rubble from the collapse of the upper structure. The pit was dug directly in the ground and its side walls were covered with finer clay plaster. A smoothed clay heating surface, which resembles dome construction and was rich in organic mixtures, with a central perforation measuring 0.16 m in diameter, was produced to cover the shallow pit. The builders formed two small adjacent cavities at the western part of the heating surface of the hearth, possibly as auxiliary constructions for certain cooking practices or other food-preparation routines (Fig. 12). After the heating surfaces had been constructed, a low perimetric side wall with a maximum height of 0.20 m was built using a coiling technique, leaving an average opening of 0.30 m on one side of the structures in order to facilitate cooking activities. The outer surface of the side walls is rough, with no preserved signs of smoothing or decoration.

The steps involved in constructing the two identical portable features, T.S. 107 and T.S. 111, resemble the steps for manufacturing a large pot. These two earthen structures are comparable in size and height (Fig. 13). They consisted of two parts, both constructed using a coiling technique applied to tempered earth with organic inclusions. Macroscopically, both parts seem to have been constructed with the same earthen material. The clay includes a high concentration of organic material (chopped chaff, straw and grass) and possibly intentionally powdered gravels. Abundant organic matters at both structural parts of the features were possibly used to make the constructions lighter for their potential transfer. The lower part of the structure is a curved, round discoidal plate with round edges averaging 0.45 m in diameter. The centre of this circular plate was hollowed, where the upper cylindrical feature was placed and adjusted. The

https://doi.org/10.1017/S0959774322000427 Published online by Cambridge University Press

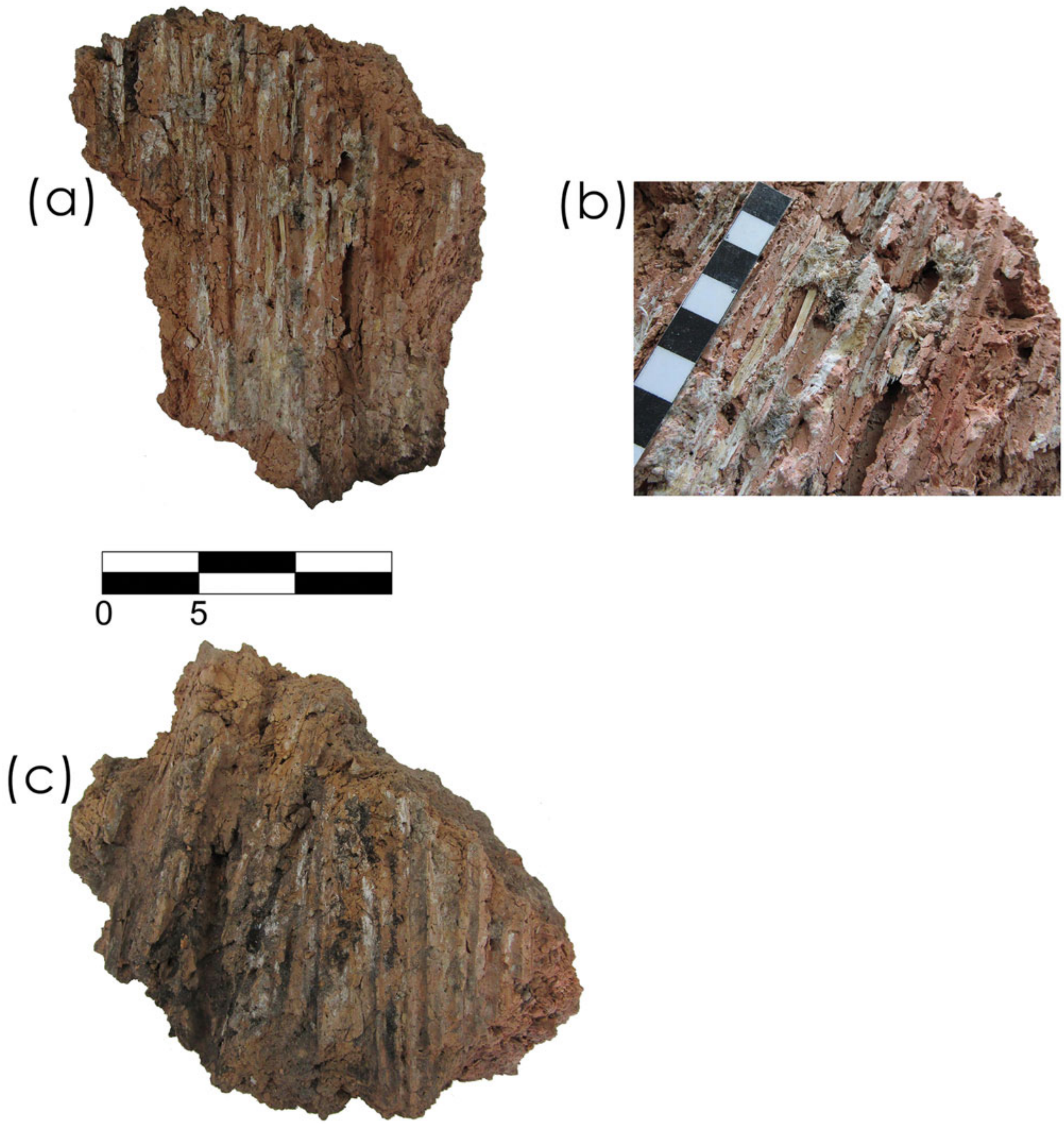


Figure 10. *(a, c) Daub fragments with impressions of parallel reed stems; (b) detail of (a) with reeds preserved in a silicified form. (Photographs: D. Kloukinas.)*

upper part of the structure is a clay cylinder with an open-mouth top end averaging 0.24 m in diameter and a bottom base attached to the lower part of the construction. The sequence of construction starts with building the round discoidal plate by successively stacking coils. The outer and bottom inner surfaces of the plate part were smoothened and left to dry. Further smoothing and plastering at the outer surface of the clay plate was then performed. The cylindrical top part was produced separately. First, the builders made an even, circular clay plate, which constituted the base of the cylindrical tube. Successive coils were then stacked one on top of the other, reaching a maximum height of 0.15 m.

https://doi.org/10.1017/S0959774322000427 Published online by Cambridge University Press

