The contribution of soil micromorphology in understanding the use of space in Area Pi at Malia (Crete)

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Abstract

Geoarchaeology uses sediments to define the relation between human, soil and environment by approaching, among other questions, the use of space in different earthen structures. During the excavation of Area Pi in Malia, Crete, different questions were raised concerning the use and function of the space in and around the Neopalatial building (ca. 1700-1450 BC). Geoarchaeological study, using soil micromorphology, was applied in three rooms (Rooms 19, 25 and 16) dated from Middle Minoan II to Late Minoan IA period in order to understand more thoroughly the activities of the Minoan inhabitants. The study allowed a correlation of archaeological and micromorphological data, to challenge hypotheses and propose interpretations on the use of space and spatial organization of occupation. The study revealed successive frequently used plaster floors in Room 19, exterior but roof protected space for the Space 25 and for Room 16 the study proposed the presence of a hole in the roof relating to a movable hearth.

Keywords: soil micromorphology, Crete, Minoan period, Malia, use of space

Introduction

The study of archaeological sediments in micro-scale can reveal activities and human behaviors that sometimes, are not evident through a "classical" archaeological approach. Geoarchaeology, using soil micromorphology, studies sediments in micro-scale in order to provide information on earthen construction techniques, the site formation processes and the use of space.

The term "Geoarchaeology" was first proposed by Butzer (1982) in his book *Archaeology as Human Ecology,* where he introduced Man as a geomorphic factor, equivalent to the natural ones. In this book he describes, in a theoretical way, the site formation processes. These processes have been the subject of several studies since the 1980s (i.e. Courty *et al.*, 1989; Gebhardt, 1990; Wattez, 1992; Gé *et al.*, 1993; Wattez and Courty, 1996; Cammas, 1994; 1999; Matthews, 2001; Karkanas, 2001; 2006; Wattez, 2009; Shillito *et al.*, 2011; Onfray, 2017; Kulick, 2019). The classification of geoarchaeology either as a discipline or as an interdisciplinary approach is still an ongoing debate (Davidson and Shackley, 1976; Rapp and Gifford, 1982; Fouache, 2010).

Sediments are considered as cultural artifacts that record human and natural processes (Schiffer, 1983). Geoarchaeology applied within a site aims to shed light on questions related to construction techniques of earthen structures like floors and wall, provide information on the use and function of a space (activity surfaces) and define the post-depositional processes that could affect earthen structures. In order to do that, geoarchaeology uses different methods. One of the most important is soil micromorphology and the study of thin sections applied in different archaeological and geographical contexts in order to characterize the *chaîne opératoire* of earthen construction techniques, from the collection of raw material to the setup technique (Cammas, 1994; Cammas, 2003; Cammas and Wattez, 2009; Wattez, 2009; Onfray, 2017), the site formation processes in both open-air site or caves (Matthews, 2001; Karkanas, 2001, 2006; Karkanas *et al.*, 2007; Karkanas and Stratouli, 2008; Karkanas and Efstratiou, 2009; Shillito and Matthews, 2013; Karkanas and Van de Moortel, 2014; Shahack- Gross *et al.*, 2014) but also define post-depositional processes that affect earthen material (Friesem *et al.*, 2014).

The archaeological site of Malia comprises one of the oldest Minoan palaces, surrounded by the Bronze Age town which has been partially excavated for a century (Poursat, 2010). The excavations were mostly carried out during the 19th century without involving neither geo- nor bioarchaeological methods. The archaeological project on Area Pi, one of the urban districts of Malia (conventionally named after the letters of Greek alphabet), is the first project that includes intra-site geoarchaeological approach using soil micromorphology, a method infrequently used on Cretan sites. Excavations of the Area Pi sought to explore a building of the Neopalatial period (Middle Minoan III-Late Minoan I, ca. 1700-1450 BC), a period which still remains obscure at Malia (Manning, 2014; Gomrée *et al.*, 2012).

Different constructions were discovered in Area Pi and initially interpreted according to plan and assemblages of artifacts and ecofacts. Primary deposits are not numerous, because of a (perhaps gradual) abandonment of the Area during Late Minoan IA (LM IA) period. The micromorphological study was undertaken in order to provide a more thorough sight of activities and of the spatial organization in the Area Pi. Earthen floors, abundantly used in the Area Pi, can record traces of human or animal activities. The nature of earthen floors allows the application of geoarchaeological approach using soil micromorphology, in order to question archaeological interpretations on the use of space and on spatial distribution of activities. The micromorphological analysis defines, through different indicators, the use of space in an earthen structure, provides information on different activities that occurred in the space and proposes interpretations concerning its function (Gé *et al*., 1993; Nicosia and Stoops, 2017). The study of samples, in micro-scale, from different rooms in Area Pi contributes to better define the organization and the density of activities and the use of space.

