2 Shaping the Built Environment
Transformations in Building Materials and Techniques

2.1 The Built Environment at the Micro-Scale

The act of building implies the choice of transforming the natural environment into a constructed environment. This means that a series of actions and processes are deliberately undertaken by social agents to shape their own living space. It is clear, therefore, that this 'space' reflects ideas, ideologies and relationships of individuals and communities, and it represents the arena within which social, economic and political relations are played out. This act of shaping the built environment is crucial for understanding the relationship between human actors and the physical environment they operated in. The built environment is an integral portion of the culture, and it represents not only the physical context within which the social interactions are enacted, but is also an active agent which contributes to structure social life.

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Watkins (2004; 2009) affirms that the built environment as a cultural construct emerged in Southwest Asia at the end of the Epipalaeolithic and the beginning of the Neolithic with the appearance of "villages with architecture". However, it is important to underline that the creation of a built environment does not imply necessarily an act of construction *sensu-stricto* – as a long-lasting project aimed at building permanent architectural forms (e.g. buildings, villages, necropolis etc.). Instead, it necessarily encompasses an act of transformation, which is aimed at modifying the physical environment to adapt it to human exigences. In this regard, open areas, cultivated fields or natural shelters can be classified as built environments (Lawrence, Low 1990).

The built environment – in all its forms – is highly informative of past societies that shaped and interacted within and with it. Therefore, shaping the built environment is an act of place-making, because the actions and interactions of individuals who built, organise and use that space contribute to making it a dynamic context of experience and memories (cf. Fisher 2009a; Ramussen 1962; Rapoport 1969; 1990).

To understand the processes that generated and created the built environment, we have to analyse and reconstruct its *chaîne opératoire*. The first step of this process includes those actions aimed at transforming the natural environment by interaction with the local physical environment, by selection and transformation of local resources and by use of specific expertise and application of certain technologies. In this chapter, this first step is examined by analysis of aspects of continuity and transformation in the use of building materials and techniques applied in the construction of prehistoric households and settlements in Cyprus, from the selection of raw materials to the construction of buildings as spaces of action and interaction. The aim is to discuss the way architecture configured social practices and enacted the formation, reproduction and transformation of identities, roles and statuses over the course of Cypriot prehistory in different regional contexts.

In Cyprus, the natural environment has always offered a vast range of materials and resources that have been exploited since early Prehistory. The construction of prehistoric building spaces on the island was presumably based on a well-defined set of technological principles which were most likely shared amongst the community and passed down from generation to generation, largely as technical knowledge (Clarke 2007c, 125). Despite close analogies in materials and techniques applied in houses and settlements construction can be noted in the architectural tradition of prehistoric Cyprus, transformations appear in the way prehistoric communities of the island organised and shaped their built environment through time. This is because changes in 'architecture' do not exist in a vacuum, but are inextricably linked to the dynamics of social interaction. In analysing aspects of continuity and change in the built environments of Cypriot prehistory, it is important to look at them as dynamic contexts and to examine transformations in the social environment, not as a unilinear process. Differences can be observed between sites, suggesting that communities in different parts of the island structured their social and economic practices in distinctive ways.

In this chapter, these aspects of continuity and transformation are analysed according to three lines of evidence, which have been organised into three discrete sections. In the first section, the role of the natural environment in the construction of the built space is analysed. The aim is to explore how natural environment and environmental changes have affected or constrained building practices and traditions. Raw materials procurement is examined, seeking to understand the local physical environment and how local and regional resources were selected and exploited. The second section is aimed at examining the paramount importance of technological processes in building construction in the analysis of the socio-cultural choices operated by individual and communal agents. Earthen materials and technologies, pyrotechnology of plaster materials, stone carving and dressing activities are taken into consideration as principal natural agents in the construction of the Cypriot prehistoric built environment. A final section is dedicated to the examination of gendered practices and strategies in technological and labour organisation, in order to analyse and discuss the role and involvement of men, women and other community members in the operation of buildings and settlements construction.

2.2 Environment, Ecology and Material Engagement

In this section, the relationship between climatic and environmental settings and the use of specific building materials and technology is explored in order to analyse the role of the natural environment in the formation and reproduction of socio-cultural identities and the wider ecological and social implications of this in the practice of building construction.

2.2.1 Climate, Environmental Changes and Building Tradition

The actual environmental condition of Cyprus, characterised by a summer-dry Mediterranean-type climate (Pantelas 1996; Androu, Panagiotou 2004), only partially corresponds to conditions characterising the island during prehistory. Paleoclimatic proxies from the Eastern Mediterranean point to a clear interruption of the warm and humid Early Holocene climate at about 6500 BP, when a process of aridification increasingly affected the entire region. Despite a possible phase of moister climate around 5000 BP, a long-term trend towards drier conditions possibly prevailed and a severe drought has been recorded at about 3200 BP in the whole Eastern Mediterranean (Robinson et al. 2006; Roberts et al. 2011). This period corresponds to the end of the Bronze Age and many authors have related this climatic shift to the Late Bronze Age crisis (Clarke et al. 2016, with references; see also Scirè-Calabrisotto et al. 2017). Following this climatic framework, we may assume that the recorded fluctuations between dry and wetter periods have strongly impacted on environmental conditions in the island and related socio-cultural and economic practices, including building construction activities.

In his analysis on cultural responses to aridity in the Middle Holocene, Brooks (2006) notes that there is widespread evidence that increases in social complexity during this period coincided with climatic and environmental deterioration. Far from arguing in favour of environmental determinism, he adopts a coevolutionist approach and sees the natural environment as the context within which social change occurs, providing both opportunities and constraints on social, cultural, economic and technological innovation (30). In the last few years, paleoenvironmental studies conducted in the Mediterranean region[1] have attributed to the Holocene natural environment a dynamic role, in contrast to the previously established view of a more stable and passive setting to cultural change.

The evidence available nowadays for Cyprus suggests that the entire archaeological record developed within a dynamic context of recurrent climatic and environmental change (Wasse 2007, 47-8; Hazell et al. 2022).

The more stable social and economic strategies between the 7th and the 5th millennium BC (Peltenburg 2004), changed at the end of the 5th millennium. According to Clarke (2007b) and Todd and Croft (2004), changes in climatic conditions might have been partially responsible for an interruption of the existing environmental condition, favouring social transformations and an increasing necessity of innovation and re-adaptation.

But how these climatic and environmental changes and related social dynamics have impacted on the prehistoric architecture of Cyprus? Is it possible to recognise any change of adaptation to new environmental conditions in the archaeological record of prehistoric Cyprus?

1 Cf. Bini et al. 2019; Burstyn et al. 2019; Dean et al. 2015; Kaniewski et al. 2018; Palmisano et al. 2019; Roberts et al. 2008.

A preliminary assumption is that changes in building materials and techniques are more gradual than in other evidence of material culture (cf. Clarke 2007c). This happens because knowledge of building construction becomes embedded in social practices, and it is perpetuated across generations in the long term with little variation (Gieryn 2002).

To examine the relationship between climate and the built environment in prehistoric Cyprus I apply a framework developed by Jennifer Moody (2009) for Aegean Bronze Age architecture, based on an earlier work by Baruch Givoni (1969) on architecture and climate. The framework is based on five variables: ventilation, insulation, shade, artificial heat, artificial cooling. Each of these variables may give indications to assess the climate suitability of ancient architecture. For example, the presence of multiple windows and doors can contribute to good ventilation within buildings (Givoni 1969), and it is a preferred building attribute in hot-humid environments, less in hot-arid ones where ventilation is undesirable as it brings hot air inside the structures; whitewashing exterior walls can reduce the absorption of thermal radiation by 85% and therefore it is desirable in buildings of hot and arid climates **[tab. 2.1]**.

A number of prehistoric Cypriot sites – from the Aceramic Neolithic until the Middle Bronze Age – are reviewed under this perspective by a collection of the building's main attributes, including the topographical position of the settlement, building form, building orientation and occurrence of doors and windows, wall thickness, building materials used etc. **[tab. 2.2: 'Attributes']**. Each of these attributes contributes to giving information on choices operated by prehistoric Cypriot communities when shaping their built environment by interacting with an existing natural environment. Therefore, any aspects of continuity or change in architectural materials and techniques applied in the contexts analysed can be indicative of possible changes in environmental and social settings.

Table 2.1 Architectural variables taken into consideration in the analysis of the prehistoric Cypriot built environment and their related building attributes and benefits

Variables	Building attributes	Benefit	Climate type
Ventilation	• Building orientation; • Door placement; • Presence of multiple windows and doors	Supports breeze circulation within the building structure	Hot-humid
Insulation	• Minimal or no windows; • Whitewash on the exterior/interior wall surface; • Thick walls; • Thick flat roof	Reduces sun penetration and helps thermal efficiency	Hot-arid
Shade	• Tall buildings; • Narrow paths/streets/passageways • Roofed courtyards	Creates shades and reduces sun penetration	Hot-arid
Artificial heat	• Occurrence of hearth/oven; • Small rooms	Helps to increase the temperature within buildings	Cold-seasonal
Artificial cooling	• Occurrence of wells/water channels; • Big rooms; • Occurrence of trees and gardens	Helps to maintain a pleasant temperature within buildings	Hot-humid and hot-arid

Analytical limitations are given by the fact that archaeological data available from prehistoric Cyprus are not always homogeneous. Some important sites were excavated in the mid- and post-war years and, despite these analyses were excellent for that time, they lacked details and quality of data of modern and contemporary examinations. Furthermore, for sites of the north region of Cyprus, we rely almost exclusively on data from excavations conducted prior to 1974 (cf. Clarke 2007c, 113). The second issue consists in the fact that at most sites only the ground floor of buildings is preserved and most walls stand less than one meter high, making the reconstruction of windows and roofs problematic.

Table 2.2 reports the main data collected in this analysis. For each of the six archaeological periods analysed – Aceramic Neolithic, Ceramic Neolithic, Early Chalcolithic, Late Chalcolithic, Early Bronze Age, Middle Bronze Age – two representative settlements have been selected **[tab. 2.2]**.

Table 2.2 Building attributes analysed in the prehistoric Cypriot settlements examined, and evaluation of five variables

	Aceramic Neolithic		Ceramic Neolithic		Early Chalcolithic	
Attributes/Variables	**Khirokitia**	**Cape Andreas**	**Epiktitos**	**Sotira-*Teppes***	***Ayious***	***Mylouthkia***
TOPOGRAPHY	On the slopes of a prominent hill	On a rocky spur	On a headland	On a high promontory	On a high plateau	On a coastal plain
BUILDING FORM	Circular	Circular	Sub-rectangular/ Semi-subterranean	Sub-rectangular	Semi-subterranean structures and pits and tunnels	Semi-subterranean structures (wider than Ayious)
Variable 1: VENTILATION	POOR	POOR	POOR	POOR	VERY POOR	VERY POOR
Building orientation	Any direction?	Any direction?	Any direction?	Long axis directed east-west; or SE/NE orientation	Any direction?	Any direction?
Windows	Small windows (?)	One?	One?	-	-	-
Doors	One (0.5 m wide)	One	One, narrow entranceway	One, of ~0.70 m, on the south	One	One
Variable 2: INSULATION	GOOD	MODERATE	MODERATE	MODERATE	-	MODERATE
Wall thickness	0.40-0.50 m	< 0.40-0.40 m	-	0.40-0.50 m	-	-
Building materials	Limestone blocks and mud walls	Limestone blocks and mud walls	Limestone slabs or rubble foundation with mud plaster/pisè wall	Rubble foundation with mud plaster wall/wattle and daub	Mud and timber	Mud and timber
Whitewash on the external wall	Internal and external surfaces were covered with havara plaster	No	No	No	No	Frequently in mud plaster
Roof	Flat roof of timber and reeds	-	Flat roof of timber, reeds and mud	Flat roof of reed and mud roof	-	-
Variable 3: SHADE	MODERATE	POOR	GOOD	MODERATE	-	-
Building elevation	One floor	One	One-two (?) floors	One floor	One floor	One floor
Proximity to other structures	Narrow passageways. Buildings very close to each other	Wide passageways. Building more distant	Narrow passageways. Buildings close to each other	Wide passagewas. Buildings close to each other	-	-
Courtyards and open spaces	Small courtyards and rare open areas	Frequent open areas	Small open areas	Some building had courtyards	None	None
Variable 4: ARTIFICIAL HEAT	GOOD	MODERATE/ GOOD	GOOD	GOOD	MODERATE/ GOOD	GOOD
Small building/rooms	Yes	Yes	Yes	Yes	Yes	Yes

	Aceramic Neolithic		Ceramic Neolithic		Early Chalcolithic	
Attributes/Variables	**Khirokitia**	**Cape Andreas**	**Epiktitos**	**Sotira-*Teppes***	***Ayious***	***Mylouthkia***
Hearths/oven	Yes	Indoor hearths are rare. Generally, they are placed in open areas	Yes	Yes	Rare	Yes
Variable 6: ARTIFICIAL COOLING	POOR	POOR	POOR	POOR	POOR	POOR
Big rooms	No	No	No	No	No	No
Water channels	No	No	No	No	No	No