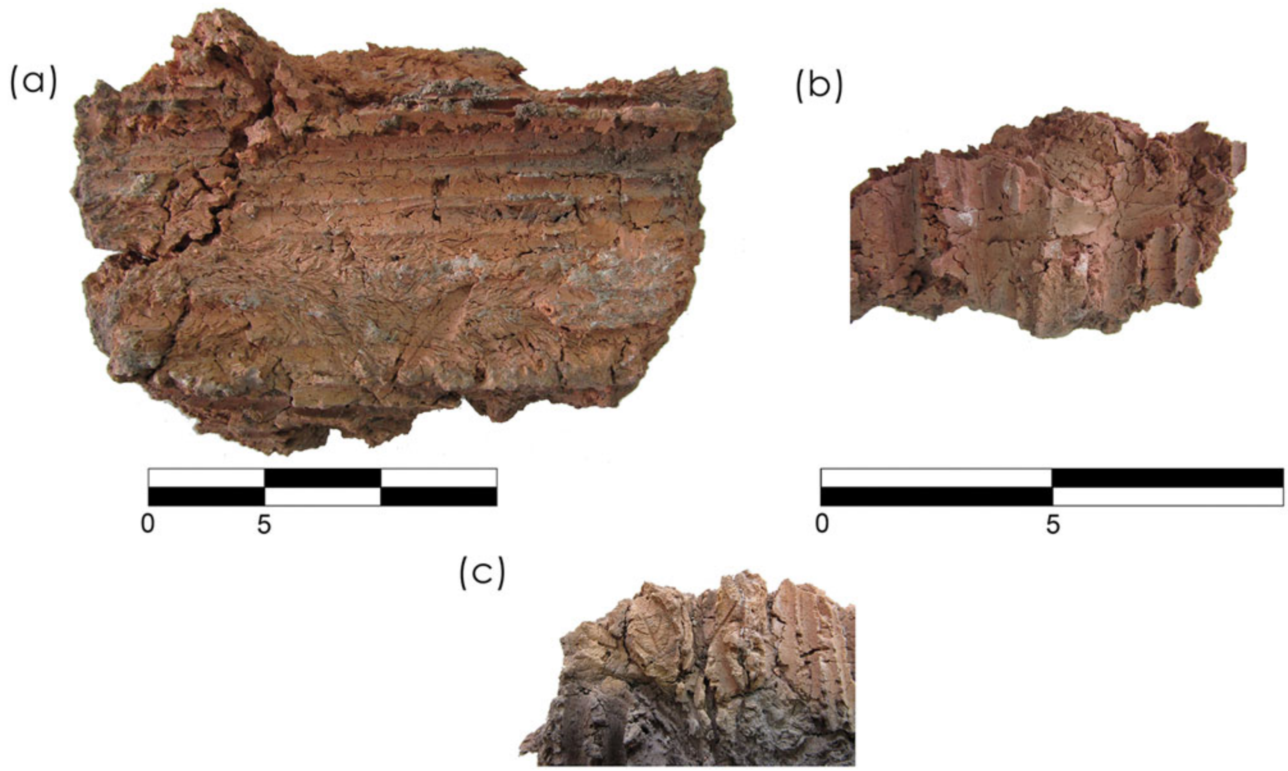


Figure 11. *(a, c) Daub fragments with impressions of reed inflorescences, reed stems and leaflets; (b) Daub fragment with impression of reed stems and probable cordage material. (Photographs: D. Kloukinas.)*

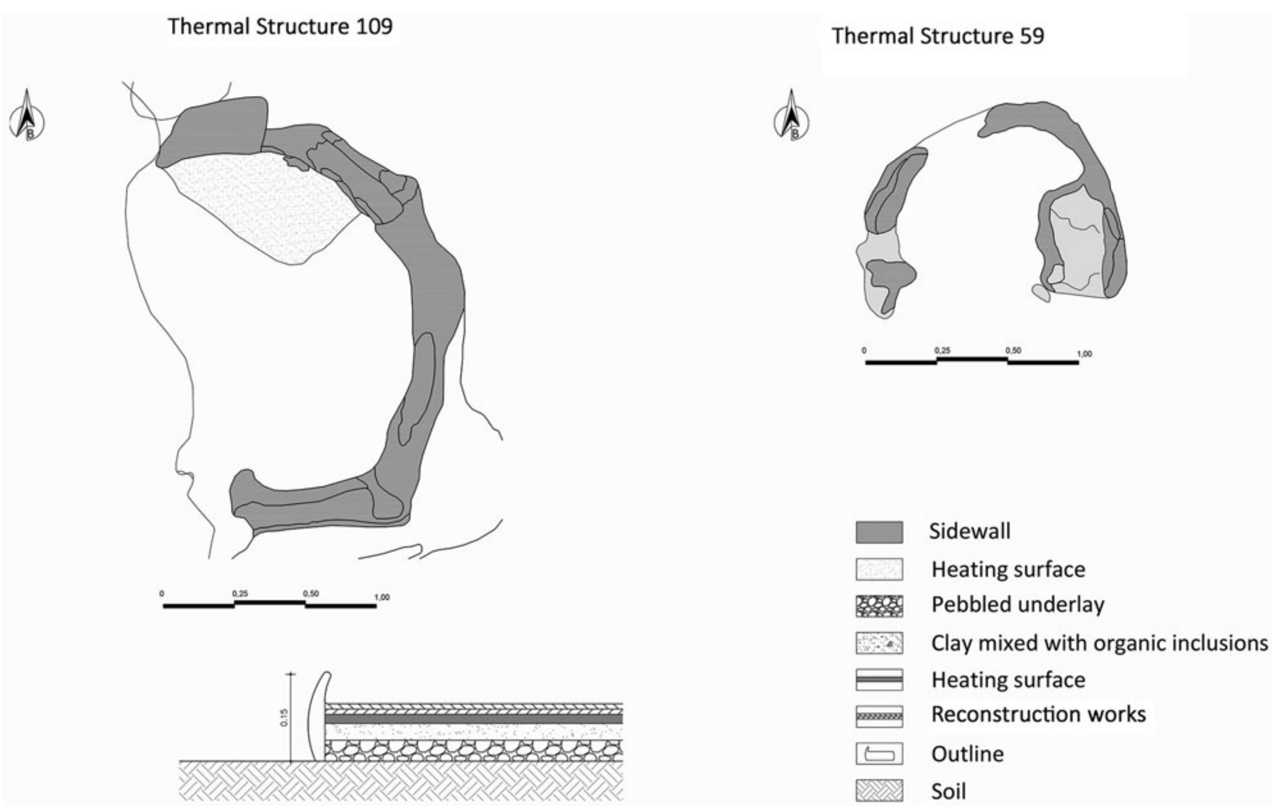


Figure 12. *(a) Plan of hearth 109; (b) section of hearth 109; (c) plan of hearth 56. (Drawing: K. Roumelioti.)*

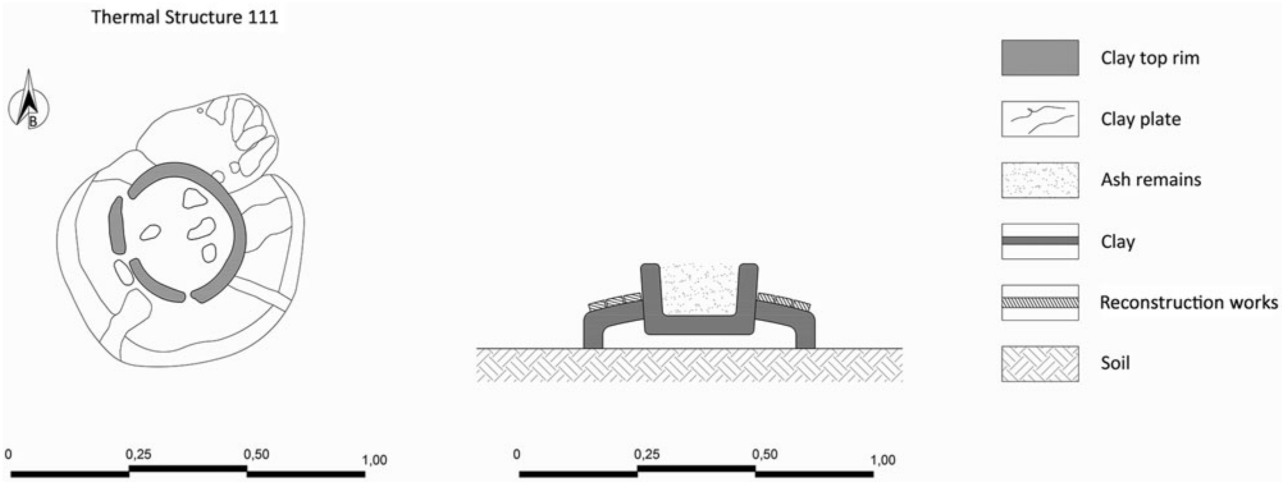


Figure 13. *Plan and section of portable feature 111. (Drawing: K. Roumelioti.)*

The outer surface of this clay tube was smoothed, whereas the inner surface of the structure was left rough. Before this part was dried, it was attached with its base down on top of the clay plate, leaving the top open mouth to form the upper end of the whole structure. The structures were initially dried and then fired to solidify them for use.