The Area Pi at Malia

The site of Malia is located on the northern coast of Crete in a context of terra rossa and calcareous formation, next to a swamp (fig.1) (Lespez *et al*., 2003). The Area Pi, where this study is concentrated, is located at the north-west of the Minoan palace. Archaeological excavations from 2005-2014 (under the aegis of the French School at Athens) revealed a complex of rooms, mainly interpreted as domestic areas and some open spaces (fig.2) (Pomadère, 2009; 2011; Gomrée *et al*., 2012; Alberti *et al*., 2019). The occupation of the Area spans across protopalatial and neopalatial periods, however, building Pi is mainly dated to the Middle Minoan III (MM III) and Late Minoan IA (LM IA) period (ca. 1700-1450 BC) (Manning, 2014; Gomrée *et al*., 2012).

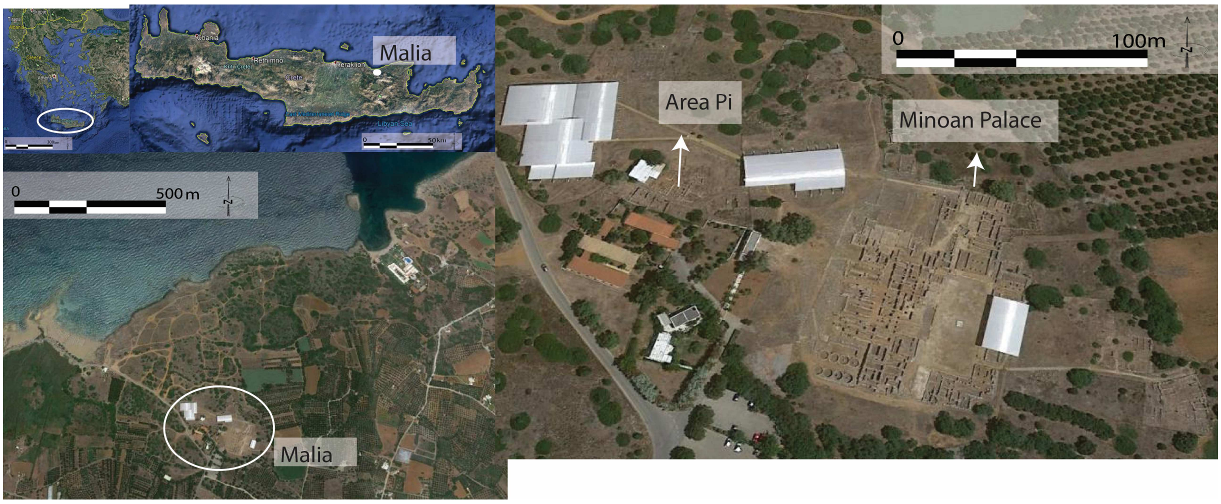

Figure 1: The location of Malia in Crete and the Area Pi within the site (©Google Earth).