	Middle/Late Chalcolithic		Early Bronze Age		Middle Bronze Age	
	Laona	**Mosphilia**	**Marki**	**Kaminoudhia**	**Alambra**	**Erimi-*LtP***
TOPOGRAPHY	On a prominent, narrow ridge, near the Dhiarizos River	On a gently slope, 1 km from the coast	On sloping fields south of the Alykos River	On a promontory	On the flank of a ridge	On a terraced hill on the eastern bank of Kouris river
BUILDING FORM	Circular	Circular	Rectangular	Rectangular	Rectangular	Rectangular
Variable 1: VENTILATION	MODERATE/ POOR	MODERATE/ POOR	MODERATE/ POOR	MODERATE/ POOR	MODERATE/ POOR	MODERATE
Building orientation	Mostly NE/SW	Mostly NE/SW	Any direction?	Any direction?	Any direction?	Mostly N/S
Windows	-	-	-	-	-	Possibly on the roof?
Doors	One with a preferred SW or W/NW orientation	One, generally with a preferred S/SE orientation	One. The majority of doorways are ~0.60-1.10 m	One	One, generally measuring 0.6-1.3 m	One, rarely two
Variable 2: INSULATION	GOOD	GOOD	GOOD	GOOD/ MODERATE	GOOD/ MODERATE	GOOD
Wall thickness	0.50-0.75 m	0.40-0.75 m	~0.50 m	~0.50 m	0.47-0.68 m	0.50 m
Building materials	Base of blocks of local stone and mud/daub superstructure	Generally stone footing and mud superstructure. Other wall types also occur	Stone footing and mudbricks superstructure	Stone footing and possible mudbrick superstructure	Stone footing and possible mudbrick superstructure	Stone footing and mudbricks superstructure
Whitewash on the external wall	Yes, mud or pulverised havara/kafkalla in the inner and external wall surface	Yes, mud renders, clay renders and lime plaster renders were applied on the external wall surface	Yes, layers of clay and lime plaster on the exterior wall surface	No	No	Yes
Roof	Flat roof of timber and reeds?	Flat roof of timber and reeds?	Flat roof of timber and reeds?	Flat roof of reed and mud roof?	Flat roof of reed and mud roof?	Flat roof of reed and mud roof?
Variable 3: SHADE	MODERATE	MODERATE/ GOOD	MODERATE/ GOOD	MODERATE/ GOOD	MODERATE/ GOOD	MODERATE/ GOOD
Building elevation	One floor	One floor	One floor	One floor	One floor	One floor

	Middle/Late Chalcolithic		**Early Bronze Age**		**Middle Bronze Age**	
	Laona	**Mosphilia**	**Marki**	**Kaminoudhia**	**Alambra**	**Erimi-*LtP***
Proximity to other structures	Buildings close to each other	Buildings close to each other	Narrow passageways. Buildings close to each other	Buildings close to each other	Buildings close to each other	Passageways are wide, even if buildings are close to each other
Courtyards and open spaces	Open spaces	Communal courtyards	Courtyards are very frequent	Open spaces are rare	Courtyards are very frequent	Large open spaces, sometimes roofed
Variable 4: ARTIFICIAL HEAT	GOOD	GOOD	GOOD	GOOD	GOOD	MODERATE
Small building/rooms	Relatively small buildings (internal diameters 3.8-6 m)	Relatively small buildings	Yes	Yes	Relatively small buildings	Large
Hearths/oven	Yes	Yes	Yes	Yes	Yes	Very rare
Variable 5: ARTIFICIAL COOLING	POOR	POOR	POOR	POOR	POOR	GOOD
Big rooms	No	No	No	No	No	Yes
Water channels	No	No	No	No	No	Yes

Data collected point to a consistency in building materials and techniques over the course of Cyprus prehistory with no abrupt change. On the basis of the five variables analysed, the solutions adopted for the construction of these prehistoric settlements are those typically used in construction techniques in Mediterranean hot-arid climate areas (Givoni 1969, 328-40).

In Cyprus, where hot days alternate with cool nights, a characteristic building form is one that takes advantage of the heat-retention qualities of heavy masonry (Philokyprou 2015). As we can see from table 2.2, the insulation rate in all the settlements analysed ranges from moderate to good **[tab. 2.2]**. Prehistoric buildings in Cyprus were constructed with thick walls of 0.40-0.50 m, with few rare exceptions as at Cape Andreas-*Kastros*, where wall footings are reported to be less than 0.40 cm in width (Le Brun 1985). The hypothesised thick flat roofs made of layers of reeds and mud (cf. Thomas 1995) further contributed to insulating the structures. Roof, in fact, is the building element that mostly receives the impact of the midday sun and therefore construction techniques were adopted in the past to permit the roof to have heat-retention characteristics similar to the walls (Lapithis 2018, 97-8). The application of layers of white plaster or whitewash in the interior and exterior wall surfaces of buildings in most of the settlements analysed **[tab. 2.2]**, and the frequent use of white calcareous stones for the construction of buildings wall bases – especially in those settlements located in the Circum-Troodos Sedimentary Succession region, where calcareous stones are abundant, such as the Neolithic Sotira-*Teppes* and the Early Bronze Age Sotira-*Khaminoudhia* and Middle Bronze Age Erimi-*Laonin tou Porakou* (henceforth Erimi-*LtP*) **[fig. 2.1]** – also contributed to maintaining internal spaces well insulated from the hot air of the day. A concomitant factor ensuring thermal comfort to buildings was the recurrent presence of shades, obtained by the construction of narrow passageways between structures and presumably roofed courtyards

Ventilation instead was not taken into great consideration. In fact, according to archaeological reconstructions, most of the prehistoric buildings in Cyprus were presumably constructed with one main door and small windows. However, it is important to underline that data concerning original building openings are only hypothesised.

While no direct evidence of artificial cooling solutions can be identified based on available data, the presence of indoor and sometimes outdoor fire installations in most of the contexts examined is indicative of the importance of a heating source for food processing but also for warming up.

Temperature fluctuations across the entire prehistoric period on the island might have favoured adaptations in the materials and techniques used in building construction. As indicated by data collected in table 2.2 and as also suggested by Thomas (1995, 178), it is possible that the increasing use of stone and the decreasing use of timber – especially from the Late Chalcolithic onwards – may reflect denudation of the landscape both for erosion by human use and climate change, and maybe restricted access to local resources (see also Peltenburg et al. 2003, 273) **[tab. 2.2]**.

Data analysed indicates that at the transition between the Ceramic Neolithic and the Early Chalcolithic, there is a shift to timber-frame semi-subterranean structures, as shown by evidence from Early Chalcolithic Kalavassos-*Ayious* and Kissonerga-*Mylouthkia*. Similar post-frame subterranean structures have been also identified at the Ceramic Neolithic Kalavassos-*Kokkinoyia* (Clarke 2004; 2007b; 2016) and Philia-*Drakos* (cf. Knapp 2013, 171, with references). This shift, which represents just a short parenthesis in the stone and mud building tradition of prehistoric architecture in Cyprus, has been interpreted by Peltenburg as a practical solution to the emergence of new settlements in heavily wooded environments (Peltenburg et al. 2003, 272-5). Clarke, instead, suggests that the shift to timber-frame subterranean structures was favoured by climatic deterioration (2007b). This may have led to deep changes in social practices, possibly introducing a change to a more mobile existence based on hunting and the concomitant transition to less complex building methods.

In this regard, it is interesting to mention a study by Zhai and Previtali (2010) on the environmental evaluation of vernacular architecture in different locations and climates around the world. The study reveals that fully or partially subterranean dwellings are more frequently observed in cold and hot climates, never in humid climates; the total absence of ventilation in subterranean structures would cause excessive dampness in humid-climate areas creating an uncomfortable and unhealthy building space. Among the advantage reported by Malaktou et al. (2016) in a study on thermal assessment of vernacular sub-terranean dwellings in Cyprus, this type of building requires minimum maintenance, and guarantees higher static performances during earthquake events and better thermal behaviour (a difference of 4.5 °C, according to Kharrufa 2008) compared to above-ground structures.

Looking at the Early Chalcolithic contexts, it is possible to argue that the shift to semi-subterranean structures may be possibly seen as a tentative adaptation to a more arid climate, as a consequence of the increasing drying after ~7000 cal. yr. BP (Palmisano et al. 2021; Clarke et al. 2016; Wasse 2007). The appearance of these subterranean structures in the architectural record of prehistoric Cyprus presumably responded to changes in social strategies and use of space; changes that were possibly driven also by different climatic and environmental patterns on the island (for a detailed discussion on this point see Knapp 2013, 192-4).

The second major change identified in the prehistoric archaeological record examined is represented by the passage to rectilinear and then rectangular architecture, which completely replaced the circular architectural module at the beginning of Prehistoric Bronze Age Cyprus. This fundamental shift in building technology reflects crucial transformations in household and community structure during the Early and Middle Bronze Age periods, and possibly was favoured by more stable climatic and environmental conditions on the island, as reported by paleoclimatic proxies from the Eastern Mediterranean (Palmisano et al. 2021). Local communities became more adaptive to climate change thanks also to technological advancement, subsistence strategies and social organisation. The rectangular model therefore evolved 'naturally' from the climate conditions, the needs of the household and the social structure of the community (see also § 3.1.1). A representative element of this gradual transformation of the building form is the courtyard, which became a constitutive component of the 'house' in Prehistoric Bronze Age Cyprus. The 'courtyard house', which Gjerstad (1926) first identified at Alambra in 1924, become progressively more common from the Philia period onward, as attested at Early Bronze Age Marki-*Alonia* and Middle Bronze Age Alambra-*Mouttes*, Erimi-*LtP*, Kalopsidha (Webb 2009). Courtyards have social but also ecological functions. They guarantee additional space for activities and interaction in the building structure and offer a sense of enclosure to the household members (Abass et al. 2016). In this perspective, the courtyard works as an extension of the house, and – as underlined by Webb (2009) – the different use and functions of courtyards during the occupation of Early Bronze Age Marki-*Alonia* reflects the transformation of household groups and their dynamic relationships during the entire settlement lifespan. In this discussion, it is important to underline that courtyards provide also climatic benefits. According to studies on the Mediterranean vernacular architecture, they are microclimate changers due to their ability to mitigate high temperatures, channel breeze and adjust the degree of humidity within buildings (Philokyprou, Limbouri-Kozakou 2012). Courtyard houses possibly responded also to the exigence of improving the thermal efficiency of the structures; a fundamental benefit that was not fully provided by circular buildings of the early prehistoric period (on the thermal efficiency of circular *vs.* rectangular structures, see Sok Ling et al. 2007; Raof 2017). The use of lime plaster materials also contributed to reducing humidity levels within buildings, and this would have guaranteed better preservation conditions for stored products within rectangular structures (Amadio 2018; see also Duru et al. 2021). This would have had implications for building longevity.

2.2.2 Natural Environment and Procurement Strategies

This section aims to analyse the relationship between the natural environment and the practice of selection and procurement of building materials; in particular, the intention is to discuss and understand if the natural environment dictated the choice of building materials or if culture had an impact on selection processes. Analyses of prehistoric architecture sustain the existence of a direct relationship between the availability of natural resources and the choice and use of specific building materials (cf. Braidwood, Braidwood 1982; Duru 2002; Woldring 2002). However, more recent studies on prehistoric earthen architecture (Love 2013a) have demonstrated how, in some cases, informed choices prevailed over pragmatic explanations for the selection of building materials. By analysing a group of prehistoric Anatolian contexts, Love suggests that materials employed in construction are not only indicative of what resources were available in the local natural environment, but also illustrate how culture has a significant impact on the choice of materials.

In studies of prehistoric Cypriot architecture, the common assumption is that the types of materials and technologies used in building construction are a direct result of the local environment.[2] This is certainly correct, since the selection and use of materials for

2 Cf. Wright 1992; Coleman et al. 1996, 23-4; Mantzourani 2003; Swiny, Rapp, Herscher 2003, 59; Frankel, Webb 2006a, 7.

buildings construction, both in antiquity and in vernacular traditional architecture, mostly respond to functional and practical drives (Oliver 2006, 129-40). Nevertheless, archaeological examples illustrate that the choice of building materials is not only environmentally determined by resource availability. In some cases, accessible materials were just one of the factors which determined the set of possibilities available to the builders.