The single oven T.S. 109 found in the deposits of Building 3 follows the standard construction steps with other parallel examples of contemporary sites in northern Greece, such as Avgi (Kalogiropoulou in press; Stratouli *et al*. 2020), Servia (Ridley *et al.* 2000) and Dikili Tash (Prévost-Demarkar 2019). A shallow pit of 0.10 m depth was cut in the ground and its side walls were covered with clay plaster. A pebbled layer was spread on the bottom of the cut for the construction of the underlay. This was subsequently covered by a clay layer mixed with organic inclusions, which formed the heating surface of the structure. Four successive heating surfaces were identified on oven T.S. 109, showing evidence of reconstruction work. All four heating surfaces were simply smoothed. A coiling technique applied to tempered clay with abundant organic inclusions was used for the construction of the side walls and the roofed chamber construction. Coils were put successively one on top of the other to produce the side walls and vault of the structure. The side walls have been preserved to 0.15 m height and were covered with clay plaster from both sides (inner and outer). The form of the vault is unknown (either curved or flat), due to the lack of material remains from this part of the structure. The oven had a wide (1.55 m) entrance opening at its western side. Based on experimental work, after the end of the construction the feature was left to dry for one or two days according to weather conditions and then a light fire would be started so the oven could harden properly (Conati Barbaro *et al*. 2019; Duričić 2014, 265).

The rectangular bench, low in height and above the ground, was constructed directly on top of the floor of the house. The underlay of the structure was made using mixed materials, such as pebbles and twigs. Its side walls were made by placing two parallel lines of large potsherds vertically on the ground. Neolithic builders filled its two side walls with earth rich in organic inclusions. They then smoothed the upper surface of the structure with finer clay fabric, without any organic mixtures. After its construction was complete, the bench was left to dry before being used. Evidence of low heat or burning could be linked with the destruction by fire and collapse of Building 3.

Step 5. Use and function

The function of the two case-study buildings is difficult to decipher in their full extent. Evidence from the interior of Building 4 is quite limited, as the floor surface was found empty of *in situ* structures. Based on the current analysis of architectural and contextual data, Building 4 represents the residence of a single unit or of a nuclear family, and hosted various domestic activities, such as sleeping, storage, protection from weather, and gathering (Flannery 1972). On the other hand, Building 3 differs considerably in terms of preservation. Apart from the numerous thermal structures and rich archaeobotanical assemblage of stored products, a large group of pots includes a deep bowl turned upside down, a storage vessel and part of a large pithoid vessel directly associated with working bench T.S. 108.

Macroscopic, spatial and contextual analysis of the nine clay-based thermal structures in Kleitos 2 supports their primary domestic-scale use. Consistent typological evidence of their size, shape and construction suggests that all nine structures were used for daily domestic routines, such as cooking, food preparation, lighting and heating. Instead, it could be proposed that due to its outdoor spatial allocation between Buildings 3 and 4, hearth 56 could be a shared structure for the residences of both domestic units. Furthermore, the form of hearth 56 and the perforation of its heating surface indicates the performance of certain cooking routines that involved boiling (Kalogiropoulou in press). Contextual and archaeobotanical remains in Building 3 point to extensive storage and food-preparation activities, compatible with the domestic operations of a household (Valamoti & Stylianakou 2015; Ziota *et al*. 2013, 75). Nevertheless, the rich assemblage of six *in situ* thermal structures and the great accumulation of portable finds at the deposits of Building 3 in Phase C, together with its continuous rebuilding at the same place, make possible the hypothesis of a suprahousehold or a medium-scale gathering place addressed to more people or different groups within the community. Such a place has been identified at the adjacent Kleitos 1 settlement. Therefore, a tradition of community sharing cannot be excluded in the case discussed (Kalogiropoulou & Ziota 2021). Additionally, the diverse group of clay-based structures in Building 3 suggests a high degree of variability of cooking-related practices. The large single oven enabled baking and roasting, while open-air direct or indirect cooking, such as boiling in pots, roasting on the heating surfaces, grilling, warming of cooked food in skins or baskets, smoking and parching, could be performed on the two hearths (Atalay & Hastorf 2006; Hastorf 2017; Valamoti 2011). The central placement of the bench in easy reach from all six structures underlined its auxiliary use as a food-preparation platform.

Furthermore, the use of the two portable structures T.S. 107 and T.S. 111 could be better understood from their content. The top cylindrical tube of T.S. 107 was filled with ashes and layers of carbonized organic material, while the inner surface of the bottom clay plate was sooted. Additionally, the structure was placed directly on top of a layer of large, joined potsherds, possibly used as a supplementary heating surface for the placement of cinder or low-heat fire underneath the feature. A functional hypothesis for these twin features is that they were used for smoking raw ingredients, such as meat and fish. Smoking is a suggested practice also used for preserving food at Neolithic sites in Greece and could partly explain the portability of the structures (Kalogiropoulou in press).

Step 6. Maintenance, reconstruction, and end life

In terms of maintenance, the renovation of building walls and the heating surfaces of thermal structures was common. The successive layers of wall plaster indicate that the occupants carried out periodic (wholesale or not) renovations and repairs of wall surfaces. Evidence of repeated renovation and reconstruction works, which reached four successive heating surfaces, can be identified in two hearths. Up to four replastering layers are recorded on the outer surface of the lower plate part of the twin portable features. In addition, a minimum of seven successive layers of renovation works on the top surface of the bench are also noted.

Regarding their end life, all the buildings uncovered at the site and at the neighbouring site of Kleitos 1 were burnt. Comparable assemblages in the wider Balkan region have often been seen as the result of intentional conflagration aimed at marking the location and providing a foundation for the new structure (Stevanović 1997, 338). According to the excavators (Ziota *et al*. 2013), in the case of Kleitos 2 there is no evidence of a widespread conflagration episode. In the case of the earlier phase of Building 3, destruction by fire and the collapse of the reed-thatched roof resulted in the preservation of large quantities of stored products (Valamoti & Stylianakou 2015, 67; Ziota *et al*. 2013, 76) and *in situ* features. It is hard to ascertain whether this supports a sudden destruction episode or a differential function of the building. Whatever the case may be, the building was replaced and set alight twice more before being abandoned. Building 4 was also destroyed by a fire, which led to the preservation of collapsed, fire-hardened superstructural material on top of a thin greyish-black layer representing the floor. Nevertheless, no *in situ* internal installations were uncovered. Again, it is difficult to determine whether a situation entailing the clearance of the inventory of the building before conflagration was involved.

Evidence regarding how the end life of the thermal structures was reached at the Neolithic site of Kleitos 2 points to practices of abandonment. The thermal structures in Kleitos 2 do not show any signs of intentional destruction. When out of use, cooking installations were abandoned with no distinct causal indications. When inside buildings, the end life of cooking installations is synonymous with that of the destruction of the building, as in the case of the seven features found in the rubble remains of Buildings 3 and 4. The two features found outdoors went out of use without any signs of demolition or intentional damages.

Discussion: socializing the *chaîne opératoire* of earthen architecture

Any attempt to people the prehistoric past clearly faces serious difficulties. It is not possible to identify a simple relationship between architectural features and individual acts of kinship or co-residency and technological traditions, except through specific examples (see Hodder 2013). Nevertheless, the purpose of this analysis has been to focus on earthen structures as works of architecture and social practice and to underline the multiple dynamics involved in their construction (see Vellinga 2007). The entire project of building a house or a thermal structure is here viewed as a dynamic taskscape (Ingold 1993), where various operations are characterized by their own temporalities and socialities. Carried out either in succession or in parallel with one another, the different stages of the project often intersect with other activities, bring together different bodies of social interactions and correspond to various socio-cultural concerns. *Chaine opératoire* has been a valuable tool to organize, compare and approach the social effects of building making through the nuanced steps of practice and to tackle technological skills and know-how, social time, labour, solidarity and traditions of construction that contain the core of this research.