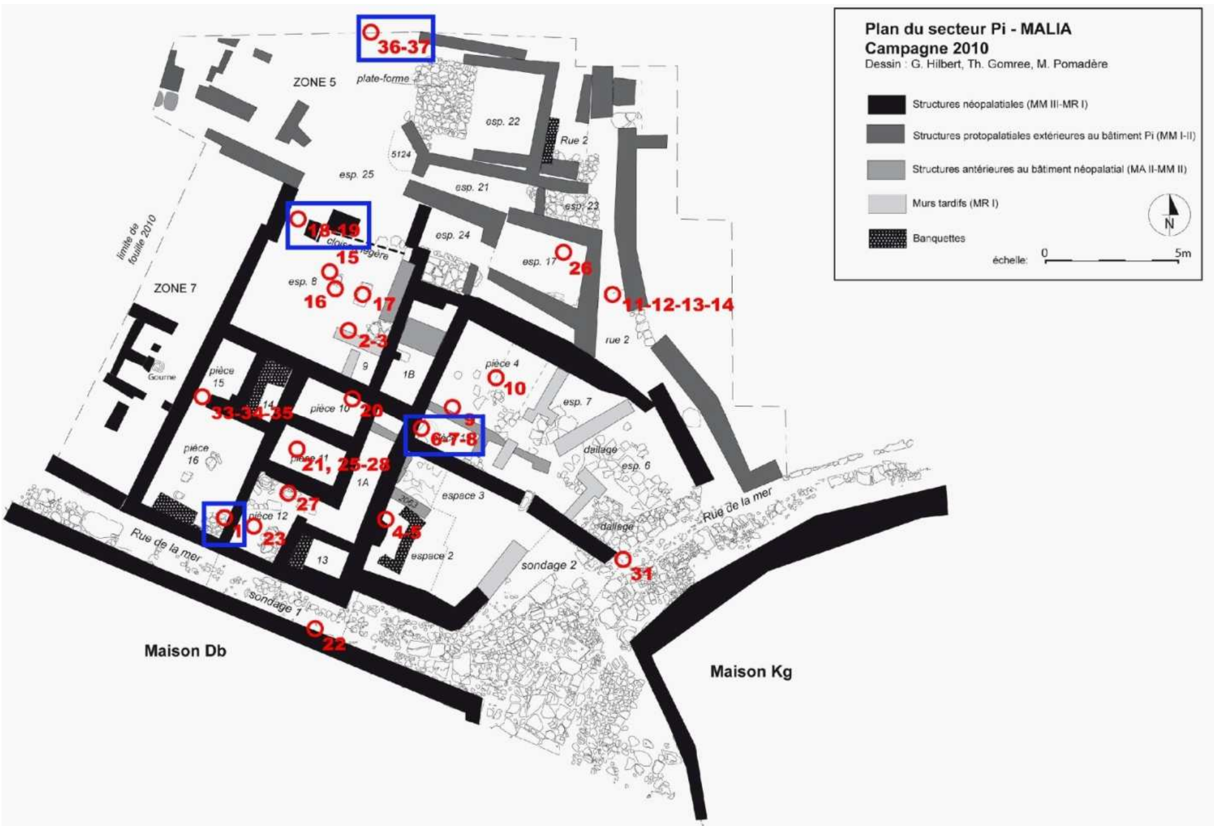

Figure 2: Plan of Area Pi showing the different excavated spaces. Red numbers and circles correspond to micromorphological samples and those in blue rectangle are used for the present study (Pomadère, 2009). Sample 1 comes from Room 16, samples 6, 7 and 8 are from Room 19,

samples 18 and 19 come from the southern part of Space 25 (in transition from Space 8 to 25) and sample 36 comes from the northern part of Space 25.

Materials and Methods

In order to characterize the use of space, we applied intra-site geoarchaeological approach which uses soil micromorphology as the main tool (Courty *et al.*, 1989; Cammas and Wattez, 2009). Samples were collected from floors of different rooms of Area Pi based on the questions raised during the excavations (fig. 2). Unfortunately, the person who was in charge for geoarchaeological study and sampling during the excavation (2008-2014), is not any more a member of the team and no document of sampling protocol or of samples' exact position is available. We only have data on the layers that have been sampled and the room they belong. Samples of undisturbed blocks were consolidated at the soil laboratory of the department of «Dynamique des Milieux et Organisation Spatiale» at Agroparistech in Paris and studied under a polarized microscope according to guidelines of Bullock *et al.* (1985) and Stoops (2003, 2010). The present study is based on samples from Room 19 dated to Middle Minoan III period and Room 16 of the Late Minoan IA. Space 25 was used from Middle Minoan II to Late Minoan IA.

The functional approach applied at Malia defined different indicators that can be used for identifying the nature and the use of space (Gé *et al.*, 1993; Wattez and Courty, 1996; Stordreur and Wattez, 1998; Wattez *et al.*, 1998; Wattez, 2009). Four indicators have been defined:

1. The inclusions of animal and plant origin (charcoals, bones, excrements, burnt bones and aggregates). These indicators are related to different activities that can occur in a room such as the presence of hearth or the preparation and consumption of food;

2. The microstructure of trampling effect. Microstructure of earthen material interacts differently in trampling pressure in wet or dry environmental conditions;

3. Pedo-features of hydric conditions in the floor. Pedo-features of superficial runoff or the presence of coatings related to the water circulation in the soil can be considered as indicators of hydric conditions.

4. Biological activity. Activity of soil fauna and flora can be developed simultaneously to the occupation or after the abandon. Biological activity developed in the sub-surface is considered

as contemporaneous to the occupation. Sometimes, horizontal channels and chambers of worm activity are deformed under trampling pressure. Post-depositional biological activity of soil fauna and flora destroys sediment organization in more than one micro-layer and it is characterized by thick and long channels or chambers. Interconnected chambers and vughs related to root activity are also identified in the samples, where, in some cases, residues of plant/roots tissues have been observed.

A combination of those indicators allowed the creation of 4 micro-facies based on the nature of activities in a space and the degree of frequency. Micro-facies are summarized in table 1 and they can shed light on the nature and the use of space in Area Pi. The interpretations proposed are based on proportional comparison between the Spaces/Rooms under study.

Micro- facies	***Micro-residues of plant and animal origin***	***Microstructure of trampling effect***	***Pedo-features of hydric conditions in the floor***	***Biological activity***
Frequent and clean interior surfaces	+	++	-	-
Irregularly frequent used and non-clean interior surfaces	++	+	++	++
Frequent used and maintained semi open-air surfaces	++	++/ +++	++	++
Irregularly frequent used and non-maintained semi open-air surfaces	+	++	++	+++

Table 1: Micro-facies of activity surfaces identified in Malia and they correspond to the use (frequently or irregularly used) and the maintenance (maintained/clear or not maintained) of surfaces and their position (interior or semi open-air surfaces). Indicators and their frequency (+++ high presence, - low presence) are defined after a correlation of data collected from the samples under study. This table of frequency concerns only Room 16, 19 and Space 25.

Results

Room 19- Middle Minoan IIIA

Room 19 is a small space situated in the middle of the building. Entire vases, in a primary destruction deposit, including a pithos, have been found in the room, but no floor could be clearly attributed to Middle Minoan IIIA (MM IIIA) period. Activities of MM IIIA period seems to take place on the remains of the MM II floor. Fragments of plaster floors found in the Room may belong to this previous occupation (MM II) period or to fallen plaster from the wall (Pomadère, 2009).