The selection and procurement of materials for building construction in Cyprus was favoured, since the early prehistory, by a geological diversity and variable geomorphology, both of which created a unique landscape and natural environments. The Troodos Mountain Range is the main geomorphological feature of the island **[fig. 2.1]**. This area forms the central bedrock unit of Cyprus – the Troodos zone –, which consists of a stratified ophiolite complex, characterised by a sequence of plutonic rocks (i.e. basalt, gabbro and dolerite), overlaid by a sheeted dike complex and pillow lavas topped with iron and manganese-rich sediments (Zomeni 2012a). Available raw materials used in construction practices from the prehistory until the present days include a range of volcanic and metamorphic rocks, notably harzburgite, diabase and gabbro (Philokyprou 2015, fig. 2), and deposits of bentonitic clays (sodium montmorillonite; cf. Atalar, Kilic 2006), along with several pigments applied as ancillary decorative materials in building surfaces, including umber, ochre and terra verte (Cullis 1924). Around the Kyrenia mountains outcrops – in the Northeast of the island –, the so-called 'Pantadaktylos Zone' consists of gravel, conglomerates, marl, and mostly abyssal turbidites with shallow environmental chalk, marl, limestone, and gypsum finishing. In this area, dolomitic limestone and gypsiferous bentonite have been the most exploited materials in construction activities. The Mesaoria Group is located between the Kyrenia and Troodos ranges and consists of rocks of the deep and shallow marine environment of marl, sandy marl, conglomerates of gypsum and fluvial deposits. Swelling clays of the Mesaoria Group also occur as a result of the alteration of the Troodos ophiolite. Holocene alluviums, which are widespread in the Mesaoria plain, and at the east and west coasts as well as at the stream beds all over the island, contain gravel, sand, and silt – which have been largely used as aggregates materials in the manufacture of different products, including mudbricks – as well as alluvial montmorillonite clays. In the Southwest part of the island, the Mammonia terrane represents a complex of igneous, sedimentary and metamorphic rocks. Limestone, mudstone, quartzitic sandstone, together with rich clay melanges have always represented important sources of raw materials. In the South of Cyprus, sedimentary rocks, ranging in age from Upper Cretaceous to Miocene, are extensively exposed in an area extending between the south of the Troodos ophiolite and the south coast from Larnaka in the east to Paphos in the west. This

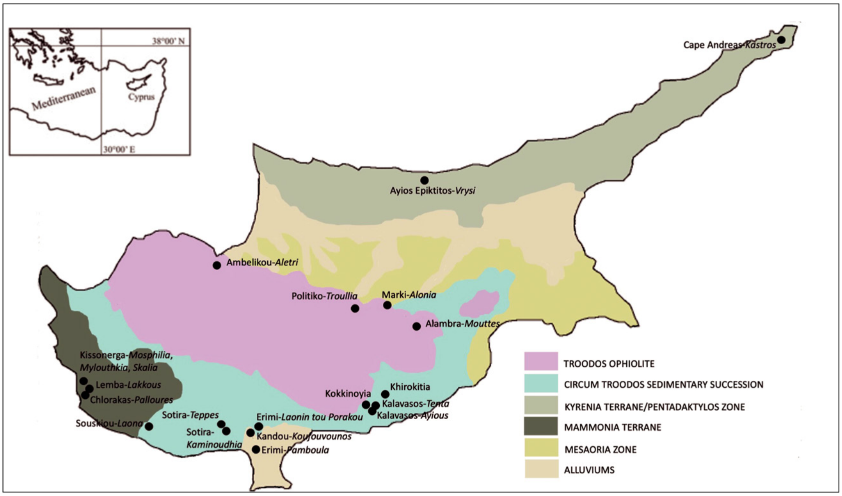

Figure 2.1 Geological map of Cyprus with the sites analysed and mentioned in the text

zone is composed of mostly chalks, marl and gypsum and montmorillonite clays. These carbonates have been source rocks for building materials on the island since Early Prehistory (Zomeni 2012b).

As illustrated in figure 2.2, almost all the prehistoric Cypriot settlements were constructed exploiting the natural bedrock, both by using it as a stable foundation for the upper-standing structures or by using its derived materials – field stones and stone blocks – to construct wall footings and walls **[fig. 2.2]**. Few exceptions are represented by the Neolithic sites of Khirokitia-*Vouni* (henceforth Khirokitia), where structures could also be entirely of mudbricks, by rare examples of mud architecture with post-infrastructure as at House 24 in Sotira-*Teppes*, and by the timber-framed semi-subterranean structures of the Early Chalcolithic sites of Kalavassos-*Ayious* and Kissonerga-*Mylouthkia*. Locally available stone materials were preferred for building construction – e.g. diabase and other igneous and metamorphic rocks were chosen in settlements at the foothills of the Troodos, calcarenites and limestones were adopted in settlements of the Circum Troodos Sedimentary Succession region – in order to limit the effort and labour necessary to transport heavy stone materials from a distant location. However, according to Peltenburg (1998, 244), the footings of the buildings of the Ceremonial Area at Chalcolithic Kissonerga-*Mosphilia* (Buildings 2, 4, 100, 206) were built with imported calcarenites, and not with local fieldstone. Possibly, Buildings 1, 2, 3 at Late Chalcolithic Chlorakas-*Palloures* were constructed with imported calcarenites as well (Schubert 2018, 77-8). Similarly, at the Early/Middle Cypriot site of Marki-*Alonia*, large cal-

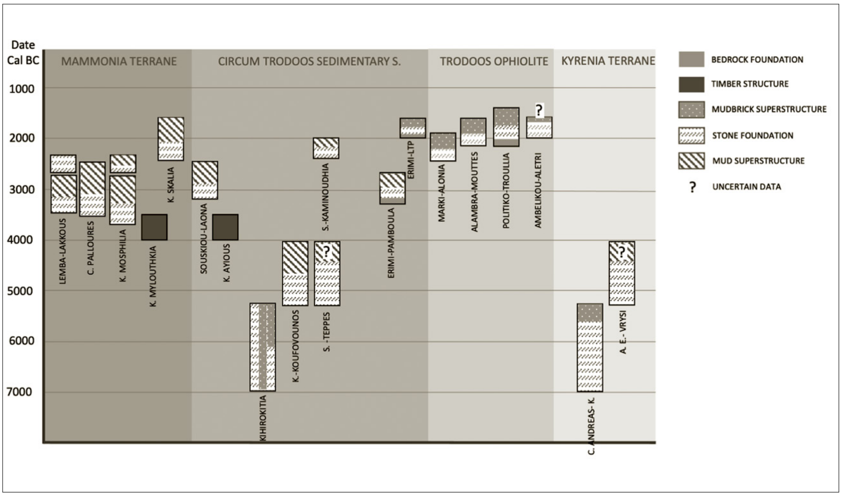

Figure 2.2 Building materials and techniques in analysed prehistoric contexts

carenite blocks were used for footing, mostly in the later stage of construction at the site. These blocks were brought from a considerable distance. According to Xenophontos, they derive from the Athalassa formation exposed some 10 km north and northeast of Marki (Xenophontos 1996, 18; Frankel, Webb 2006a, 7).

Considering that this coarse-grained yellowish stone is not of particularly high quality and does not weather well (Frankel, Webb 1996, 56), and assuming that other stone materials were easily available in the surrounding landscape at these sites, the preference in the selection of this material for footing construction must have been based on cultural factors rather than on functional choices.

The primacy of material choices and agency over resource availability is further attested at Sotira. Both the Neolithic settlement (*Teppes*) and the Early Bronze Age site (*Kaminoudhia*) are located close to water springs. Calcareous colluvial soils are also plentifully available in the settlements' area. However, unlike the majority of the prehistoric settlements in Cyprus, mudbricks and mud walls are scarcely attested. The limited occurrence of earthen materials in these contexts has to be primarily related to erosion and preservation issues – which generally affect semi-arid areas in the Mediterranean region (Friesem et al. 2011) –; however, comparing the architecture of Sotira-*Teppes* and *Kaminoudhia* with those of other prehistoric Cypriot contexts, appear evident that, in these two settlements, building with stone prevailed over building with earth. Selection dictated by socially constructed choices is also indicated by the fact that coeval settlements located in the same region with similar resources available, may adopt different materials and techniques in building construction. Neolithic Sotira-*Teppes* and Kandou-*Koufouvounos*, are less than 8 km distant from each other and are characterised by similar morphological and geological formations, dominated by chalk and marl **[fig. 2.1]**. Despite the similarities in natural resources, the two sites were constructed using different materials and techniques. At *Teppes*, most walls were founded directly on bedrock or on sterile eroded material overlying the latter. Calcareous fieldstones were the principally attested material in wall construction (Dikaios 1961, 155-6). At *Koufouvounos*, instead, earthen materials and mudbricks appear to have been more largely employed (Mantzourani 2000; 2003; 2009, 221-3).

Also interesting is the permanence, within circumscribed regional contexts, of specific building techniques adopted over a long-time span, suggesting that technical knowledge was possibly circulating between community groups over the course of generations, possibly fostered by marriages and trade contacts. This was identified in the Kouris Valley area, where settlements adopted the techniques of building walls by carving the calcareous bedrock floor in order to obtain semi-sunken buildings with stable foundations. This foundation type is scarcely attested in other contexts with similar geomorphological characteristics, except for a few buildings at Chalcolithic Souskiou-*Laona* ('dished hollow' foundation type; cf. Peltenburg et al. 2019, 76-8). The described technique has been observed at Chalcolithic Erimi-*Pamboula* (Diakaios 1961; Bolger 1988), at Middle Bronze Age Erimi-*LtP* and at the Late Bronze Age *Pamboula*. Here Weinberg (1983, 54) reported that structures were constructed almost entirely into the bedrock floor "leaving a base where the wall foundation was laid" (pl. 12 a). The choice of building structures by carving the bedrock to create semi-sunken floors to provide an integral wall base for wall superstructure might be interpreted in practical and ideological terms. From a functional point of view, the technique of construction using the limestone bedrock as foundation provided greater stability to the structures and improved insulation against hot summer temperatures, water ingress and dampness and humidity during rainy winters, increasing life-quality conditions (Thomas 2005b, 187). From an ideological perspective, the practice of constructing on the calcareous bedrock is likely to have contributed to creating a sense of immutability, which possibly fostered the formation of community identity and memory (Knapp 2009). In addition, as stone embodies permanence, the community likely used this to communicate social order and to negotiate power (Fisher 2009b, 192-3; Bukach 2003, 21). The recurrence of this practice might suggest that – within regional contexts – communities developed knowledge across generations about landscape advantages and limitations, and selected materials and techniques according to the perception of the natural environment, cultural choices, and social restraints (Arnold et al. 1991, 88;

Neupert 2000). Available building materials were considered as a set of resources, not as a set of limitations (Johnson 2010).

2.3 Integrating Analysis of Socio-Economic and Technological Choices and Practices in Building Construction

Understanding the technology of building construction is fundamental to the analysis of the socio-cultural choices operated by individual and communal agents and therefore to reconstructing the socio-cultural context in which these agents acted and influenced (Sillar, Tite 2000). The recognition of the active role of material culture in the construction and reproduction of social relations and cultural values has the potential to enhance the analysis of past societies, through the examination of material choices, labour investment, craft specialisation and level of technical knowledge (Bourdieu 1977; Hodder 1986; Lemonnier 1992; van der Leeuw 1993). Analysing the choices involved in architectural material manufacture enhances the knowledge of the social processes involved in house construction. Even in environments where there are limited choices and resources, materials will gain significance from the specific circumstances of their selection, manufacture and placement. Building materials express and materialise social relationships (De Marrais, Castillo, Earle 1996; Hendon 2004, 276; Matthews 2012, 183-5), therefore their analysis and the resulting examination of practices related to their selection, procurement and processing may offer interesting insights into the interrelation of past societies with their natural environment, and may contribute to shed new light into the socio-cultural developments behind the complex organisation of architectural practices.

2.3.1 Earthen Architecture Practices

Earthen architecture is one of the most impressive expressions of the human ability to create a unique built environment from modest natural resources. Because earthen building forms and materials are the results of assimilation between the natural and built environment, their analysis may shed light on community strategies of adaptation to natural resources and their transformation into material culture. In prehistoric Cyprus both the favourable climatic condition – characterised by mild winters and hot summers – and the abundance of natural resources, including water, wood and suitable soil sources, certainly supported the development of an earthen architecture tradition. However, the identification of earthen products in archaeological contexts of prehistoric Cyprus may be challenging. Earthen architectural products are sun-dried, therefore when a building is abandoned, they progressively degrade and dissolve in earthen debris. Only in some exceptional instances, when fire destruction occurs, substantial remains or earthen walls are preserved (Friesem et al. 2011; 2014; Lorenzon 2021). Due to their limited preservation, earthen materials are often dismissed from systematic studies on Cypriot architecture and are barely mentioned in excavation reports and publications. Even though they rarely receive as much attention as other material assemblages, such as ceramic or lithics, there is growing recognition in geoarchaeological studies on the island of the importance of earthen materials in the analysis and reconstruction of archaeological contexts.[3]

In prehistoric Cypriot architecture, destruction layers generally comprise different types of evidence illustrating the various uses to which earth was put in construction techniques **[box 2.1]**. These include intact, fragmented or degraded mudbricks; fragments of roofing materials and samples preserving the impression of wooden elements – possibly related to roofing structures, door or window infrastructures, and shelves – and mud coating. Given the limited data available, the discussion in this section will be mostly based on mudbrick materials, since these are the most easily identified and recorded materials in prehistoric contexts of the island.

In Cypriot prehistoric architecture mud or mudbrick walls are generally laid on top of a stone footing made of rubble or blocks of local stones **[fig. 2.2]**. This technique prevents erosion and protects mud of mudbricks superstructure from potential floods. Wall erosion is also prevented by the coating of the wall with mud plaster and by its regular maintenance (Aurenche 2003; Wright 2005; Devolder, Lorenzon 2019). Rarely the stone socle is absent; in this case, the earthen wall is set directly on a low foundation course as attested at Late Aceramic Neolithic Khirokitia (Le Brun 1984, 20-3).

The first point of discussion pertains to the appearance of mudbrick technology in Cyprus. One common assumption is that mudbrick production progressively emerged in the passage from circular to rectangular architecture, which in Cyprus occurred at the beginning of the Philia phase. In examining the architecture of prehistoric Cyprus, Wright (1992) argues that the transition from circular to rectangular structures afforded a change in building materials. However, recent studies on near eastern and Anatolian architecture indicate that the shift from circular structures to rectangular does not directly correlate with the adoption of mudbrick technology (Aurenche 1993; Love 2013a). As argued by Rapoport (1969), construction and materials have relatively little effect on the ultimate form

3 Cf. Thomas 2005b; Mylona et al. 2017; Philokyprou 2016; Lorenzon, Iacovou 2019; Amadio, forthcoming.

of a building. In Cyprus, this is well demonstrated by the early production and use of mudbricks – despite being hand-made – in the Early Aceramic Neolithic circular structures at Kalavassos-*Tenta* (Todd 1987) and Akanthou-*Arkosykos* (Sevketoglu, Hanson 2015), and successively in the Late Aceramic Neolithic Khirokitia (Le Brun 1984, 23) and Cape Andreas-*Kastros* (Le Brun 1981; 1985).