Moving beyond the conceptual links identified, similarities in the *chaînes opératoires* of the features under study are noted. In both buildings and thermal structures, the procurement and processing of the earth used for construction purposes required a comparable set of technical gestures, embodied skills and mental operations. As has been argued (Catapoti & Relaki 2020), these may be viewed as fundamental within the technical regimes that defined a Neolithic *being-in-the-world*. Kleitos inhabitants were evidently familiar with the local geology in terms of the available soils and sediments as well as the properties of the resources used. This acquired knowledge is evident from the selection of varied clay sources and the use of specific clay to certain parts of the earthen structures. Such an example is the application of yellow marl in specific parts of the features, for wall plastering in buildings and thermal structures, on top of the underlay construction of their heating surfaces, or for the construction of auxiliary plaster floors for food preparation attached to cooking-related structures, as in the cases of hearths T.S. 112 and T.S. 56. Our step-by-step analytical approach gave us the chance to identify more details of construction practices that unfolded the skills and capability of Neolithic builders at Kleitos 2. For example, abundant organic matter in all thermal structure categories was used in the tempering of specific parts of their construction, as in side walls, vault elements or the plate part of portable structures, possibly to reduce the overall load of the features. Lighter constructions with abundant organic matter in the clay parts of the roofs/ceilings of the buildings were also chosen.

As is the case with 'techniques of the body' (Mauss 1936), these 'instrumental techniques' and the related technological know-how were socially and culturally acquired and transmitted within groups and between contiguous communities (Oliver 2006). Neolithic builders in Kleitos 2 were making recurrent choices in both material selection and technological application. Intra-site standardization of the forms and techniques of the earthen features studied here attests to the existence of community-wide traditions dictating the processes and steps of construction. Even if the technologies applied were, to an extent, set by the affordability of the materials, the consistency of combinations of raw materials and techniques for particular parts of the constructions shows technological standardization and know-how that was potentially passed down from one generation to another through education, experimentation, practice and observation. To this end, intensive earthwork activity and pit digging also required skills shared and transmitted among the builders. In the case of thermal structures, the typical *chaîne opératoire* of building technology, material selection and form suggests a common tradition that could potentially indicate specific cooking routines, culinary preferences and tastes (Hastorf 2017, 41; Özbaşaran 1998, 558). Although the assemblage of thermal structures is diverse, evidence of regularity in the selection of material resources and the sequence of construction is marked. Except for the building consistency of side walls and vault parts described above, the construction of the underlay in all categories of cooking-related features in the settlement suggests the systematic placement of pebbles and twigs for the making of the substructure layer (instead of other materials such as, for example, straws, reeds, daub, or sherds in second use, also available on site). In this respect, the heating surfaces of the oven and of all four hearths recorded at Kleitos 2 were made by a finer clay layer that was simply smoothed and not polished, as is the case of other contemporary sites in the region (e.g. Kleitos 1, Avgi, Servia).

Apart from the acquisition of skills and techniques inscribed in the hands and muscles of the inhabitants (Robb 2007, 84), the construction process as a whole reveals itself as a significant *faire social*. The spatial allocation of earthen structures was defined by social organization, social interaction and affiliations. The spatiality of building practices, which is not always emphasized in other sorts of technical actions, plays a central role in architectural works. The settlement space emerges from practices and is dictated by socially and culturally informed possibilities that define where architectural earthen structures will be built (Fitzjohn 2013; Love 2013a; McFadyen 2016; Nielsen 2016). This is significant when trying to understand the underlying decision-making process. In the case of Kleitos 2, all four buildings were subsequently constructed along a north–south axis and were grouped at the central area of the settlement, forming close spatial associations (Fig. 2). The central outdoor space developed among the buildings hosted numerous communal domestic routines and socialities, such as food preparation and cooking, as indicated by the construction of hearth T.S. 56, that enabled visibility and social monitoring among the co-residences. To this direction, the maintenance and reconstruction of specific features in the same position indicates that certain practices were associated with fixed notions of place. The fact that the Neolithic inhabitants repeatedly reconstructed Building 3 in the same place raises the possibility that certain social units were related to specific plots of land. Along with the incorporation of preceding architectural elements in the final Phase C, this could be linked to claims of locus and residence (Bailey 1990; Tringham 2000), which would have had a considerable influence on the spatial allocation of the dwellings. Similar practices, including the replastering of side walls and the renovation of heating surfaces, are regularly recorded in the case of thermal structures. They are interpreted as efforts to prolong the life and use of the structures in fixed spaces and to retain their spatiality, thus maintaining a routine choreography for food preparation and cooking (Felski 2000; Kalogiropoulou 2014; Kalogiropoulou & Ziota 2021; Sørensen 2000, 161).

Discussing the procurement of materials and the construction stages, several socialities, temporalities and dynamics are involved. The working group participating in the construction processes is a dynamic one and may range from a restricted number of individuals belonging to the extended household or close kin to a much larger group, or even a community-wide one. Its size and synthesis depends greatly on the task undertaken and the labour force that a dwelling group can mobilize thanks to its kinship relationships, reciprocal obligations and status (Wilk 1983, 105). It is not uncommon for the time-consuming, labour-intensive process of constructing a house to involve collective work by groups exceeding the size of the future resident unit. Whether causally related to or encouraged by the 'domestic mode of production' (Sahlins 1974), such practices have been interpreted as coping mechanisms to counteract risks of economic failure (Halstead 1989, 72–3) and as 'a capital of services rendered' (Bourdieu 1977, 60) within a wider context of reciprocity and solidarity in practice. The gathering and assembling of reed bundles, for example, would have been a demanding, time-consuming activity involving considerable quantities of plant material (Bakels 1978, 90; Fitzjohn 2013, 635). Inherent temporalities are hidden, for instance, in relation to the process of drying the earth used for construction purposes and the plasters, in the allocation of raw materials to the designated area of construction, as well as to the seasoning of structural timbers or the use of wattles while fresh and flexible. Moreover, time and labour are key factors for intensive earthwork activities and pit digging, which would demand collective work or a large group of people undertaking the tasks. The construction of Buildings 3 as potential suprahouse or communal gathering place could offer an exceptional opportunity for social interaction and cohesion in this respect. Certain tasks that were more demanding in terms of technical knowledge and craftsmanship would have been carried out by smaller groups of skilled and experienced individuals. The procurement and working of structural timbers, for example, could have involved individuals with a good knowledge of the appropriateness of tree species from the surrounding microenvironments. Other operations, which required the aid of several hands and involved more generic knowledge and skills, could have been carried out by larger groups of helpers and ascribed with significant affinal connotations (Hugh-Jones 1995, 228). These tasks include the digging and paddling of soil, the transfer of bulky resources (including earth and water) and daubing or plastering. The setting of the main frame and the thatching of the roof are also occasions for communal labour, potentially supervised by experienced individuals (Waterson 1997, 126–7).