The lower part of the stratigraphy (SU5055 and SU5052) contains coarse elements mixed with human debris such as ceramic, ashes and bones (tab. 2) (fig.3A). This layer can be interpreted as a leveling floor followed by the setup of thinner and finer successive surfaces. Successive plastered surfaces are quite common in Malia and relate~~d~~ to a regular maintenance of the space (Shaw, 2009). Both leveling floor and occupation surfaces are mainly made of red non-birefringent striated clayey sediments. The surfaces (SU5043) are made of white carbonated silty sand sediments, interpreted as a plaster, that were colored by red wash on the top (fig.3B). The red paint wash (*badigeon* in French) was made of red clayey sediments mixed with large quantities of water. The horizontal distribution of clays shows that wash was applied by spreading it on the surface (Wattez 2009; Karkanas, 2019). The successive surfaces are thin (around 5 mm of thickness) with fine horizontal cracks that create a prismatic microstructure as a result of trampling activity (Gé et al 1993; Rentzel *et al.*, 2017; Karkanas 2019) (fig. 3C). Biological activity and micro-residues of human activity are very few on each surface (tab. 2).

Higher in the stratigraphy (see SU5024: filling of destruction deposit), some residual surface crusts in relation with heterogenic material and a high degree of biological activity confirm an abandonment level or a thick leveling deposit composed of fine material mixed with some pebbles in order to prepare the space for the next occupation dating from LM IA.

Discussion on the use of space in Room 19

The low quantity of micro-artifacts on surfaces suggests a clean space or activities with low production of debris. Moreover, no traces of sweeping or scratching (such as sorted elements or depression filled with heterogeneous material) have been observed in relation with surfaces

(Miller *et al*., 2010; Benerjea *et al.*, 2015). Evidence of sweeping activity might can be revealed by the micromorphological study of more samples from different place or the corners of the room where cleaning activity could not be regular, but at this stage of the research, no more samples are available for comparison. The presence of plant mat, according to present evidence, is not proposed because of the quasi-total absence of phytoliths from the samples (Wattez and Coury 1996; Karkanas and Efstratiou 2009; Shillito *et al.* 2011).

The combination of a clean space containing high degree of trampling suggests a frequently used and well-maintained space which refers to the frequently used and clean interior surfaces micro-facies. Based on available micromorphological evidence, it could be proposed that the space was not used for activities that left traces (hearth, domestic activities). Micromorphological interpretation corresponds well to the interpretation of archaeologist as a storage room, suggested by the presence of a pithos and of a dozen of other vases (one amphora, at least five jugs and several cups). It is a small space (ca. 2x1m) where activities were limited, but where people would have entered and walked around frequently (tab. 2).

The floor of the room 19 was made of sediments coming from geological settings in the vicinity of the site (terra rossa formation) (Lespez *et al*., 2003). Room 19 was plastered and painted with red color, perhaps during MM II when this type of plaster is well attested at Malia (Dandrau, 1999; Schmid and Treuil, 2017). However, it seems that the plastered floor of Room 19 was destroyed partially, probably before MM III. Plaster fragments, either from floor or from the wall, can be identified only by microscopic analysis but some larger ones were collected during excavation. Micromorphological study in Area Pi showed the use of red striated clay of low birefringence as a paint wash. According to previous analyses conducted at Malia, the red color results from the use of ochre (Dandrau, 1999, 30-31; Schmid and Treuil, 2017, 142). In Middle Minoan Koumasa and other sites such as Phaistos, Knossos, Ayia Triada and Kommos, the red color also comes from the use of iron oxides (hematite or goethite) (Boness *et al*., 2017).