Hand-shaped mudbricks coexisted – well into the Chalcolithic period – with mud wall construction; a technique consisting in the super-imposition of successive layers of mud fashioned directly in position on the wall (also known as 'cob', see Wright 2005; this technique is frequently confused with *pisè*, see Thomas 2005a, 22) **[box 2.1]**.[4] According to the analysis conducted by excavators, these early mudbrick prototypes were characterised by an irregular loaf shape and inconsistent proportions (Le Brun 1984, 31; 1981, 81) **[tab. 2.3]**. Local calcareous sediments were used in their manufacture; calcium carbonate represents the principal component in these early bricks (Le Miere 1984). The addition of vegetal matter is also attested in all the mudbricks recorded in these Neolithic contexts (Le Brun 1984, 31; 1981, 81), possibly to compensate for the low malleability of these high calcareous sources and to prevent shrinkage during drying (cf. Amadio 2018). It is important to stress that vegetal tempers are key components in the *chaîne opératoire* of mudbrick manufacture. They play a structurally important role with regard to material performance and preservation (Lorenzon 2021). Vegetal inclusions – straw especially – help to conduct water out of the brick matrix and to distribute stress over the whole material (Devolder 2009).

Mud wall constructions occurred throughout the entire Chalcolithic period in Cyprus. The choice of building with mud instead of mudbricks, however, should not be seen as an involution but as a choice dictated by cultural and functional reasons. As argued by Thomas (2005a, 186-7), mud-built walls were not simple achievements. They required high expertise and skills, as demonstrated by the well-built structures of Kissonerga-*Mosphilia* (e.g. B3 or B206; Peltenburg 1998) or by the mudwall houses of Area 1 at Lemba and roundhouses of Souskiou-*Laona* (Peltenburg 2019, 76-80). The shift to a built-stone foundation and mudwall during the passage to the Middle and Late Chalcolithic, may also be seen as a form of improvement in which greater care and skills are being expressed and demonstrated (Thomas 2005a, 187).

Mudbrick technology was more widely adopted at the beginning of the Philia period and mostly during the Prehistoric Bronze Age. The diffusion of mould-shaped prototypes is attested at many Early and Middle Bronze Age sites, including Marki-*Alonia* (Frankel, Webb 2006a, 7; 1996, 55-6), Alambra-*Mouttes* (Coleman 1985, 132;

4 See also Thomas 1995, 23-5 and Philokyprou 2016.

Coleman et al. 1996, 24-5), Politiko-*Troullia* (Fall et al. 2008), Erimi-*LtP* (Bombardieri 2017, 11; Amadio 2017, 265; Amadio, forthcoming), Ambelikou-*Aletri* (Webb, Frankel 2013b, 184-5, fig. 8.15) and possibly Kissonerga-*Skalia* (Crewe 2013; 2014) and Sotira-*Kaminoudhia* (Swiny, Rapp, Herscher 2003, 59). Where intact mudbricks were recovered, the consistency in size and shape suggested that wooden forms were used for their manufacture (Frankel, Webb 2006a, 8; Bombardieri 2017, 11) **[tab. 2.3]**.

At Erimi-*LtP*, I conducted a more in-depth study of mudbricks recovered at the site in order to collect data about the manufacturing processes applied for the production of these building materials. Philokyprou (2016) reports two methods in the manufacture of mould-shaped mudbricks, which were used both in ancient and traditional architecture. The first involved placing the mould on the ground, which was then filled with clay, smoothing the upper surface, and leaving the mixture to dry; the second involved placing an amount of wet mixture by hand on the ground, before pressing a rectangular mould on top of it to remove the extra material. Intact mudbricks examined at Erimi-*LtP* show a typical section characterised by a pinched edge in the upper surface and a rounded profile in the basal edge **[fig. 2.3]**. This specific morphology may be indicative of the practice of patting mud into the mould and not completely filling the right-angle corners at the bottom (cf. Nordarou et al. 2008), hence suggesting that the first method described by Philokyprou was used. The length, height and width of intact mudbricks analysed are consistent. Macroscopic observations indicate that they measure 40 × 14 × 12 cm, with minor variations of 1-2 cm **[tab. 2.3]**. Considering that the width of the limestone wall bases in the buildings analysed at Erimi-*LtP* is approximately 50 cm, it is possible that mudbricks were laid with their long axis transverse to the wall in order to make a thick structure with a single set of bricks (Nodarou et al. 2008). Furthermore, examinations of intact portions of collapsed limit walls indicate that mudbricks were laid according to the running bond technique (Lorenzon, Iacovou 2019; Wright 2005, 104). In a single case, the English bond technique was noted in a small partition wall of Area A (Building-Unit SA IV-Area A) **[fig. 2.4]**.

So far, fired bricks are attested at Early Bronze Age Marki-*Alonia*, presumably pertaining to a building of Phase C, corresponding to the Early Cypriot I-II or Philia occupation phase (Frankel, Webb 2006a, 8), and Middle Bronze Age Ambelikou-*Aletri* (Webb, Frankel 2013, 185). They are characterised by smaller sizes than sun-dried prototypes **[tab. 2.3]**. The lack of pyrotechnological prototypes at other Prehistoric Bronze Age Cypriot contexts should not be connected to the lack of technological skills, as developments in technology are not necessarily of unilinear evolution (Matthews et al. 2013, 125-8), but may be affected by many variables including social, environmental and technological choices (Arnold 2000, 361-5). This lack may be explained by the fact that there was no need for baked mudbricks as sun-dried materials were resistant enough (Rosenberg et al. 2020). The choice of producing sun-dried mudbricks had advantages, including saving energy required for fuel collection and the burning, but also disadvantages, *in primis* the necessity of regular maintenance practices including frequent re-plastering of walls external surfaces to prevent decay (Keefe 2005).

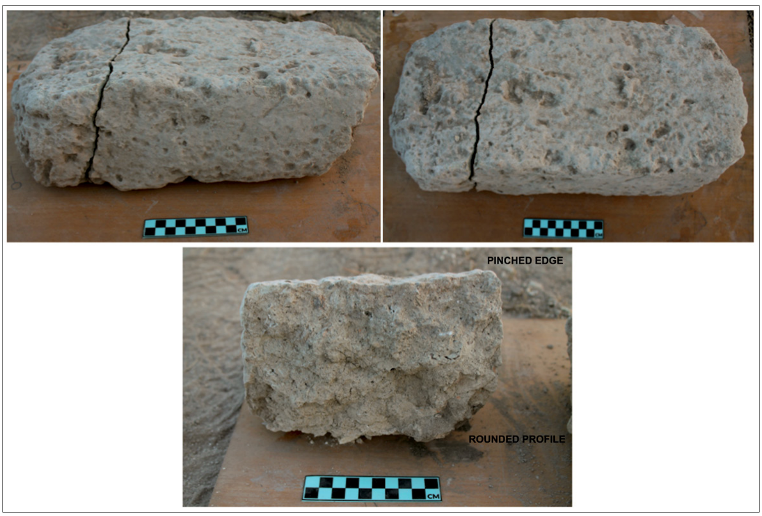

Figure 2.3 Example of intact mudbrick recovered at Middle Bronze Age Erimi- LtP from the destruction sequence of building-unit SA XII- Workshop Complex. Note the pinched edge and the rounded profile visible in the section (Photograph by the Author)

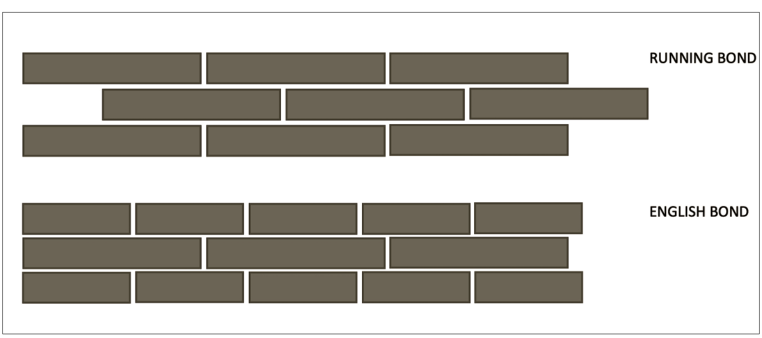

Figure 2.4 Mudbrick masonries identified at Erimi-LtP

Table 2.3 Mudbricks technologies and measures at prehistoric Cypriot settlements

Site	Mudbrick technology	Measures (cm)
Khirokitia-*Vouni*	Hand-shaped	c. 35 × 20
Cape Andreas-*Kastros*	Hand-shaped	c. 30 × 15 × 8.5
Marki-*Alonia*	Mould-shaped Fired	60 × 10 24 × 14 × 8.5
Alambra-*Mouttes*	Mould-shaped	70 × 32
Erimi-*LtP*	Mould-shaped	40 × 14 × 12
Ambelikou-*Aletri*	Mould-shaped (?)	Approximate size: 18 × 10 × 15 10 × 16 × 10 (not complete examples)

Data available for prehistoric earthen architecture in Cyprus indicate that raw materials used for mud walls and mudbricks manufacture were preferentially selected locally (Thomas 2005a, 186-7). Micromorphological analysis conducted on mudbrick samples from Erimi-*LtP* suggests that sediments and tempers were selected by builders on the basis of expertise and perception of practical and functional choices (cf. Amadio 2017, 225-6; Amadio, forthcoming; for general references, see Arnold 2000, 341-57; Sillar, Tite 2000). For instance, red-brown calcareous soil – formed by the slow weathering of limestone with enrichment of Fe_2O^3 – was selected for mudbricks production as naturally rich in carbonate rock inclusions, which contribute to preventing cracks and rapid degradation (Hoard et al. 1995). This aspect demonstrates a profound knowledge of the local material properties and an engagement with the natural resources, validating the idea of the established human-environment interrelationship. The dataset examined at Erimi-*LtP* further revealed that mudbricks were manufactured according to different recipes (cf. Amadio 2017), and these different mudbrick types were recurrently used in many buildings of the Workshop Complex and of the domestic units. Considering this, one possible explanation would be that mudbrick production and construction was a communal task where recipes were shared by the whole community and possibly perpetuated by transmission (Rosenberg et al. 2020); alternatively, this may possibly indicate that different groups of builders prepared mudbricks according to their knowledge and experience, then these multiple batches were used for communal constructions (Lorenzon, Iacovou 2019).

The limited data available for prehistoric earthen architecture in Cyprus does not make it possible to assess the scale of production of these products. That prehistoric people were well acquainted with earthen building techniques seems clear – this is well demonstrated by the large production of earthen products and the expert use of earthen building techniques –, but it is not possible to infer whether or not they were specialists. Extensive use of mudbricks, especially during the Prehistoric Bronze Age period, must have contributed to the development amongst community groups of the practical knowledge necessary to produce structurally efficient mudbrick walls, skills that were possibly acquired through the observation and direct participation in building projects (Devolder, Lorenzon 2019; Palyvou 2005).

The production of earthen materials, mudbricks mostly, was very presumably a part-time occupation for these prehistoric communities; especially because the production could have been conducted only in certain periods of the year – mainly during hot and less-rainy summers (Norton 1986). However, it is further possible that – with the emergence of supra-household forms of labour organisation during Middle Bronze Age Cyprus (cf. Webb, Knapp 2021; Crewe 2017, 149) – this production could have become a full-time or semi-full-time occupation for a sector of the population. Data from Erimi-*LtP* demonstrate that – at least for the construction of the communal productive area of the settlement, the so-called 'Workshop Complex' (Bombardieri 2017) – the mudbrick manufacture was at supra-household level, possibly conducted by semi-specialised workers, as indicated by the circulation of recipes and the consistency in shape and size of mudbricks recovered and analysed at the site (Amadio 2017; Amadio, forthcoming).

Box 2.1
The Earthen Architecture Tradition in Mediterranean Prehistory

Earth is the most accessible and versatile resource used in architecture. For its easy accessibility and the low energy consumption required for its extraction, earth has been chosen by ancient communities to create and shape their built environment since the first appearance of more permanent settlements (Berge 2009, 120). Depending on its natural characteristics, earth can be sourced, manipulated and transformed into a building material (Keefe 2005, 51-8; Norton 1987, 9-19). However, the diverse use of available natural resources is the result of human choices, based on practices and experiences. It is the synergic action of exogenous and endogenous factors, given by a combination of environmental settings and socio-economic conditions, which contributes to creating the basis of empirical knowledge and generates a variety of earthen products and earthen building techniques.

The favourable climatic conditions of the Mediterranean region have favoured the development of building techniques based on the manipulation of raw earth. On one hand, the hot summer sun helps the earth product to easily indurate; on the other hand, the mild winters limit the erosive process of heavy rains and winds, consequently reducing time-consuming maintenance activities and ensuring good preservation to earthen structures. The tradition of building with earth in the Mediterranean region has endured since the prehistoric period, and it is so deeply rooted in the Mediterranean culture that it has become part of the local identity (Pica 2017; Guillaud, Alva 2003).