Instead, the construction of thermal structures is a smaller-scale project with obvious differences in both the time and the people required. It therefore involves different dynamics in terms of decision-making and planning, as well as in terms of social participation and human agency. The construction of a single thermal structure is a much less time-consuming task compared to buildings, even in the case of large and structurally demanding features. Moreover, any category of thermal structure could be accomplished by a single individual or a small group of co-residents or family members. The necessary quantities of raw materials suggest that the procurement of materials—including extracting soil, selecting pebbles, processing organic materials, and acquiring twigs—did not constitute a copious or time-consuming step in the manufacturing chain. The intermediate steps carried out to access and process the different categories of raw materials were neither particularly time-consuming nor technologically demanding. Moreover, the different stages of the building process—including flattening the soil, digging shallow pits, framing the underlay with pebbles or twigs, chopping organic inclusions, mixing soil and layering heating surfaces—are tasks that could be carried out by a single person or a small team of not necessarily exceptionally skilled but nonetheless experienced co-workers. The community preference for the indoor allocation of thermal structures made their construction a private process, less visible to the wider community, not only during construction but also during their use. At the same time, the possibility of a community-wide Building 3 made the features accessible to the group of participants allowed indoors, enabling visibility of the structures. Regardless of their domestic or communal function, however, numerous social interactions were developed among co-users and co-residents during the use of thermal structures.

The above analysis suggests that the processes involved in constructing the diverse categories of earthen structures pose different demands and provide different opportunities for social interaction, co-operation and shared experiences among the participants. The actual construction of earthen buildings should be seen as 'the culmination of an extended process of planning and preparation' (Robb 2007, 83), which brings together varying groups of people and allows group affiliation and unity to manifest itself. In terms of both its construction and the end result, the house may be seen to have served an outward purpose, communicating with the community. This is often expressed in the form of elaborate rituals and community-wide festivities following certain stages of the process, including the gathering and assembling of materials, arrival of helpers, foundation of the new structure and its completion (Gibson 1995, 144; Jennings 2003, 145; Kerlogue 2003, 63; Oliver 2003, 119; Skafida 1994; Waterson 1997, 121). Thermal structures, on the other hand, have served both outward purposes with the features built at the open-air spaces of the settlement, but also the inward-looking aspects of the dwelling group or of the social group(s) taking part in possible communal activities. What is more, the sharing of the hearth, as well as the cooking and eating arrangements, often symbolize the unity of the household (Carsten 1995, 113; Trankell 2003, 137). The construction process for thermal structures, which is carried out at the level of the dwelling group, may also invoke similar notions of belonging.

Thinking of architecture as a 'cumulative process' (Benson & Whittle 2007, 359) that involves numerous sets of practices, decision making, human interactions and collaborations is an effective mode of argument, when it engages with the details of the evidence (McFadyen 2016, 60). The employment of *chaine opératoire* in this material-based analysis has proved to be a useful tool for understanding elements of community formations and deciphering the many actions and social interactions behind participation and co-working for the construction of earthen architecture. Through the nuanced study of building making, we have argued that Neolithic architecture was primarily a set of community practices and involvements that embedded decisions, traditions, technological skills and social collaboration. Moreover, the integration of time and space in this technological study of architecture has offered a window on the planning strategies of Neolithic communities, which has further expanded the boundaries of the analytical method to a rather targeted, human-centred endeavour. Including the proxies of time, labour investment and spatial arrangements in the analytical methodology developed has shown that earthen structures of Kleitos 2 constitute assemblages bringing together materials from the local environment, techniques and various actors. The materials, including both earth and timber, and the techniques used are characterized by malleability, intertwined by numerous agencies and temporalities. As seen by the study of the different *chaînes opératoires*, the techniques used at Kleitos 2 are defined by standardization, which may reflect their social transmission. There are common materials and operations between the different categories of earthen structures studied. Nevertheless, there is a difference in scale (and probably participation), which should be seen as meaningful in terms of the socialities involved. Overall, the construction period of earthen structures created a gathering routine in practice that may have enhanced collaboration and reciprocity, empowered social ties and shared memories, and ultimately sustained communal solidarity. In conclusion, this study reveals that as architecture is accepted as active material culture (Love 2013b, 755), we gradually become better at understanding its contribution in the shaping of past social formations.

Note

1. D. Kloukinas wishes to extend his thanks to Prof. Maria Ntinou for bringing to his attention alternatives on the use of reeds as roofing materials.

Acknowledgements

The authors would like to thank the Director of the Ephorate of Antiquities of Florina, Dr Christina Ziota, who has generously given her permission for the study of the material and has always been supportive of our research. We also wish to extend our gratitude to the Director of the Ephorate of Kozani, Dr Areti Chondroyianni-Metoki, who has kindly provided all the help we have required in terms of people and resources. Drawings were produced by J. Donati, A. Marda-Stypsianou and K. Roumelioti, whom we thank wholeheartedly. This research was co-financed by Greece and the European Union (European Social Fund-ESF) through the Operational Programme 'Human Resources Development, Education and Lifelong Learning 2014–2020' in the context of the project 'Searching for the Neolithic "Landscapes of Action" through an analysis of architectural remains: the case of Kleitos 2, Kozani' (MIS 99092). Any remaining mistakes are, of course, the responsibility of the authors.

Evita Kalogiropoulou
Aristotle University of Thessaloniki
Faculty of Philosophy
School of History and Archaeology
54 124 Thessaloniki
Greece
Email: ekalogiropoulou@uoc.gr

Dimitris Kloukinas
Aristotle University of Thessaloniki
Faculty of Philosophy
School of History and Archaeology
54 124 Thessaloniki
Greece
Email: dkloukinas@yahoo.gr

Kostas Kotsakis
Aristotle University of Thessaloniki
Faculty of Philosophy
School of History and Archaeology
54 124 Thessaloniki
Greece
Email: kotsakis@hist.auth.gr

References

Andreou, S., M. Fotiadis & K. Kotsakis, 1996. Review of Aegean prehistory, V: the Neolithic and Bronze Age of northern Greece. *American Journal of Archaeology* 100, 537–97.

Atalay, S. & C. Hastorf, 2006. Food, meals, and daily activities: food *habitus* at Neolithic Çatalhöyük. *American Antiquity* 71, 283–319.

Bailey, D.W., 1990. The living house: signifying continuity, in *The Social Archaeology of Houses*, ed. R. Samson. Edinburgh: Edinburgh University Press, 19–48.

Bailey, D.W., 1996. The life, times and works of House 59 from the Ovcharovo tell, Bulgaria, in *Neolithic Houses in Northwest Europe and Beyond*, eds T. Darvill & J. Thomas. Oxford: Oxbow, 143–56.

Bakels, C.C., 1978. *Four Linearbandkeramik Settlements and Their Environment: A paleoecological study of Sittard, Stein, Elsloo and Hienheim*. Leiden: Leiden University Press.

Balfet, H., 1973. A propos du tour de potier. L'outilet le geste technique [About the potter's wheel. The tool and the technical gesture], in *L'homme, hier et aujourd'hui. Recueild'étudesen homage à A. Leroi-Gourhan* [Man, yesterday and today. Collection of studies in homage to A. Leroi-Gourhan], ed. M. Sauter. Paris: Cuja, 109–22.

Benson, D. & A. Whittle (eds), 2007. *Building Memories: The Neolithic Cotswold long barrow at Ascott-under-Wychwood, Oxfordshire*. Oxford: Oxbow.

Bottema, S., 1982. Palynological investigations in Greece with special reference to pollen as an indicator of human activity. *Paleohistoria* 24, 257–89.

Bourdieu, P., 1977. *Outline of a Theory of Practice*. Cambridge: Cambridge University Press.

Cahen, D. & C. Karlin, 1980. Les artisans de la préhistoire [Prehistoric craftsmen]. *La Recherche* 11(116), 1258–68.

Carsten, J., 1995. Houses in Langkawi: Stable structures or mobile homes?, in *About the House: Lévi-Strauss and beyond*, eds J. Carsten & S. Hugh-Jones. Cambridge: Cambridge University Press, 105–28.

Catapoti, D. & M. Relaki, 2020. Why the Neolithic is (r)evolutionary. *Journal of Material Culture* 25, 289–308.