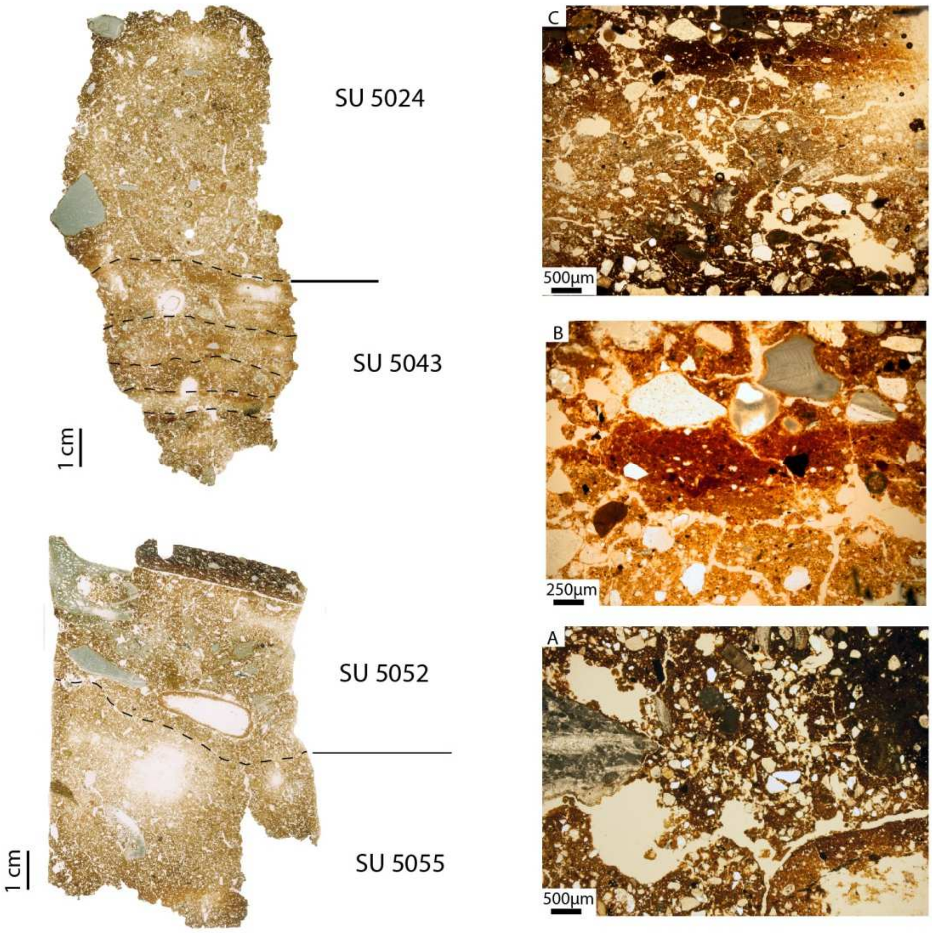

Figure 3: Scan of thin sections from Room 19. A: Coarse and heterogeneous elements partially accommodated that form the leveling floor (SU 5052 and SU 5055) on which surfaces are developed (PPL); B: Red colored wash applied on the top of plastered floor (SU 5043). The microstructure is massive. The matrix is impregnated of red oxides (PPL); C: Well-maintained surface made of white carbonated sediments interpreted as a plaster and covered by a red wash on the top. Fine cracks on the white part of the surface are created due to trampling pressure (SU 5043) (PPL).

Space 25- Middle Minoan II-LM IA

Continuing towards the north of Area Pi (fig. 2), Space 25 was interpreted, based on archaeological data, as an open-air space during the Neopalatial period (Pomadère, 2009, 2011) that could have been used as a court, garden or sheepfold. The passage (entrance) separating Space 8 and 25 (fig. 2) presents a succession of micro-layers (fig. 4A and 4B). The floor (SU 5099) is constructed and characterized by coalescent clumps limited by fine curve cracks and the distribution of sand grains is homogeneous. Both of elements show mixed and blended material before the setup phase (Cammas, 2003; Wattez, 2009). Fine horizontal cracks related to textural and structural crusts and fine cracks around the aggregates are the result of trampling (Gé *et al.*, 1993) (fig.5A). Some structural crusts point to a circulation surface and they are in relation with platy aggregates and to the horizontal distribution of inclusions such as sand grains (Rentzel *et al.*, 2017) (fig. 5C). Some channels of worm activity, simultaneous to the occupation, appear deformed under the trampling pressure (fig.5D). Human micro-residues such as micro-charcoals (0-2%), pottery sherds (2-5%), burnt aggregates (2-5%) and bones (0-2%) (tab. 2) of different sizes are present on crusts and related to the trampled surfaces (fig.5E). The micromorphological analysis does not reveal any excrement residues that could explain the use of space as a sheepfold (Matthews *et al.*, 1997; Shillito *et al.*, 2011; Shahack-Gross, 2017). Furthermore, none of the indicators of an open-air space such as rain drop effect or runoff marks are observed (Onfray, 2017). However, we noticed the presence of oxidize pedo-features (2-5%) and fine dusty clay coatings (2-5%, 50-100µm of thickness) in the voids, related to the leaching of fine sediments in very humid conditions (fig.5B).

Higher in the stratigraphy (SU 5059), environmental conditions seem to be drier while oxidize pedo-features (0-2%) and coatings are fewer (0-2%) and thinner than before (10-30µm). Trampling is more expressed in dryer conditions creating more intense cracks and structural and textural surface crusts are more common. Also, the porosity is open and the biological activity is more intense than in lower micro-layers. The variation of thickness and the abundance of clay coatings in the voids of different micro-layers suggest seasonal variations during the occupation of the Space 25 rather than post-depositional processes. Despite the seasonal environmental variations, no changes in the frequency of the use of space have been observed.

In the northern part of Space 25 (sample 36) (fig. 2, 4C), the sample was retrieved more than 5m north of building Pi. This area offers evidence of building activity only from the proto-palatial period while the neopalatial occupation is attested only by a layer of sherds (dump). The microstratigraphy was formed by the accumulation of trampled debris which created fine curve cracks and some textural and structural surface crusts on aggregates (fig.5F). However, trampling effects are less intense than in the southern part of the Space 25. Biological activity of worms and root (Babel 1975) is stronger than in the southern part destroying the microstructure. Chambers and channels of biological activity are deformed due to trampling pressure (fig.5G). However, post-depositional biological activity of soil fauna and flora is quite strong: wide channels pass through trampled surfaces. Dusty clay coatings are presented on this location as well. Vertical changes on the thickness of coatings suggest seasonal environmental variations (fig.5H; tab. 2). Micro-residues of human activities (charcoals 0-2%, burnt aggregates 0-2%, shell 0-2%, bones 0-2%) have been found in relation to the surfaces.