Used mainly as a solid constructional element in the formation of building walls, earth can be manipulated and shaped according to different methods and technologies. This variety illustrates the many properties and potentialities that this material can offer. Before discussing the various methods and products of earth construction, it is useful to briefly mention the main practices operated by builders to give the necessary strength to this material.

a) Dry Earth Construction: The simplest way to give earth some coherence is by compacting and compressing it. This practice contributes to diminishing the volume of the material and increasing its density. Denser and more compact the earth is, stronger and more coherent the earthen product will be (Wright 2005, 86-7; Norton 1986, 24).

b) Mud Construction: Earth can be consolidated to a greater or less degree by using water. The practice of mixing earth with water brings the clay particles close together. While the water remains in the mixture, the aligned clay particles slide easily across one another conferring plasticity to the earthen product (Wright 2005, 86-7). When the earthen product is subjected to heat, the water evaporates, the aligned clay particles bond together and the material hardens. If the mixture is burnt at high temperature, the water is driven out and chemical reactions, including the melting of some elements, contribute to transforming the mixture into a strong solid product (for an in-depth explanation of transformations occurring on heated clay materials, see Weiner 2010, 92-7, 194-206).

a. Dry Earth Construction

Pisè de terre/Rammed Earth
The term *pisè* is frequently employed – erroneously – by archaeologists to indicate any kind of mud superstructure (Aurenche 2004, 138-9; Wright 2005, 87-8; Thomas 2005a, 19-21). However, the etymological sense of the French words is 'to tamp/ram' (to compress) and this is the valid use of the term. The basic procedure of *pisè* includes the compaction of earth in a dry or very low humid state, between two pieces of wooden forms which are held firmly in position upon the wall being constructed (Gandreau et al. 2021, 6). Each time the space between the forms is filled up with earth and compacted, the formwork is dismantled and moved to the next section of the wall to be built **[fig. 2.1.1]**. Rammed earth walls are monolithic. The width of the wall may vary according to the intended height of the wall and the quality of the soil (Norton 1986, 35). However, generally, walls are between 0.40 and 0.50 m in thickness, as this seems an optimum width which is both thick enough to provide a large mass of earth for compaction to be achieved, but not so thick as to produce internal stress and collapse (Thomas 2005b, 21-5). This is a technique that certainly requires skills and equipment, more than mudbrick manufacture for example. In archaeological contexts, the identification of rammed earth constructions may be challenging. Prehistoric structures in rammed earth are better preserved in arid and semi-arid areas of the Mediterranean region (Friesem et al. 2011).

b. Mud Construction

The difference with the previous method consists in the addition of water to form the mud.

Wattle and Daub
This is one of the simplest and cheapest forms of wall construction. The structure of the wall is provided by a framework of vertical posts set into the ground. Branches or reeds are woven horizontally between the posts to form a lattice. Mud is applied to the framework on both the inside and the outside, at a sufficiently wet consistency for the mud to be applied between the branches **[fig. 2.1.1]**. Mud is applied in layers, and cracks which can occur in earlier layers during construction can be subsequently filled in. A range of different aggregates can be mixed to the soil to improve its binding properties; these may include vegetal fibres, straw, animal hair (Norton 1986, 25). Walls are usually thin, < 0.50 m. This technique has many advantages: little skills are required; relatively small amounts of earth are needed, making it a technique suitable also in contexts where suitable soil is not available on-site; framework can be obtained also with irregular pieces of wood; the framework provides resistance to the collapse in case of earthquakes. Wattle and daub walls, however, require constant maintenance. Unfortunately, evidence for the use of daub on most sites is very poor. In archaeological contexts, it is more frequent to find deposits of degraded clay materials in the abandonment layers of the structure. More fortunate situations are represented by contexts destroyed by fire: in this case, it is possible to retrieve heat-consolidated daub fragments which preserve the impression left by the wooden post **[fig. 2.1.2]**.

Mudwall/Cob
One of the lesser-known methods of wall construction. Present in many parts of the world, it is often confused with rammed earth constructions. The characteristic feature of a mud wall is that it is a monolithic construction fashioned directly in position on the wall. Earth, in a plastic state, is piled, shaped and compacted by hand without the use of any framework **[fig. 2.1.1]**. The materials from which mud wall is constructed vary considerably from region to region and through time. Clay is an important component in providing the cohesion and stability of the structure. Aggregates also play a fundamental role in ensuring strength to the final product. Despite the simplicity of this technique, its major disadvantage is represented by the fact that large quantities of earth and water are needed. If the wall is not preserved *in situ*, it is extremely difficult to identify it in archaeological contexts.

Mudbricks/Adobe
Mudbricks represent one of the most versatile ways of using earth for construction. Mudbricks have been used since early prehistory to build almost every type of domestic and public building. The earliest type of mudbricks was hand-modelled out of plastic earth in the proportion of 40-75% sand, 10-30% silt, 15-30% clay (Norton 1986; Keefe 2005). Mould shaped mudbricks are contemporary to the first type. In this case, mud is pushed or thrown into a mould; the mould is then removed and the brick is left to sun-dry **[fig. 2.1.1]**. The size of the mudbrick is chosen to suit the way brick material will be used in the wall. Mudbricks can be square or rectangular, according to local building tradition and practical and functional choices. An advantage of mudbricks is that they can be made directly at the source of raw materials and then moved to the building site; this is much more economical than moving loose earth and water. Another advantage includes the fact that a minimum of equipment is required to produce high-quality mudbricks. Finally, they allow great flexibility in the size and shape of the walls. The identification and excavation of mudbricks in archaeological contexts can be difficult, often requiring a good knowledge of local sediments and environmental conditions. This is even more problematic for early prehistoric architecture, in which sun-dried and irregularly shaped bricks were being used (Thomas 2005, 23-5).

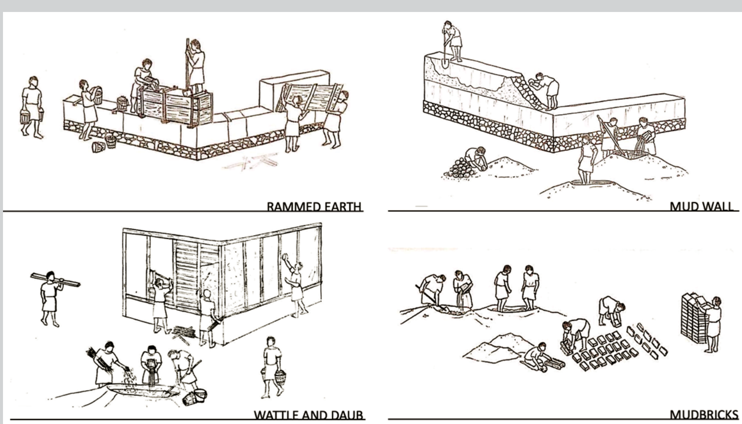

Figure 2.1.1 Methods of construction with earth. © After Gandreau et al. 2021, redrawn by the Author

Figure 2.1.2 Fragments of clay applied on the roofing structures in Building SAIII-Workshop Complex at Middle Bronze Age Erimi. Impressions left by wooden posts are evident

Several research programmes and platforms have been set up in order to disseminate scientific data, research initiatives and information about earthen architecture, focused both on archaeological and vernacular structures. Here is a list of the main European associations and platforms:

- **CRAterre**. Association and Research Laboratory of the École Nationale Supérieure d'Architecture de Grenoble: http://craterre.org.
- **RÉSEAU TERRE**. This association has the aim of promoting and developing the research about earthen architecture, from prehistory until the present day: https://reseauterre.hypotheses.org.
- **EARTH ARCHITECTURE**. Web site and Blog which focus on all aspects of humankind's relationship to making things with earth: http://eartharchitecture.org.
- **CITTÀ DELLA TERRA CRUDA**. Association aimed at promoting and protecting the earthen architecture heritage of the Mediterranean region: https://www.terracruda.org/it.
- **UNI TERRA**. Networking platform for the global exchange of information, experience and know-how in earth architecture and building with earth at an academic level: https://www.uni-terra.org.

2.3.2 Plaster Production and Pyrotechnology

The analysis of plaster making, including the selection and use of materials and the technology applied in plaster manufacture, has been shown to provide key evidence with which to examine the social processes involved in building construction and maintenance.[5] The examination of plaster manufacture, likewise mudbricks production, represents a significant source of data to reconstruct individual and communal practices in prehistoric communities and to study processes of social, cultural and economic transformations.

When we refer to plaster, we indicate a prepared plastic product which is applied in the construction of horizontal (floors) and vertical (walls) surfaces, but also as coating of installations such as basins and channels. In Cypriot prehistory, a range of different products was used in plaster production, notably mud and/or dung, lime and gypsum. Mud plasters and lime/gypsum plasters existed side by side since early prehistory. They both served the same functions of protecting vulnerable building elements, providing durable floor surfaces and enabling more elaborate architectural detailing. However, the preparation of these products required different technologies. While mud plasters were easily produced by combination and mixing of clay-rich sediments, aggregates of organic (i.e. dung, chaff, straw) and inorganic origin (i.e. sand-size rocks, sand-seize quartz) and water, the production of plasters made of lime or gypsum involved more sophisticated technologies, based on different stages of preparation and pyrotechnological processes (Wright 2005, 143-50; Artioli 2010) **[box 2.2]**. The knowledge to produce these synthetic materials is one of the several important trajectories in the technological evolution of human history (Friesem et al. 2019). The conditions for producing lime and gypsum plasters differ radically, and each of these methods has advantages and limitations. Temperatures ranging from 800-1000 °C are required to produce lime plaster. This implies a good supply of fuel and preferably some arrangements to conserve the heat generated. Gypsum, instead, can be burned at lower temperatures of 100-200 °C. The produced plastic materials differ in their mode of setting: gypsum set very quickly, lime – instead – takes considerably longer to set and shrinks during the process. The final products are obviously different. Lime plaster is a hard and durable material, while gypsum plaster is less resistant and more subjected to degradation and dissolution in water (Wright 2005, 143-5; Thomas 2005a, 26-7).

As Thomas (2005a, 25-6) claimed, it is extremely important to understand the nature of plaster materials in order to examine their

5 Cf. Clarke 2012; Garfinkel 1987; Goshen et al. 2017; Karkanas, Efstratiou 2009; Miriello et al. 2011; Matthews et al. 2013; Philokyprou 2011.

socio-cultural significance. Achieving a complete characterisation of plaster products in archaeological contexts may be challenging, and without micro-analytical examinations it is difficult to recognise lime and gypsum plasters and distinguish them from mud plaster materials **[box 2.2]**. Given this difficulty, references to plaster or lime plaster in reports and descriptions of prehistoric Cypriot architecture are sometimes vague, because they are based only on generic observations conducted in the field with the naked eye. Furthermore, the attested use – both in ancient and traditional architecture (Thomas 2005b; Ionas 1988) – of plasters made of pulverised chalk or local *havara* mixed with water makes the identification even more complicated. In fact, the resulting plaster material shows the same morphological (colour and strength) and chemical composition as lime plasters (when referring to lime plasters. The definition 'lime plaster' is used in this volume to indicate a material produced by a pyrotechnological process. Only the combination of macroscopic and microscopic analyses can support a valid examination and characterisation of these materials **[box 2.2]**. For this reason, the present discussion will be mostly based on data deriving from more detailed analyses, which integrate macro-examinations and micro-analytical techniques.

Box 2.2
The Lime Cycle. Analytical Techniques to the Study of Ancient Plaster Materials

'Plaster' is a general term that refers to prepared plastic products which can be made of mud, dung, gypsum, lime or mixtures of these materials (Goshen et al. 2017). While mud and dung attain plasticity when wet without specific pre-treatment, gypsum and lime acquire plasticity following specific pyrotechnological processes that include heating, slaking, aging and application (Artioli 2010). The production of these pyrogenic products requires organisation strategies and investment of work for quarrying of raw materials, fuel supply and craft expertise, therefore – in archaeological contexts – plasters are considered key materials to study evolution in technology, production and labour organisation in early communities (cf. Clarke 2012; Thomas 2010; Matthews, French 2005). In Cypriot prehistoric architecture, mud, gypsum and lime plasters were extensively used since the Neolithic (Philokyprou 2012a), and were produced either for building purposes (for the construction of floors, for coating walls and installations) and for decoration. According to Philokyprou (2012b), lime is the preferred pyrotechnological product used in the production of plaster materials in Cyprus since early prehistory. This is possibly due to the fact that, despite the production of lime plaster requires more sophisticated procedures – including higher firing temperatures –, the end-product is much more resistant than gypsum plaster (Wright 2005; Artioli 2010).