Chondrou, D., 2020. Daily practices and special events: exploring grinding technologies at the two neighbouring settlements of Kleitos in Late/Final Neolithic northern Greece. *Documenta Prehistorica* 48, 286–310.

Chourmouziadis, G.H., 1971. Δύο νέαι εγκαταστάσεις της Αρχαιοτέρας Νεολιθικής εις την Δυτικήν Θεσσαλίαν. [Two new settlements of the Early Neolithic period in western Thessaly]. *Athens Annals of Archaeology* 4, 164–75.

Conati Barbaro, C., C. La Marca, V. Forte, G. Eramo, I. M. Muntoni & A. Rossi, 2019. Firing the earth. The early Neolithic ovens of Portonovo (Marche, Italy), in *Architecture of Fire*, ed. D. Georgiou. Oxford: Archaeopress, 16–29.

Coupaye, L., 2015. Chaîne opératoire, transects et théories: quelques réflexions et suggestions sur le parcours d'une méthode classique [Operational chain, transects and theories: some reflection and suggestions on the course of a classic method], in *André Leroi-Gourhan 'l'homme tout simplement'*, ed. P. Soulier. Paris: Éditions de Boccard, 69–84.

Cresswell, R., 1990. A new technology revisited. *Archaeological Review from Cambridge* 9, 39–54.

Dobres, M.-A., 2000. *Technology and Social Agency*. Oxford: Blackwell.

Dobres, M.-A. & J.E. Robb, 2000. *Agency in Archaeology*. London/New York: Routledge.

Dobres, M.-A. & J.E. Robb, 2005. 'Doing' agency: introductory remarks on methodology. *Journal of Archaeological Method and Theory* 12, 159–66.

Duričić, A., 2014. The construction of the Neolithic oven: experimental archaeology, in *Archaeotechnology: Studying technology from prehistory to the Middle Ages*, eds S. Vitezović & D. Antonović. Belgrade: Izdavač Srpsko arheološko društvo, 257–76.

Efstratiou, N. 2002. *Εθνοαρχαιολογικές Αναζητήσεις στα Πομακοχώρια της Ροδόπης* [Ethnoarcaheological investigations at the Pomakochoria of Rhodope]. Thessaloniki: Vanias.

Eriksen, M.H., 2016. Commemorating dwelling. The death and burial of houses in Iron and Viking Age Scandinavia. *European Journal of Archaeology* 19, 477–96.

Felski, R., 2000. The invention of everyday life. *New Formations* 39, 15–31.

Fitzjohn, M., 2013. Bricks and mortar, grain and water: tracing tasks and temporality in Archaic Sicily. *World Archaeology* 45, 624–41.

Flannery, K., 1972. The origins of the village as a settlement type in Mesopotamia and the Near East, in *Man, settlement and urbanism*, eds P. Ucko, R. Tringham & G. Dimbleby. New York (NY): Academic Press, 23–53.

Fotiadis, M. & A. Hondroyianni-Metoki, 1997. Κίτρινη Λίμνη: διαχρονική σύνοψη, ραδιοχρονολογήσεις και η ανασκαφή του 1993 [Kitrini Limni: diachronic synopsis, radiocarbon dating and the excavations in 1993]. *The Archaeological Work in Macedonia and Thrace* 7 (1993), 19–32.

Fotiadis, M., A. Hondroyianni-Metoki, A. Kalogirou, Y. Maniatis, A. Stroulia & C. Ziota, 2019. Megalo Nisi Galanis (6300–1800 bc): constructing a cultural sequence for the Neolithic of West Macedonia, Greece. *Annual of the British School at Athens* 114, 1–40.

Gell, A., 1998. *Art and Agency. An anthropological theory*. Oxford: Oxford University Press.

Georgiadou, A., 2015. *The Neolithic House at Sosandra*. Thessaloniki: University Studio Press.

Gibson, T., 1995. Having your house and eating it: houses and siblings in Ara, South Sulawesi, in *About the House: Lévi-Strauss and beyond*, eds J. Carsten & S. Hugh-Jones. Cambridge: Cambridge University Press, 129–48.

Gillespie, S.D., 2000. Lévi-Strauss. Maison and société à maisons, in *Beyond Kinship. Social and material reproduction in house societies*, eds R.A. Joyce & S. D. Gillespie. Philadelphia (PA): University of Pensylvania Press, 22–52.

Gosselain, O.P., 2017. Comparative technology, in *Field Manual for African Archaeology*, eds A. L. Smith, E. Cornelissen, O.P. Gosselain & S. MacEachern. Tervuren: Royal Museum for Central Africa, 292–5.

Halstead, P., 1989. The economy has a normal surplus: economic stability and social change among early farming communities in Thessaly, Greece, in *Bad Year Economics: Cultural responses to risk and uncertainty*, eds P. Halstead & J. O'Shea. Cambridge: Cambridge University Press, 68–80.

Hastorf, C.A., 2017. *The Social Anthropology of Food. Thinking about eating from prehistory to the present*. Cambridge: Cambridge University Press.

Hatzimichali, A. 2010. *Σαρακατσάνοι* (δεύτερος τόμος) [*Sarakatsani* (volume two)]. Athens: Angeliki Hatzimichalis Foundation.

Hill, J., 2003. *Actions of Architecture and Creative Users*. London: Routledge.

Hodder, I., 1998. The domus: some problems reconsidered, in *Understanding the Neolithic of North-western Europe*, eds M. Edmonds & C. Richards. Glasgow: Cruithne Press, 84–101.

Hodder, I., 2012. *Entangled. An archaeology of the relationships between humans and things*. Oxford: John Wiley & Sons.

Hodder, I., 2013. From diffusion to structural transformation: the changing roles of the Neolithic house in the Middle East, Turkey and Europe, in *Tracking the Neolithic House in Europe*, eds D. Hofmann & J. Smyth. New York (NY): Springer, 349–62.

Hondroyianni-Metoki, A., 2011. Kleitos 2009. The excavation on the eastern edge of the Neolithic settlement 'Kleitos 1' and at the settlement 'Kleitos 2'. *The Archaeological Work in Upper Macedonia – AEAM 1, 2009*, ed. G. Karamitrou-Mentesedi. Aiani: Ministry of Culture and Athletics, 30th Ephorate of Prehistoric and Classical Antiquities, Archaeological Museum of Aiani, 231–44.

Hugh-Jones, S., 1995. Inside-out and back-to-front: the androgynous house in northwest Amazonia, in *About the House: Lévi-Strauss and beyond*, eds J. Carsten & S. Hugh-Jones. Cambridge: Cambridge University Press, 226–52.

Ingold, T., 1993. The temporality of the landscape. *World Archaeology* 25, 152–74.

Ingold, T., 2013. *Making. Anthropology, archaeology, art and architecture*. Abingdon/New York: Routledge.

Jennings, N., 2003. *Clay Dabbins: Vernacular buildings of the Solway Plain*. Kendal: Cumberland and Westmorland Antiquarian and Archaeological Society.

Jones, A., 2007. *Memory and Material Culture*. Cambridge: Cambridge University Press.

Kalogiropoulou, E., in press. *Cooking Together. Kitchen spaces, commensality, and the formation of social identities in Neolithic Greece*. Oxford: BAR Publishing.

Kalogiropoulou, E., 2014. In search of social identities: the contribution of thermal structures in the organisation of space in Neolithic Macedonia, in *1912–2012. A century of research in prehistoric Macedonia*, eds E. Stefani, N. Merousis & A. Dimoula. Thessaloniki: Archaeological Museum of Thessaloniki, 359–72. (in Greek)

Kalogiropoulou, E. & C. Ziota, 2021. Exploring commensality, household and solidarity. Evidence of a medium-scale community gathering place in Neolithic Kleitos 1, north-western Greece. *Journal of Material Culture* 26(4), 403–32.