Discussion on the use of space in Space 25

Based on the micromorphological data, we were able to observe spatial variations within the occupation of Space 25 and to call into question the hypothesis of an entire open-air space. The absence of excrements, runoff and rain-drop features goes against this interpretation. The presence of biological activity of roots and worms (Babel, 1975; Kooistra and Pulleman, 2010) and dusty clay coatings would more likely suggest a semi- sheltered space in the Southern area during the Neopalatial phase (Pagliai and Stoops, 2010). More precisely, it could have been a space covered by perishable materials without walls. The southern part of Space 25 is characterized by frequent used and maintained semi open-air surfaces, corresponding to the area of the entrance into the house.

Concerning the northern part of Space 25, biological activity during the occupation of the Area is stronger than in the southern part, showing a less maintained space. Strong post-depositional activity is also observed. The presence of slightly fewer micro-debris and the weaker trampling activity could be connected to the larger distance to the core of activities. The northern part of Space 25 corresponds to irregularly used and less maintained semi open-air surfaces micro-facies (tab. 1). Despite the absence of some micromorphological indicators (Vissac, 2005), the hypothesis of a garden (Alberti *et al.*, 2019) should be investigated through other types of analyses such as organic carbon, image analyses and particle size distribution.

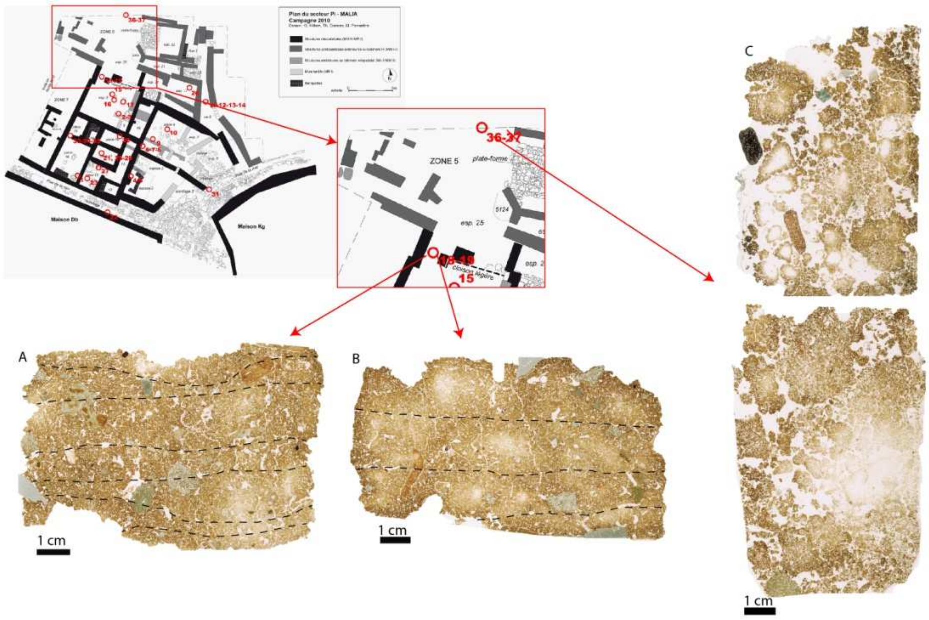

Figure 4: Position of samples from Space 25 and scan of thin sections. A and B: samples No 18 (SU 5093) and 19 (SU 5099) respectively showing the microstratigraphy and the succession of surfaces related to surfaces crusts, horizontal distribution of sand grains and trampling cracks. Micro-debris such as charcoals and bones are related to these surfaces. Biological activity is expressed by chambers and channels; C: sample 36 from the northern part of Space 25. Biological activity is more developed than in the southern part and destroyed important part of the sample.