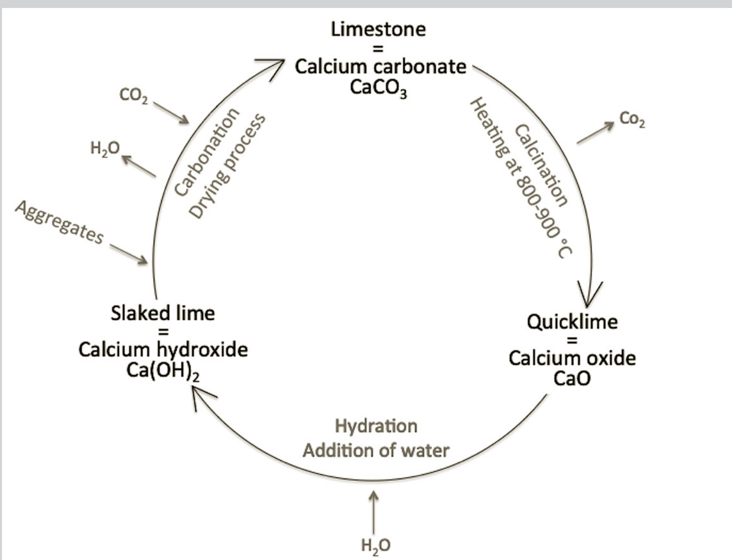

Figure 2.2.1 Lime cycle showing the processes of calcination, hydration and carbonation and the relative chemical reactions which occur during these three processes (re-adapted after Thomas 2010; Leslie, Hughes 2002)

From a technological point of view, lime plaster is the result of chemical reaction of heated calcium carbonate ($CaCO_3$) – generally limestone, marl or chalk – which is fired at high temperatures (700-900 °C) for a prolonged time, transformed into calcium oxide (CaO), and slaked with water forming a putty of calcium hydroxide ($Ca[OH_2]$) in order to produce a material that, once dried under atmospheric condition, re-establishes the same morphological, chemical and mineralogical composition of the parent material (Thomas 2010, 117-18; Leslie, Hughes 2002; Philokyprou 2012a) [fig. 2.2.1]. However, while geogenic calcium carbonate of the parent material is characterised by atomic ordered calcite, the rapid formation of pyrogenic calcium carbonate results in a microcrystalline and highly atomic disordered calcite (Chu et al. 2008; Kingery, Vandiver, Prickett 1988; Poduska et al. 2011; Regev et al. 2010; Shoval, Yofe, Nathan 2003; Shoval, Yadin, Panczer 2011; Weiner 2010). Thus, the atomic order/disorder of calcite serves as an important indicator for the formation processes of the calcite and offers reliable data to study the pyrotechnology involved in the production of calcite-based plaster materials.

Table 2.2.1 Strengths and limitations of methodological approaches used to analyse plaster materials and calcite formed by different mechanisms

Technique	**Strength**	**Limitation**	**References**
SEM-EDX	Identification of morphological and chemical composition. May support the distinction between lime and gypsum plaster	Does not identify crystalline mineral components. Does not support the identification between fired and unfired lime	Kingery, Vandiver, Prickett 1988; Gourding, Kingery 1975
Micromorphology	Identification of microstructure, inclusions, nature of aggregates and mineralogy	With no experimental comparisons, the identification of fired lime can be challenging	Goren, Goldberg 1991; Matthews et al. 1996; Karkanas 2007
FTIR	Identification of mineralogical composition. Supports the distinction between geogenic, biogenic and anthropogenic calcite using the analysis of ratio between main calcite peaks heights	Results depend on grinding setting	Chu et al. 2008
FTIR-grinding curve	Identification of mineralogical composition. More reliable distinction between geogenic, biogenic and anthropogenic calcite, as calcite peaks height analysis in not affected by grinding	Results may be altered by post-depositional calcite	Regev et al. 2010
FTIR grinding curve + angle dependant XRD peaks width	More informative than previous methods as it integrates FTIR with XRD	Less reliable results in calcite-rich environments such as caves	Xu et al. 2015

Analyses conducted by Philokyprou (1998; 2012a; 2012b) indicate that during prehistoric Cyprus mud plaster was extensively used both in the construction of floors and as an external coating for protecting walls. Local resources were selected and skilfully mixed to obtain resistant plaster materials. The combination of raw materials changed according to the function of the final products; for instance, mud plasters applied on the wall surfaces were richer in organic tempers and therefore more plastic than floor plaster; mud plaster floors, instead, were generally mixed with inorganic aggregates as sand-gravel size rock inclusions in order to result more resistant to mechanical stress (Artioli 2010). As observed at the Late Aceramic Neolithic Khirokitia, wall and floor plasters were often set in thin successive layers; a practice which was observed also in the Near East and Anatolian prehistoric contexts (Philokyprou 2012a). The placement of successive thin layers on the walls' external surfaces was made to avoid collapsing under excessive plaster weight. The vertical plaster surface was generally burnished to make it denser and harder as the more fine-grained particles were transferred to the surface layer (Philokyprou 2012a) **[fig. 2.5]**. This practice also ensured to wall plasters a better performance against dissolution and erosion by closing the voids of the plaster matrix, thus limiting water infiltration and successive cracks (Norton 1986; Keefe 2005). Floors could also have been applied in different layers. Generally, a thin layer of finer plaster was laid on top of a coarser constructional packing in order to have a more resistant floor surface. Floor layering could also be the result of frequent replastering. This maintenance practice was especially adopted when burials were placed under the floor level of houses, as widely attested at Khirokitia (Knapp 2013, 137-47; Philokyprou 1998). The practice of levelling and compressing the plaster floor before drying also created a characteristic separation of coatings in successive layers, with the finest particles on the surface and the coarser material at the bottom (Thomas 1995).

Another common practice was to plaster the interior wall and the floor of buildings at the same time, using the same material. Rounded pebbles were set in the lower part of the wall, between the vertical surface and the floor **[fig. 2.6]**, in order to make the application of the plaster layer easier, but also to possibly increase water tightness within the building and/or to avoid rodent activities inside the building (Amadio 2018; Philokyprou 2008; 2011; Matthews et al. 1997). This practice has been recorded in several prehistoric contexts, including Chalcolithic Kissonerga-*Mosphilia* and Middle Bronze Age Alambra-*Mouttes* and Erimi-*LtP* (Philokyprou 2011; 1998, 234-47; Amadio 2017, 127-8), suggesting that similar techniques were widespread in different regions of the island.

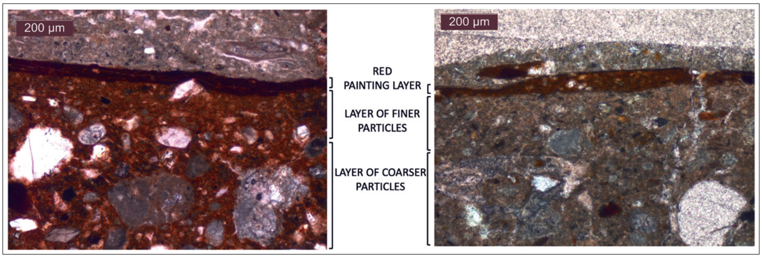

Figure 2.5 Photomicrographs (in plane-polarized light -PPL) of mud plaster applied on the external wall surfaces at Middle Bronze Age Erimi-LtP. Note the layer of finer particles closer to the surface (just beneath the red painting layer) as a result of burnishing. © Author

Figure 2.6 Technique used in the application of plaster on wall and floor surfaces at Middle Bronze Age Erimi-LtP. Pebbles (on the bottom left of the image), were set at the conjunction between the floor and the vertical surface of the wall. © Author. Courtesy of L. Bombardieri

Lime and gypsum plasters are both attested in Cyprus, confirming the simultaneous circulation of different technologies during the entire course of Cypriot prehistory. Very early evidence of lime plaster industry has been documented at the Early Aceramic Neolithic site of Akanthou, on the north coast of Cyprus. This seems to predate the appearance of pyrotehcnology in the island at the 9th millennium BC (Sevketoglu 2000; Sevketoglu, Hanson 2015). Confirmation of these data (Sevketoglu, Hanson 2015) implies that Cyprus was at the forefront of the adoption and development of lime plaster technology in the Eastern Mediterranean (the earliest evidence for the use of lime – even if sporadic – was reported from the Middle and Late Epipalaeolithic in the southern Levant).[6]

Lime plaster prevailed over gypsum plaster production during the Late Aceramic Neolithic period, as reported by analysis conducted by Philokyprou (2012a) and, according to present data, continued to be attested as the main plaster material even in the later prehistoric period (1998; 2012b). According to Philokyprou (2012b), this is surprising considering that the island has the most notable deposits of gypsum, and many prehistoric settlements are situated in the proximity of gypsum quarries. The preferred production of lime plaster appears peculiar also thinking about the easier procedures involved in the manufacture of gypsum plaster, as discussed earlier. An explanation is possibly identifiable in the longer durability and resistance of lime products compared to gypsum plasters.

A hiatus exists in the record of Early Chalcolithic Cyprus, where there is an absence of evidence pertaining to the production of lime plaster – with the possible exception of Kissonerga-*Mylouthkia* (Croft, Thomas 2003, 107-27). Plaster industry re-emerges at a large scale during the Middle Chalcolithic (Thomas 2005a, 187), as indicated by the occurrence of frequent lime plaster surfaces at Kissonerga-*Mospihilia* (Philokyprou 2012a; Thomas 1995, 40; 2005a, 187), and by evidence from Lemba-*Lakkous* (Thomas 2005a, 187; Peltenburg 1985), Souskiou-*Laona* (Dalton 2019, 91-6) and Chlorakas-*Palloures* (Klinkenberg 2021, 32-49). Thomas (1998; 2004; 2005a) examining this lack, discards the possibility that the diffusion of lime plaster during the later phases of Chalcolithic Cyprus was the result of internal developments deriving from increasing contact with the Levant – contact between the two countries, in fact, is attested since the Early Chalcolithic. That the decrease in lime plaster production during the Early Chalcolithic has to be connected to a lack of fuel resources – as a consequence of progressive deforestation on the island – is also incorrect. Experimental analysis conducted by Thomas well demonstrated that the production of lime plasters does not require a large amount of wood (2005a). Furthermore, experimental analysis conducted on fuel sources indicates that wood is not the preferred material to maintain high temperatures – as those required for lime calcination – over a prolonged time; dung instead is much more effective (Braadbaart et al. 2012; see also Gur-Arieh et al. 2014, with references). The absence of plaster may be possibly connected to the more ephemeral character of Early Chalcolithic timber-framed structures. The possible seasonal nature of these structures (Clarke 2007c, 124-6) maybe did not require the use of long-lasting materi-

6 Cf. Bar-Yosef, Goring-Morris 1977; Goring-Morris et al. 1997; Kingery, Vandiver, Prickett 1988; Valla et al. 2007.

al, such as lime plaster. We can speculate that the production of lime returned to be on a larger scale with the emergence of more 'stable' structures during the Middle and Late Chalcolithic. While this remains a possible explanation, it is prudent to await further evidence to validate this assumption.

The large diffusion of lime plaster industry at the end of Chalcolithic contrasts with data from Prehistoric Bronze Age Cyprus. Optical microscopic analysis conducted on plasters from Early and Middle Bronze age Cypriot settlements indicates that during this period, mud plaster was more commonly attested than lime plaster (Philokyprou 1998; 2012a; 2012b). The use of lime plaster is confirmed at Early Bronze Age Marki-*Alonia*; however, this material was not frequently applied in floors construction (Frankel, Webb 1996, 56; 2006a, 10-11; Philokyprou 2012a). At Early Bronze Age Sotira-*Kaminoudhia*, the identification of lime plaster is based on macroscopic analysis only. Evidence indicates that the use of what was recognised as lime plaster was restricted to the manufacture of circular and rectangular bins; less frequently it was applied as wall render and as flooring materials (Swiny, Rapp, Herscher 2003, 59-61). In many buildings at Sotira-*Kaminoudhia*, the foundation bedrock was used directly as a floor without any plaster application, even if the calcareous geology of the area provided abundant raw materials and the natural environment offered easy access to water and wood resources (Swiny, Rapp, Herscher 2003, 60-1). The preferential use of mud plaster in floors and wall surfaces at Middle Bronze Age Alambra-*Mouttes* constitutes further evidence of the presumed decrease of lime plaster application (Coleman et al. 1996, 25; Philokyprou 2012b, 187). The use of lime plaster for specific buildings or installations, however, highlights the importance of this material in specific contexts, as identified by Gjerstad, who reports the occurrence of a lime plaster floor in Room 6 at Middle Bronze Age Kalopsidha (1926, 22-9; Frankel, Webb 2006a, 10-11), but as also recorded at Amebelikou-*Aletri*, where lime was applied only for the construction of a circular hollow in Unit 1 (Frankel, Webb 2014). While we do not yet have any definitive data about the nature of plasters produced at Middle Bronze Age Kissonerga-*Skalia* and Politiko-*Troullia*, recent analyses conducted at Erimi-*LtP* indicate that both mud plasters and lime plasters were used at the site (Amadio 2018; 2021).

Combined macroscopic, micromorphological, spectroscopic (FTIR) and elemental (SEM-EDX and XRF) analyses revealed the occurrence of different recipes in the manufacture of plaster materials. The identification of specific recipes in plaster production, the use of selected tempers to obtain diverse plaster types, and the repeated occurrence of specific floor plaster types in particular areas and building units of the settlement, suggest that the production at Erimi-*LtP* was most probably carried out by workers specialised in building tasks, and the recurrence of this practice across the settlement suggests that this was organised at a communal level. In fact, if the production of plaster was conducted at a household scale, we may expect to find a specific plaster type spatially limited to one building unit or a few related buildings. On the contrary, plasters appear to have been produced depending on specific uses of buildings and spaces where they were applied. The evidence of community-wide use of specific resources for material contexts and functions might endorse the assumption of the possible existence of cooperative forms of labour and specialised or semi-specialised work (Arnold 2000, 341-57) at this site (cf. Amadio 2018; 2021).