Karamitrou-Mentesidi, G., 1987. Προϊστορικοί οικισμοί Κίτρινης Λίμνης (Σαριγκιόλ) Κοζάνης [Prehistoric settlements of Kitrini Limni (Sarigkiol) in Kozani], in *Αμητός: τιμητικός τόμος για τον καθηγητή Μανόλη Ανδρόνικο* [Amitos: honorary volume for Professor Manolis Andronikos]. Thessaloniki: Aristotle University of Thessaloniki, 391–416.

Kay, K., 2020. Dynamic houses and communities at Çatalhöyük: a building biography approach to prehistoric social structure. *Cambridge Archaeological Journal* 30(3), 451–68.

Kerlogue, F., 2003. Malay meanings and metaphors in the Jambi Seberang house, in *The House in Southeast Asia: A changing social, economic and political domain*, eds S. Sparkes & S. Howell. London/New York: Routledge, 53–66.

Kloukinas, D., 2014. Neolithic Building Technology and the Social Context of Construction Practices: The Case of Northern Greece. Unpublished PhD thesis, Cardiff University.

Kloukinas, D., 2017. Pictures of home: regional perspectives into the Neolithic building technology of northern Greece, in *Communities, Landscapes, and Interaction in Neolithic Greece. Proceedings of International Conference, Rethymno*, 29–30 *May* 2015, eds A. Sarris, E. Kalogiropoulou, T. Kalayci & L. Karimali. Ann Arbor (MI): International Monographs in Prehistory, 167–86.

Kloukinas, D., in press. House construction and the study of earthen superstructural remains in Neolithic northern Greece: an overview, in *New Perspectives on Ancient Earthen Architecture: Detection of structures and characterization of building techniques*, eds A. Peinetti, P. Mylona, L. Jallot & J. Wattez. Oxford: Archaeopress.

Knappett, C., 2008. The neglected networks of material agency: artefacts, pictures and texts, in *Material Agency*, by C. Knappett & L. Malafouris. Boston (MA): Springer, 139–56.

Kotsakis, K., 1994. The use of habitational space in Neolithic Sesklo, in *La Thessalie: quinze années de recherches archéologiques, 1975–1990, Bilans et perspectives*, eds J.C. Decourt, B. Helly & K. Gallis. Athens: Ministère de la Culture, 125–30.

Kotsakis, K., 2019. From Sesklo to Toumba: conflict and order in the prehistoric communities, in *Η αντίπερα όχθη. Κοινωνικός χώρος και ιδεολογία στις προϊστορικές κοινότητες. Μελέτες αφιερωμένες στη μνήμη του καθηγητή Γ.Χ. Χουρμουζιάδη*. [On the other side. Social space and ideology in prehistoric communities. Studies dedicated to the memory of Professor G.H. Chourmouziadis], ed. K. Kotsakis. Thessaloniki: Aristotle University of Thessaloniki, 163–77.

Lemonnier, P. (ed.), 1993. *Technological Choices. Transformation in material cultures since the Neolithic*. London/New York: Routledge.

Leroi-Gourhan, A., 1943. *Evolution et techniques vol.1. L'homme et la matière* [Evolution and techniques vol. 1. Man and substance]. Paris: Albin Michel.

Leroi-Gourhan, A., 1945. *Evolution et techniques vol.2. Milieu et technique* [Evolution and techniques vol. 2. Environment and technique]. Paris: Albin Michel.

Leroi-Gourhan, A., 1993. *Gesture and Speech*. Cambridge/London: MIT Press.

Lewis, M. & M. Arntz, 2020. The chaîne opératoire: past, present and future. *Archaeological Review from Cambridge* 35, 6–16.

Love, S., 2013a. The performance of building and technological choice made visible in mudbrick architecture. *Cambridge Archaeological Journal* 23, 263–82.

Love, S., 2013b. Architecture as material culture: building form and materiality in the Pre-Pottery Neolithic of Anatolia and Levant. *Journal of Anthropological Archaeology* 32(4), 746–58.

Lucas, G., 2013. Afterword: archaeology and the science of new objects, in *Archaeology after interpretation. Returning materials to archaeological theory*, eds B. Alberti, A.M. Jones & J. Pollard. Walnut Creek (CA): Left Coast Press, 367–80.

Marinova, E. & M. Ntinou 2017. Neolithic woodland management and land-use in south-eastern Europe: the anthracological evidence from northern Greece and Bulgaria. *Quaternary International* 30, 1–17.

Martinez, S., 2001. A new look at house construction techniques: current research at Dikili Tash, Neolithic site of eastern Macedonia. *The Archaeological Work in Macedonia and Thrace* 13 (1999), 63–8.

Martinón-Torres, M., 2002. Chaîne opératoire: the concept and its applications within the study of technology. *Gallaecia* 21, 29–43.

Mauss, M., 1936. Les techniques du corps [Techniques of the body]. *Journal of Psychology* 32, 2–23.

McFadyen, L.K., 2006. Building technologies, quick and slow architectures and early Neolithic long barrow sites in southern Britain. *Archaeological Review from Cambridge* 21, 117–34.

McFadyen, L.K., 2007. Neolithic architecture and participation – practices of making in early Neolithic Britain, in J. Last (ed.) *Beyond the Grave: New Perspectives on Barrows*, 22–9. Oxford: Oxbow.