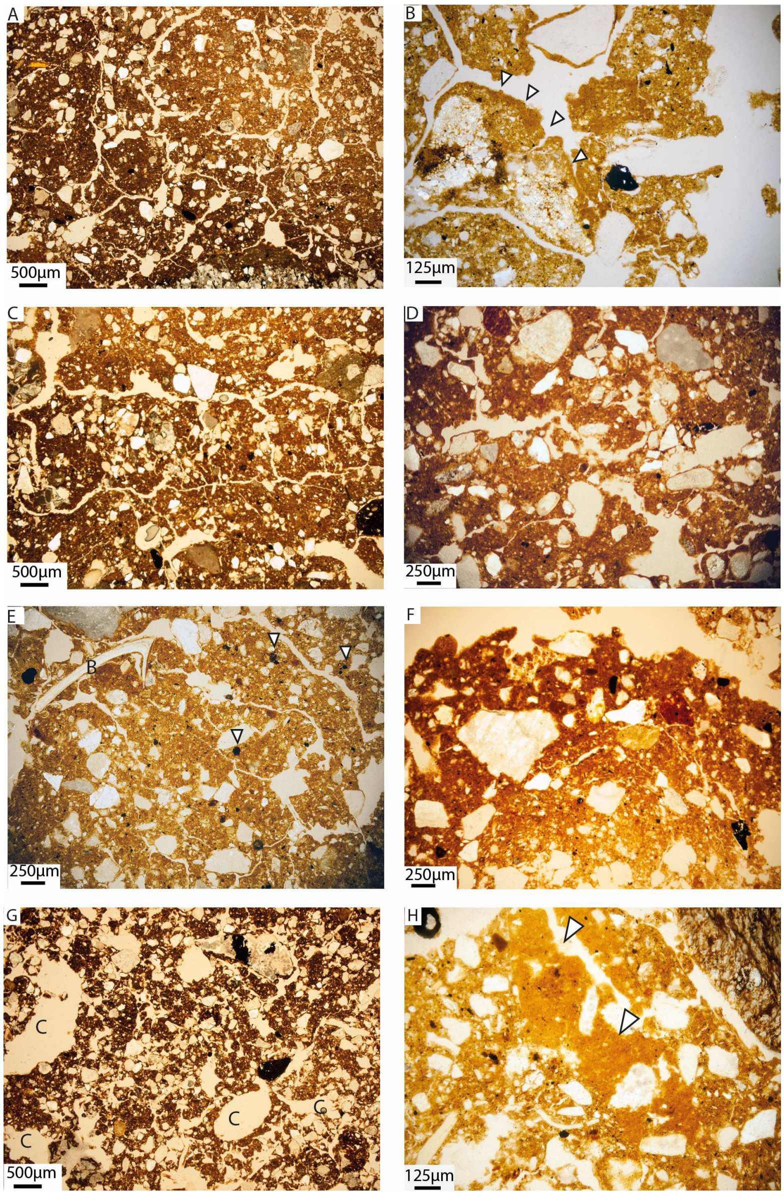

Figure 5: A: trampling cracks around aggregates (SU 5099) (PPL); B: Dusty clay coatings in pores (arrows) (SU 5099) (PPL); C: surface crust with trampling cracks (PPL); D: Biological activity channel (in the middle of the photo) destroyed due to trampling (SU 5099) (PPL); E: human micro-residues: bone (B) and micro-charcoals (arrows) (SU 5099) (PPL); F: surface crust and flatten aggregates containing sand grains (PPL); G: Chambers and channels of biological activity (C) (PPL); H: Thick dusty clay coatings in pore (arrows) (PPL).

Room 16- Late Minoan IA

Room 16 (4,25 x 3,10m) was identified as a space dedicated to various activities (food preparation, cutting stone tools, weaving etc.) based on the presence of a grindstone, cooking jar and various tools. They were concentrated on the south-west part of the Room whereas, a big part of the room was found empty. There is not any evidence of destruction and it is assumed that Room 16 was abandoned and perhaps left open (Pomadère, 2009). The sample comes from a place next to a small triangular stone pavement at the south-east corner. Several rooms of the Area Pi include a similar pavement in a corner, which suggests that they were devoted to specific needs. In one case, a tripod cooking pot was standing on the pavement, and in another one, a thick layer of ashes covered the floor abutting to the pavement. These elements point to the use of fire in relation with these pavements. The few fine cracks and the surface crust identified in the sample show a space irregularly used (SU 4091) (fig.6A). In some cases, channels and chambers of biological activity (mainly of roots and worms) are destroyed under the trampling pressure, although, the presence of trampling simultaneously with biological activity points to a poorly kept floor. In other words, despite the fact that the floor was used, it was neither regularly used nor well maintained. Burnt micro-residues such as charcoals (2-5%) and burnt aggregates (2-5%) (tab. 2) have been identified in thin sections and could be related to a hearth. The presence of dusty clay coatings shows that sediments underwent changes with regards to the humidity. This observation corresponds with the existence of a poorly protected space from the weather conditions (fig. 6B) (Onfray, 2017).

Discussion on the use of space in Room 16

Comparing archaeological data (especially the presence of a cooking jar in the room) and micromorphological observations, we assume that the pavement supported a movable hearth which could indicate the presence of a hole on the roof in order to evacuate the smoke. This chimney allowed humidity variations due to seasonal meteorological changes (humid weather, rain) to be recorded on the floor next to the hearth. At this stage of the research, clayey coatings are not considered as taphonomy effect due to the reason that their thickness varies from one micro-layer to the other but also, they are not observed in all collected samples from the Area Pi. The presence of humidity in the floor favors biological activity during the occupation, which also can affect the good preservation of the floor. Post-depositional biological activity is not as strong as it is in other rooms despite that the room was abandoned (Kooistra and Pulleman, 2010). It should be noted that manganese nodules and oxide features are presented in the sample (Lindbo *et al*., 2010). However, their abundance varies in micro-layers from 0-2% to 2-5%, where their high presence is related with thick clayey coatings. According to different micromorphological indicators and observations, such as biological activity synchronous to the occupation and irregular trampling activity, the place around the pavement seems to be irregularly frequent used and less maintained (tab. 1) than the rest of the room (cf. Onfray and Wattez, 2013; Mylona, 2018). The position of the sample in a corner, next to the pavement and the wall can explain the infrequent use of this location.