Evidence of plaster tempered with crushed ceramic was also identified at Erimi-*LtP* **[fig. 2.7]**. This plaster type is repeatedly applied as a coating for mortar installations (Bombarideri 2017; Amadio 2017). Analysis conducted indicates that the specific use of crushed ceramic aggregates within a lime binder can improve both the mechanical and hydraulic performance of the material (Turco et al. 2016; Amadio 2017, 230). Similar examples have not yet been identified in prehistoric contexts, while they appear to be attested in Late Bronze Age urban centres such as Kition, Hala Sultan Tekke, Maroni-*Vournes* and Kalavassos-*Ayios Dhimitrios*, where these plaster types have been interpreted as innovative products of specialised labour of the more complex urban societies of Late Bronze Age Cyprus (Philokyprou 2012a). The production and application of these plaster materials at Erimi-*LtP* suggest a degree of expertise and labour organisation likely to have involved authority and decision-making at the supra-household level (Amadio 2018; 2021).

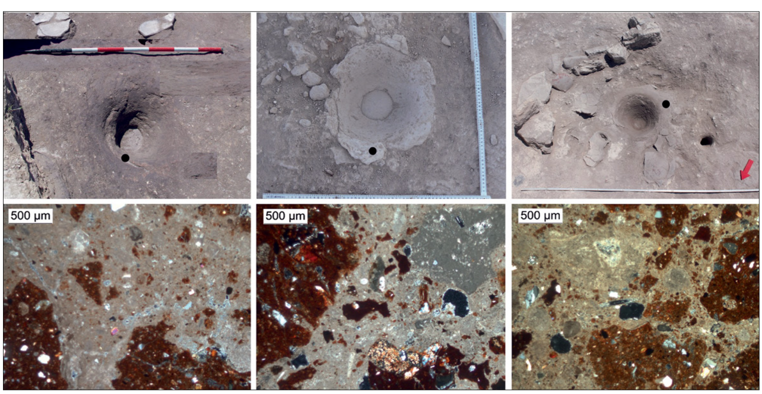

Figure 2.7 Photomicrograph (in crossed polarized light- XPL) of plasters tempered with crushed ceramic and the mortar installations where samples were taken from (the black dots mark the area where plasters were sampled) – Middle Bronze Age Erimi-LtP. Samples were taken from mortars of building-units SA I- SA IIB- SA IIa respectively. Note how the majority of ceramic inclusions have sharp edges and angular shapes, suggesting that a fired-hard material was crushed and used as temper, possibly pottery (see Amadio 2017, 92-3). © Author

It is important to stress that the production and frequent use and application of mud plasters at these Prehistoric Bronze Age contexts should not be interpreted as a lack of technical skills, but should be considered a deliberate choice operated by builders on the basis of practical reasons: plasters made of local calcareous sediments or crushed *havara*/chalk obtained a resistant product with less effort in terms of time and labour investment. In fact, examinations of experimental plasters demonstrate that materials made of crushed and pulverised *havara*/chalk mixed with water are robust and rather impermeable to liquids (Amadio 2021b). Pyrogenic lime plaster certainly required more labour investment with regard to raw material collection, fuel supply and craft expertise. Although considerable quantities of lime can be produced without a very large work investment, 4 tons – c. 3600 kg – of plaster surface can be produced by 20 workers for about five days using four burning sessions within pit-kilns, according to the calculation by Goren and Goring-Morris (2008); the vast production of pyrogenic plaster as identified at Middle Bronze Age Erimi-*LtP* demanded a whole different set of knowledge, from quarrying of suitable carbonate rocks to construction and operation of kiln/hearth, including manipulation of large quantities of quicklime (an extremely hazardous material), as well as the use of proper fuel in appropriate amounts. This multi-task organisation reinforces the idea of consistent skills and knowledge by craft people or workers who become increasingly more specialised (Matthews, French 2005, 127; Özdogan 1999, 230-2).

2.3.2.1 Carving and Dressing Stone

Stone represents one of the primary choices in building construction of prehistoric Cyprus. The wide use of stone for walls and wall footings was not only related to the easy accessibility of stone materials in the Cypriot landscape, but also and mostly to the advantages of stone architecture, including the capability to improve the static performance of the structure and to enhance the aesthetic appearance of the building (Philokyprou 2011).

Rubble stones were mostly used in Neolithic Cypriot architecture. Limestone rubble and boulders were simply collected from the bedrock. They were used with minimal or no working and were naturally irregular in shape, although in some cases the natural breakage pattern of the stone produced flat surfaces (Dimou et al. 2000). Evidence of worked blocks emerged during the Chalcolithic (Thomas 2005a, 186-7). The progressive diffusion of semi-subterranean and subterranean dwellings during Chalcolithic Cyprus and of rock-cut tombs during Prehistoric Bronze Age Cyprus indicates the increasing development of carving and dressing operations among prehistoric communities on the island. The processes of carving and dressing did not demand sophisticated tools or technologies (Wright 1992, 362). In fact, it was possible to carve and dress stone with hard stone implements (dolerite, basalt, granite and chert are the most common), and metal tools were not essential (Blackwell 2020, 215-16). However, the operational sequence behind stone-working, from extraction to final crafting, involved strategic choices, including anticipating the scale of the final project, estimating the working affordance of raw materials, assessing the availability and suitability of specific tools; all aspects which demanded a level of organisation of labour and workforce likely involving decision-making at the supra-household level (Wright 1992, 363; 2005, 33-4).

Despite no prehistoric quarries have been identified in Cyprus – most probably because more ancient quarry sites were re-exploited in later periods (Fisher 2020) –, it is possible to reconstruct the basic operations of ancient carving practices by looking at best-documented examples from more recent periods; stone carving, in fact, is generally a conservative technology (Wootton et al. 2013). The practice of carving involved distinct operations, consisting of procuring the stone – in Cyprus the local soft limestone and sandstone were preferred (Philokyprou 2011) – by cutting channels around the blocks using picks. Once the block's lateral faces were freed, it was retrieved by splitting off its lower face from the bedrock using a pick and a lever in combination with wetted wedges and a hammer (Wright 1985; 1992). This method allowed for the production of pieces of regular shape, thus permitting masons to regularise the carving process and to exploit the carved stone as much as possible in building construction (Devolder 2017). Sometimes, natural planes in the source materials likely determined the size of many blocks (Fisher 2020, fig. 11.3). According to Philokyprou (2011, 40), discontinuities in the Pachna formation facilitated the removal of rectangular pieces of stone, thus reducing the work effort necessary to conduct such demanding operations.

The basic types of mason's tools are likely to have remained constant from ancient times until the present day (Wootton et al. 2013). Wright (1992, 366) indicates two main categories of tools for stone dressing: the striking percussion tools, such as hammer, pick, axe, adze, and the struck percussion tools, like chisels and points. A further category includes non-percussion tools, like saw, drill, rasp and polisher which are not always included in the masons' toolkit according to archaeological data recovered in the Eastern Mediterranean. Uses of specific tools and technology may vary from region to region and across time, depending on different variables including the stone being worked, the final effect sought and the worker's skills and experience (Wootton et al. 2013). The architect Jeffrey (1918, 169) noted, for example, that the traditional village masons in Cyprus did not make use of the chisels – as expected after the influence of roman building methods on the island –, but carried out all work by a combination of pick and axe/adze, according to the Levantine tradition (Wright 1992, 367).

Reconstructing dressing technology and tools which may have been used by prehistoric Cypriot masons is challenging, due to the lack of archaeological evidence. The difficulty is given by the multifunctional character of these stone and metal tools, which limits the possibility to indicate with absolute certainty their exclusive use in masonry activities. In this regard, it is important to stress that multifunctional objects can be reshaped and reused until exhaustion (Boleti 2020, 246). Certain tools can also be shaped into other types of tools, as required. A flat chisel, for instance, can be shaped into a round-headed chisel by cutting its corner, according to evidence collected by traditional stone carvers (cf. Wootton et al. 2013). A general agreement (cf. Boleti 2020, with references) is that stone tools were often preferred to metal tools because of their physical and mechanical properties, mainly hardness and durability. This assumption appears to be confirmed by the persistent use of stone tools also during the later Iron Age and Greco-Roman periods (Boleti 2020, 242).

Within the category of masonry tools, chisels and flat axes are the objects more securely related to dressing activities. Stone chisels of diverse types – cigar-shaped with convex sides or with flat faces; plano-convex – have been identified at Chalcolithic Souskiou-*Laona* (Peltenburg, Bolger, Crewe 2019, 250-60) and Kissonerga-*Mosphilia* (Peltenburg et al. 1998a, 171). Most of them were recovered in settlement areas and many appear to have been hardly used (cf. Peltenburg, Bolger, Crewe 2019, pl. 111.10). Whilst the worn surface of these objects suggests that constant force was applied on these stone implements, possibly during repetitive actions like stone working (Deckers, Sewell 2019, 47-52), it is important to stress that they could have absolved also other utilitarian functions, including wood cutting and shaping and that multi-functional analyses are required to obtain more reliable data. Metal chisels are scarcely attested in the archaeological record of prehistoric Cyprus. A few examples are represented by the chisels from Chalcolithic Erimi-*Pamboula* (however fragmentary; Dikaios 1936, 50) and Lemba-*Lakkou*s (within Building 3; Slater 1985, 40-1), from the Philia burial context of Vasilia (Karageorghis 1960, 244), and from many Early and Middle Bronze Age contexts, including Vounous (Stewart, Stewart 1950, 125; Stewart 1962, fig. 100.25), Lapithos (Sjoqvist 1934; Catling 1964, fig. 4.11), Sotira-*Kaminoudhia* (Swiny, Rapp, Herscher 2003, 374-5) and Pyrgos-*Mavroraki* (Tomb 21; Giardino et al. 2002, 39). They are characterised by a long shaft with a square or rectangular cross-section, tapering butt and flaring cutting edge. Bone handles were preserved in some cases (Balthazar 1990, 377). Blackwell affirms that the dominant form in the repertoire of masonry tools – especially during Prehistoric Bronze Age Cyprus – is the single flat axe. These objects are widespread, particularly in Middle Bronze Age contexts such as Pygos-*Mavroraki*, Alambra-*Mouttes* (Blackwell 2011, 205, tab. 4:25). Pierced axes are also characteristic of the archaeological record of this period (MC I-II) (Catling 1964, 86; Balthazar 1990, 360). Flat axes were probably hafted; however, no remains of hafting materials have been found in Cyprus due to the perishable nature of the presumed handle (Coleman et al. 1996, 139).

Given the limitation of the available evidence, a further direction to the study and reconstruction of carving and dressing operations in prehistoric contexts of the island is constituted by the analysis of tool marks. Stone materials, especially when soft and porous such as limestone, tend to preserve marks left by implements when used to shape the stone surface. However, tool marks can be easily obliterated because of anthropic action, including finishing and smoothing practices, and natural erosion by wind and rain (Blackwell 2020, 217).

Due to this reason, tool mark analysis has rarely been conducted in the examination of prehistoric contexts in Cyprus. To date, limited evidence is available, but this can represent an interesting starting point for future, more systematic investigations. Analysis conducted at the Laona cemetery revealed the occurrence of tooling marks on the internal wall of the rock-cut tombs (Peltenburg, Bolger, Crewe 2019; Crewe 2019, 102-28). These consist of vertical, semi-circular grooves running parallel to one another down the tombs' walls. Variation exists in that some grooves run from left to right and others right to left; however, all marks have a similar direction and dimensions (similar width and depth). According to Robertson (2004), the carving process was achieved through the use of antler, as possibly demonstrated by experimental analysis which indicated that 10 hours of work were needed to carve a rectangular tomb of 34 × 21 × 15 cm simply by hammering by hand of an antler pick. The consistency in the direction and dimension of marks analysed in the Laona tombs suggests that these structures have all been constructed using the same (or very similar) techniques and tools. This uniformity is seen as a possible indication of craft specialisation, and the recurrence of this technique across a long-time span implies that knowledge was transmitted to successive generations. Robertson (2004) claims that this might suggest the existence of significance attached to this carving process, beyond strictly functional considerations.

Preliminary analysis on tooling marks has been also conducted at Middle Bronze age Erimi-*LtP*, focusing on marks left on the calcareous bedrock floor of the productive area of the settlement, the Workshop Complex (Amadio, Chelazzi 2013). The tool marks identified at the site were divided into three different categories on the basis of tools and techniques used, which reflect specific building practices. Group 1 comprises the signs left by a tool as a punch or a point which was used to scrabble the surface of the bedrock and to roughly dress the limestone foundation bases of building units **[fig. 2.8a]**. Group 2 comprises broken furrows left by a pointed tool, which was used to shape bedrock surfaces and corners of building units **[fig. 2.8b]**. Group 3 comprises tooling marks left by chisels; they have been divided into two sub-groups. Group 3a includes parallel vertical line marks, which are resulting from the hard striking of a chisel with a small tip; these signs are attested in vertical walls of carved basins **[fig. 2.8c]**. Group 3b comprises very close hatchings, which were obtained through the use of a chisel with a wide tip; this tool was used to smooth the limestone surfaces of channels, possibly to facilitate the flow of liquids (Amadio, Chelazzi 2013, 323-4) **[fig. 2.8d]**.