McFadyen, L.K., 2016. Immanent architecture, in *Elements of Architecture: Assembling archaeology, atmosphere and the performance of building spaces*, eds M. Bille & T.F. Sørensen. London/New York: Routledge, 53–62.
Miller, H.M.-L., 2007. *Archaeological Approaches to Technology*. Amsterdam: Elsevier-Academic Press.
Nielsen, M., 2016. Into architecture: house-building and acentered personhood in Maputo, Mozambique, in *Elements of Architecture. Assembling archaeology, atmosphere and the performance of building spaces*, eds M. Bille & T.F. Sørensen. London/New York: Routledge, 273–86.
Ntinou, M., 2014. Natural vegetation and prehistoric communities in Macedonia, Greece. A synthesis of the results of wood charcoal analysis from prehistoric sites, in *1912–2012. A century of research in Prehistoric Macedonia*, eds E. Stefani, N. Merousis and A. Dimoula. Thessaloniki: Archaeological Museum of Thessaloniki, 399–407.
Oliver, P., 2003. *Dwellings: The vernacular house worldwide*. London/New York: Phaidon.
Oliver, P., 2006. *Built to Meet Needs: Cultural issues in vernacular architecture*. Oxford: Elsevier.
Özbaşaran, M., 1998. The heart of a house: the hearth. Aşikli Höyük, a Pre-pottey Neolithic site in Central Anatolia, in *Light on Top of the Black Hill: Studies presented to Halet Gambel*, eds G. Arsebük, M.J. Mellink & W. Schirmer. Istanbul: Ege Yaginlari, 555–66.
Parker Pearson, M. & C. Richards, 1994a. Ordering the world: perceptions of architecture, space and time, in *Architecture and Order: Approaches to social space*, eds M. Parker Pearson & C. Richards. London/New York: Routledge, 1–37.
Parker Pearson, M. & C. Richards, 1994b. Architecture and order: spatial representation and archaeology, in *Architecture and Order: Approaches to social space*, eds M. Parker Pearson & C. Richards. London/New York: Routledge, 38–72.
Pelegrin, J., C. Karlin & P. Bodu, 1988. Chaînes opératoires: un outil pour le préhistorien [Operational chains: a tool for the prehistorians]. *Technologie Préhistorique* 25, 55–62.
Pelmoine, T. & A. Mayor, 2020. Vernacular architecture in eastern Senegal: chaînes opératoires and technical choices. *Journal of Material Culture* 25, 348–78.
Perlès, C., 1987. *Les industries lithiques taillées de Franchthi (Argolide, Grèce): présentation générale et industries paléolithiques*. Bloomington (IN): Indiana University Press.
Prévost-Demarkar, S., 2019. Bâtir en terre au Néolithique. Approche morpho technologique des vestiges architectureaux de Dikili Tash (Grèce) [Earth building in the Neolithic period. Morpho-technological approach to the architectural remains of Dikili Tash (Greece)]. *Bulletin de Correspondance Hellénique* 143, 1–61.
Rapoport, A., 1969. *House Form and Culture*. Englewood Cliffs (NJ): Prentice-Hall.
Ridley, C., K.A. Wardle & C.A. Mould, 2000. *SERVIA I. Anglo-Hellenic Rescue Excavations* 1971–73. London: British School at Athens.
Riede, O.F., 2006. Chaîne opératoire, chaîne evolutionaire? Putting technological sequences into an evolutionary perspective. *Archaeological Review from Cambridge* 21, 50–75.
Robb, J., 2007. *The Early Mediterranean Village. Agency, material culture, and social change in Neolithic Italy*. Cambridge: Cambridge University Press.
Sahlins, M., 1974. *Stone Age Economics*. Oxford/New York: Routledge.
Schlanger, N., 2005. The *chaîne opératoire*, in *Archaeology: The key concepts*, eds C. Renfrew & P. Bahn. London/New York: Routledge, 25–31.
Shaffer, G.D., 1983. Neolithic Building Technology in Calabria, Italy. Unpublished PhD dissertation, State University of New York, Binghamton.
Sillar, B. & M.S. Tite, 2000. The challenge of ‘technological choices’ for materials science approaches in archaeology. *Archaeometry* 42, 2–20.
Skafida, E., 1994. Κατασκευαστικά υλικά, τεχνική και τεχνολογία των πλίνθινων σπιτιών στη Νεολιθική Θεσσαλία: μία εθνοαρχαιολογική προσέγγιση. [Building materials, technique and technology of mudbrick houses in Neolithic Thessaly: an ethnoarchaeological approach], in *La Thessalie A: quinze années de recherches archéologiques 1975–1990*, eds J. C. Decourt, B. Helly & K. Gallis. Athens: Ministry of Culture, 177–88.
Skibo, J.M., 2013. *Understanding Pottery Function*. New York (NY): Springer.
Sørensen, M.L., 2000. *Gender Archaeology*. Cambridge: Polity Press.
Souvatzi, S., 2008. *A Social Archaeology of Households in Neolithic Greece. An anthropological approach*. Cambridge: Cambridge University Press.
Sparkes, S. & S. Howell (eds), 2003. *The House in Southeast Asia: A changing social, economic and political domain*. London: Routledge Curzon.
Steadman, S.R., 1996. Recent research in the archaeology of architecture: beyond foundation. *Journal of Archaeological Research* 4, 51–93.
Stevanović, M., 1997. The age of clay: the social dynamics of house destruction. *Journal of Anthropological Archaeology* 16, 334–95.
Stratouli, G., T. Bekiaris, N. Katsikaridis, D. Kloukinas, G. Koromila & S. Kyrillidou, 2020. New excavations in northwestern Greece: the Neolithic settlement of Avgi, Kastoria. *Journal of Greek Archaeology* 5, 63–134.
Trankell, I., 2003. House and moral community among the Tai Yong in Northern Thailand, in *The House in Southeast Asia: A changing social, economic and political domain*, eds S. Sparkes & S. Howell. London/New York: Routledge, 133–49.
Tringham, R., 2000. The continuous house: A view from the deep past, in *Beyond Kinship: Social and material reproduction in house societies*, eds R.A. Joyce & S.

https://doi.org/10.1017/S0959774322000427 Published online by Cambridge University Press

D. Gillespie. Philadelphia (PA): University of Pennsylvania Press, 115–34.

Tuan, Y.-F., 1977. *Space and Place. The perspective of experience*. Minneapolis/London: University of Minnesota Press.

Ulanowska, A., 2020. The chaîne opératoire as a framework for investigating prehistoric textile production: production of textile tools in Middle Bronze Age Crete as a 'troublesome' case study. *Archaeological Review from Cambridge* 35, 212–26.

Uzdurum, M., 2018. Live together around fire: hearths and the use of space at the onset of sedentism. Aşıklı Höyük (Turkey), a case study, in *From the Caucasus to the Arabian Peninsula: Domestic spaces in the Neolithic*, ed C. Douché & F. Richon. Paris: Routes de l' Órient, 11–48.

Valamoti, S.M., 2011. Ground cereal food preparations from Greece: the prehistory and modern survival of traditional Mediterranean 'fast foods'. *Archaeological and Anthropological Sciences* 3, 19–39.

Valamoti, S.M. & C. Stylianakou, 2015. Προϊστορικός οικισμός Κλείτου Κοζάνης: προκαταρκτικά αποτελέσματα από την αρχαιοβοτανική έρευνα στον οικισμό [Prehistoric settlement Kleitos Kozani: preliminary results from the archaeobotanical investigation of the settlement], in *Archaeological Research in Macedonia and Thrace* 25 (2011), 61–70.

Vellinga, M., 2007. Anthropology and the materiality of architecture. *American Ethnologist* 34, 756–66.

Waterson, R., 1997. *The Living House: An anthropology of architecture in southeast Asia*. London: Thames & Hudson.

Whittle, A., 1996. House in context: building as process in *Neolithic Houses in Northwest Europe and Beyond*, eds T. Darvill & J. Thomas. Oxford: Oxbow, 13–26.

Wilk, R.R., 1983. Little house in the jungle: the causes of variation in house size among modern Kekchi Maya. *Journal of Anthropological Archaeology* 2, 99–116.

Ziota, C., 2014. The settlement of Kleitos Kozanis in its wider natural and anthropogenic environment during the Late and Final Neolithic periods, in *1912–2012. A century of research in prehistoric Macedonia*, eds E. Stefani, N. Merousis & A. Dimoula. Thessaloniki: Archaeological Museum of Thessaloniki, 323–36. (in Greek)

Ziota, C., A. Hondroyianni-Metoki & E. Magouretsiou, 2013. Recent prehistoric research in the Kitrini Limni area of the Kozani prefecture. *The Archaeological Work in Upper Macedonia, Aiani – AEAM 2, 2011*, ed. G. Karamitrou-Mentesedi. Aiani: Ministry of Culture and Athletics, 30th Ephorate of Prehistoric and Classical Antiquities, Archaeological Museum of Aiani, 57–83.

Author biographies

Evita Kalogiropoulou is a postdoctoral fellow at the Aristotle University of Thessaloniki. She specializes in the study of thermal structures, commensality and the social interplays developed around cooking practices. Her research is engaged with aspects of social space, everyday performances, household diversities and settlement configurations of Neolithic settlements in Greece.

Dimitris Kloukinas is a postdoctoral fellow at the Aristotle University of Thessaloniki, specializing in the study of Neolithic domestic architecture. His research focuses primarily on the study of earthen structures and the spatial analysis of Neolithic settlements in both Greece and Cyprus.

Kostas Kotsakis is Professor Emeritus of Prehistoric Archaeology, Aristotle University of Thessaloniki. His research interests include the Neolithic of Greece, archaeological theory and method, and prehistoric social dynamics. Currently, he directs the Dispilio Project in west Macedonia, Greece, and the Paliambela Kolindros Excavations.

https://doi.org/10.1017/S0959774322000427 Published online by Cambridge University Press