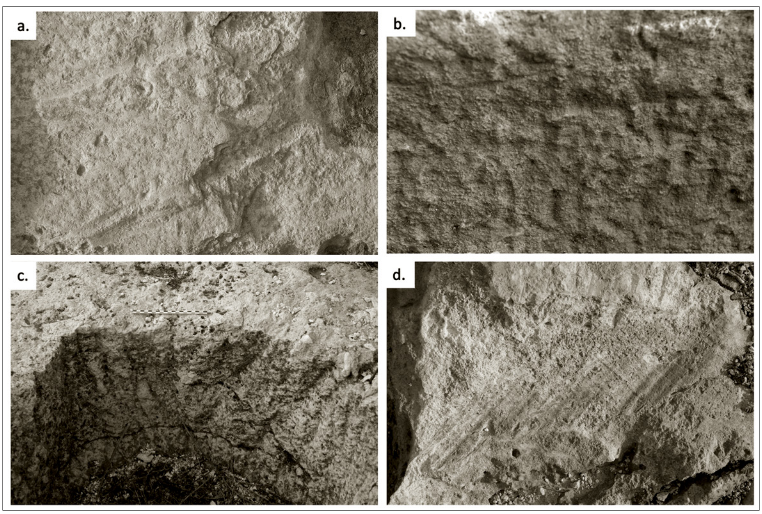

Figure 2.8 Tool marks identified on the bedrock floor at Middle Bronze Age Erimi-LtP: a) marks left by a punch or point; b) broken forrows left by a pointed tool; c) vertical line marks left by a chisel with a small tip; d) close hatching left by a chisel with a wide tip. © Amadio, Chelazzi 2013, 323-4

The evidence analysed suggests that a wide range of tools was used for carving and dressing limestone. The application of different tools and techniques according to specific building requirements is a possible indicator of specialised skills. As it was already stressed, carving and dressing stone did not require sophisticated tools; however, the conducting of these operations demanded specialised labour and the competence to organise these activities (Wright 1992, 362). At Erimi-*LtP*, the entire settlement was constructed by extensively carving the calcareous bedrock floor in order to create an organised layout, with buildings distributed on the terraced morphology of the hill. The extensive cutting of the calcareous bedrock involved in the settlement design and construction suggests advanced organisational and technological skills from the outset at the first stages of settlement construction, and presumably a degree of labour organisation at the supra-household level. The accomplishment of such an ambitious plan provides an indication of the amount of labour invested. Trigger (1990, 128-9) argues that the ability of individuals to engage in conspicuous consumption of energy and labour may be representative of power and control over natural and human resources and may therefore demonstrate a more complex social organisation. Evidence from the analysis of stone dressing at Erimi-*LtP* also indicates that a progressive development in stone working techniques was achieved during the later occupation phase of the settlement, at the end of the Middle Cypriot period. The best example of technological development in stone working is represented by the high-level technique in carving monolithic thresholds (see also § 3.1.2.1), as identified both in the productive and domestic areas of the settlement. These represent a great enhancement in the architectural elaboration and marking of boundaries of buildings, suggesting that a degree of expertise and labour organisation likely to have involved authority and decision-making at the supra-household level was emerging at the site during the course of the Middle Bronze Age Cyprus.

In this regard, it is important to consider that the creation of tools and the exchange of methods and techniques inevitably created networks of interdependence whereby people were producing things that effectively embodied themselves, through their labour and their relationships with others. The extraction of the monolith from the parent rocks, despite not requiring sophisticated technology, may have taken considerable time and a substantial group of people involved. These actions necessarily imply the need for planning, organisation and coordination, and at the same time the establishment of social roles in the project (Richards 2010). The construction of a built environment is a long-term project and the task of building large projects requires a long-term commitment as well as the ability to control resources and to coordinate substantial investment of labour. As claimed by Knapp (2009, 47), these undertakings cannot have failed to create a sense of group identity. I argue that carving and dressing operations, as well as other practices involved in building/settlement construction had, together with functional purposes, ideological implications associated with the sense of immutability and continuity, but also of strength and power, which possibly fostered the connection among community members and the natural environment (Altman, Low 1992), playing an important role in shaping socio-cultural identities and statuses within prehistoric Cypriot communities (Tilley 1996; 2004, 1-33).

2.4 Who Were the Actors? Labour Organisation, Gender and Social Agency

In the previous sections, materials and techniques adopted in construction activities by prehistoric Cypriot communities were presented with the aim of shedding light on socio-cultural dynamics, like the circulation of knowledge and the organisation of labour. In these discussions, I referred to people involved in these operations as 'builders', 'workers', 'masons'. But who were they? Who were the actors involved in these construction activities?

The study of social agency in technological and labour organisations cannot preclude the examination of gendered practices and strategies (Dobres 1995). Technology, indeed, serves as an arena in which social interactions in the planning, production, use and repair and discard of material culture are defined, expressed and negotiated (Dobres, Hoffman 1994, 224). In the analysis of architectural practices and processes, archaeologists often tend to overlook the role of women. The idea of house construction is generally perceived as solely a male activity, with the consequence that little is known about those involved in all the stages of building practices, from raw material collection to wall construction. As properly pointed out by Lorenzon (2020, 13-26), this male narrative, which is still dominant in archaeological research, is partly a consequence of the fact that architecture is still too often treated as the setting, rather than as an active agent in social life. The resulting 'faceless' reconstructions (cf. Tringham 1991) lack in identifying and recognising gendered social roles and identities, thus limiting the potential of archaeological research for understanding and reconstructing social behaviour and activities, including building construction practices.

A common misconception concerning gender in ancient societies is the idea of a different involvement of men and women in technology, production and exchange (Bolger 2003, ch. 3; 2010, 157). Traditional views of past societies have often relegated the role of women within the household space, and have limited women's practices to household-based activities, for example food processing and pottery production (on this argument see Bolger 2003). Instead, in the process of house construction, the labour of men, women and children is crucial at stages such as the acquisition of raw materials and the actual building construction and completion. Ethnoarchaeological analyses,[7] confirm this assumption and indicate that despite gendered roles in construction activities may vary across cultures and within groups in the same culture, the operational sequence of house and settlement construction is generally conducted both by men and

7 Cf. Blier 1981; Dalton 2017; Elcheikh 2018; Eyifa-Dzidzienyo 2012; Prussin 1969.

women of the community. Modern examples also suggest that in construction activities division of labour between males and females is often based on socio-cultural conventions and the assignment of tasks is generally related to the preconception that women can conduct 'simpler' activities (e.g. raw materials collection; flooring and wall plastering), while men can handle harder activities (e.g. carving and dressing operation, wall and roof elevation and construction) due to their innate and biological characteristics. In some cases, the attribution of particular tasks to women, for example the selection and collection of clays and the preparation of mixtures for plastering and decoration, is due to their greater ability to accomplish assigned responsibilities and to conduct precision work (Eyifa-Dzidzienyo 2012). While these data from modern contexts can provide a framework for examining past social systems, they cannot be directly applied to the past, since past societies have a high degree of flexibility and variability and they do not necessarily reflect the organisation of modern societies (Bolger 2013, 175; Sinopoli 1991, 169).

Going back in time to prehistoric Cyprus, studies conducted by Diane Bolger on engendered materials and spaces have demonstrated that there is little evidence for polarised gender categories during the earlier phases of Cypriot prehistory (Bolger 2010, 162-3; on this topic see also Douglas 2020). This argument is well exemplified by the results of the experimental work with the use of 'clays' in chalcolithic pottery conducted at the Lemba village (Shiels 2003; Bolger 2003), which indicates that the organisation of working practices, especially if they require complex operational sequences, are likely to demand the collective and collaborative efforts of men, women and even children.

In support of this argument, three examples are presented concerning building operations that in modern contexts are considered 'women tasks' (cf. Eyifa-Dzidzienyo 2012; Elcheikh 2018): raw material collection, plastering and surface decoration. By reviewing them from the perspective of prehistoric Cypriot communities, it appears that forms of collaborative labour, possibly involving the flexible arrangement of tasks, occurred in these village-based communities.

Raw material collection is generally believed a 'women activity' because it can be carried out despite interruptions and in combination with other household tasks (cf. Lorenzon 2020). However, experimental analysis of technological practices (Thomas 2005b) has demonstrated that the selection and collection of raw materials is an operation that needs care, acquired skills and a considerable amount of time (see also London 2002). If it is true that most of the raw materials for building construction are preferentially collected in the proximity of the settlement area, at the same time the production of building materials, such as mudbricks or plasters, requires a combination of different resources, including sediments, tempers, water, wood – as it was also stressed in the discussions presented in the previous sections. The procurement of these materials demands commitment and cooperation, thus reinforcing the assumption that in prehistoric construction practices the combined effort of all community members was essential for the accomplishment of such laboured activity.

Plaster production was also labour intensive and involved diverse steps and profound knowledge of raw materials and procedures in order to obtain a resistant and long-lasting product. While the practice of 'plastering', which consists of the final application of the plaster product on a surface, can be conducted by one person, at the same time it is important to stress that the production of the applied plaster requires a lengthy series of operations. Some of these operations needed skills – e.g. wood preparation and control of fire temperatures in order to guarantee a complete calcination process of the carbonate material **[box 2.2]**, the selection of appropriate aggregates types and the mixing of binders and aggregates in the right proportion –, therefore they could have been conducted by those with technological know-how and experience, both men and women. Other tasks, instead, required little or no skills – e.g. fuel and water collection, burnishing of the surfaces –, hence they could have been carried out by most individuals within a community, including children and adolescents. Therefore, if we consider the entire cycle of plaster production, from raw material selection to the final application of the product, it appears evident that the organisation of labour activities necessarily involved many members of the community. No skilled woman or skilled man could have been responsible for the entire cycle of operations alone without the support and involvement of communal work. This assumption is even more appropriate for pre-industrial communities – such as the village-based communities of prehistoric Cyprus –, where non-specialised or semi-specialised labour was conducted in combination with other subsistence activities (Knapp 2013, 344-7).

It is often assumed by many ethnographic examples that the person who applies the plaster, generally a woman, is also in charge of surface decoration (cf. Boivin 2000; Dalton 2017, with references; Kramer 1983, 14-50). In prehistoric Cyprus there is evidence for the diffused use of red ochre for surface decoration (on this topic see Bombardieri et al., forthcoming). Residues of ochre nodules and ground stone tools with ochre staining were identified at many Neolithic, Chalcolithic and Bronze Age sites, e.g. Ayia Varvara-*Asprokremnos* (McCartney et al. 2008; Manning et al. 2010, 695-97; McCartney 2017; McCartney; Sorrentino 2019), Kissonerga-*Mosphilia* (Peltenburg et al. 1998a; 1998b), Soskiou *Laona* (Peltenburg et al. 2019, 261), Lemba *Lakkous* (Elliott 1985, 192) Kalavasos *Ayious* (Todd 1991, 7), Erimi *Pamboula* (Dikaios 1936, 54; Bolger 1988, 66), Marki-*Alonia* (Frankel, Webb 2006a, 241), Sotira-*Kaminoudhia* (Swiny 2003, 228; Rupp 2003, 464). Plastered wall surfaces with preserved red-ochre decoration are also attested at Neolithic Kalavassos-*Tenta* (Todd 1987, fig. 39; 1998, figs 41-42) and Khirokitia (Hadjisavvas 2007, 49), at Early Bronze Age Marki-*Alonia* (Frankel, Webb 2006a, 63-4) and Middle Bronze Age Erimi-*LtP* (Bombardieri et al. forthcoming). While ochre is part of the natural resources of Cyprus, overlying the sulphide ores of the Troodos range, not all of the sites mentioned are in close proximity to the ochre natural source. The procurement of this material at a distant source implies that a considerable amount of time was needed for its collection. If women were responsible for this task – as they possibly were – it means that they spent part of their day away from home and from other domestic tasks, which presumably were conducted by other women and/or men of the household or community. It is possible that members of a particular gender group more frequently performed certain aspects of building construction. However, it is important to underline that the assigned tasks complemented each other, and activities performed by men, women and by other members of the community were finalised at realising a common project, suggesting that every task was considered as having a similar relevance in the operational sequence of building construction, no matter who the actors were.

The increasing social complexity during the Prehistoric Bronze Age Cyprus fostered a re-organisation of social and economic roles within the communities on the island (Knapp 2013, 344-7). These social transformations involved also a progressive technological specialisation and a different arrangement of labour organisation (cf. Bombardieri 2013), possibly including a more distinct division of working tasks (Bolger 2003, 61). The construction of larger settlements with little or no evidence of building differentiation suggests that forms of cooperation prevailed during this period. This "communal spirit" (Bolger 2003, 193) did not exclude women from primary productive labour. However, progressive isolation of house compounds and increasing control of access and resources appeared in the earlier phases of Middle Bronze Age Cyprus, as identified at Marki-*Alonia* (Webb 2009). In this process of household enclosure, greater time commitments by females within the domestic environment likely emerged. As suggested by Webb (2002, 93-4; 2009), this increasing division of gender roles over the course of Prehistoric Bronze Age Cyprus is attested in the repeated portrayal of women in secondary food processing activities on Red Polished ware vessels, but also on the diffusion of figurine types with representations of women as parental figures (on this point, see Bolger 2003, 193). At a speculative level, it is possible to imply that in this progressive relegation of women and of women's activities to the household space, female members of Prehistoric Bronze Age Cypriot communities also acquired an increasing role in the operations of house construction and maintenance, thus possibly playing an important part in the process of implementation of building materials production, and in the increasing specialisation of constructional techniques.