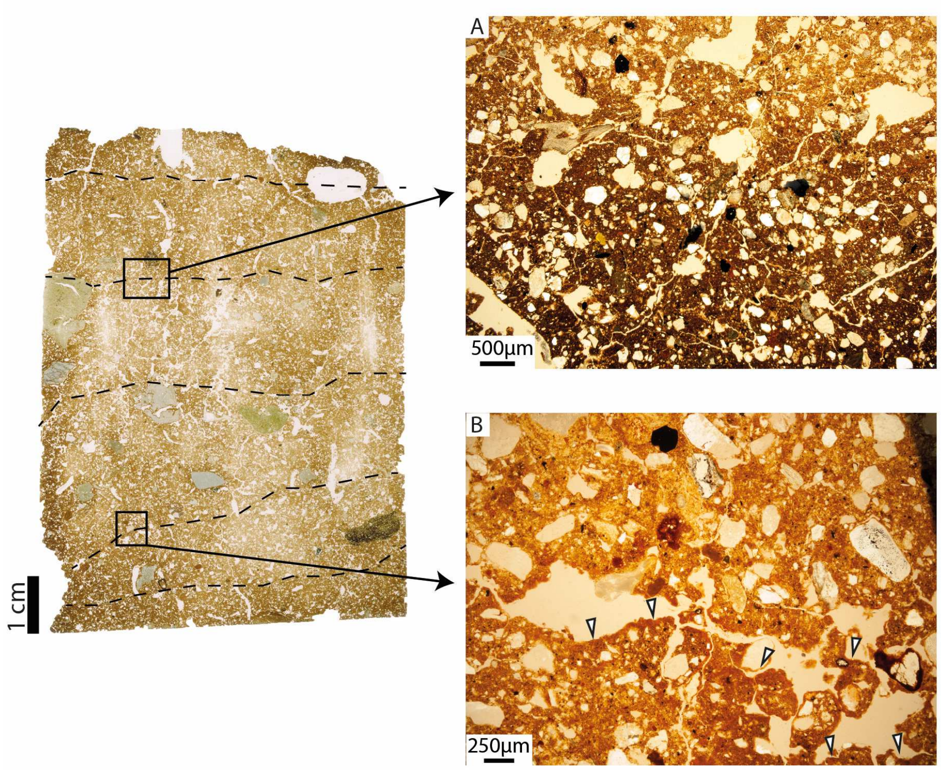

Figure 6: Scan of thin section showing the micro-layers that present characteristic of a surface (SU 4091). Rectangular show the position of photomicrographs. Photomicrographs of the sample from Room 16. A: fine cracks related to trampling pressure (PPL); B: Fine dusty clay coating in pores (arrows) (PPL).

Rooms	*Inclusions*		*Microstructure*	*Pedofeatures*
Room 19	*Preparation floor* Bones 0-2% Micro-charcoals 2-5% Ceramics 5-10% Ashes 2-5%	*Constructed floor* Bones 0-2% Micro-charcoals 0-2% Ceramics 0-2% Shells 0-2%	Massive to sub-angular. Micro-layers with spongy microstructure	Oxidize pedo-feature 2-5% Clayey coatings: very few (0-2%) max thickness: 10-20µm Red impregnation of the groundmass Biological activity very few (0-2%)
Space 25 south part	Bones 0-2% Micro-charcoals 0-2% Ceramics 2-5% Burnt elements 2-5%		Spongy to crumb microstructure	Oxidize pedo-feature 0-2% with concentrations of 2-5% Red impregnation of the groundmass Clayey coatings: 2-5% 100-150µm where they are thick and 20-40µm where they are thin Biological activity 2-5%
Space 25 north part	Bones 0-2% Micro-charcoals 0-2% Burnt elements 0-2% Shells 0-2% Ceramics 0-2%		Spongy to granular microstructure	Oxidize pedo-feature 0-2% to 2-5% in some layers Red impregnation of the groundmass Clayey coatings 0-2%, <30-50µm of thickness in the lower part and 100-150µm in the upper part Biological activity 10-20%
Room 16	Micro-charcoals (0-2%- in concentrations (2-5%) Shell (0-2%) Burnt aggregates (2-5%) Bones flakes (0-2%)		Spongy microstructure to sub-angular blocky, accommodated	Oxidize pedo-feature 0-2% to 2-5% Clayey coatings (2-5%) changes on their thickness (100-150µm) to 10-20µm where they are thin Chambers and channels of biological activity 0-2% to 2-5%

Table 2: the table summarizes micromorphological indicators (inclusions, microstructure, pedo-features), according to their frequency, used for the interpretation of Rooms in Area Pi.

Conclusions

The functional analysis in Area Pi at Malia revealed frequently used spaces that are characterized by laminar microstructures and trampling cracks. Micro-residues are generally poorly represented, a fact that shows maintained spaces and activity of low production of debris. The presence or absence of biological activity contemporaneous to the occupation constitutes an indicator on the degree of use and maintenance of spaces. For instance, in Space 25, where a sample comes from a marginal place, biological activity occurs simultaneously with evidence of occupation but surfaces are also affected by post-depositional biological activity. The presence of organic material related to human debris as well as soil humid conditions could favor soil fauna to develop under the surface. This could perhaps point to the existence of a garden. This interpretation, however, necessitates further investigation through different and more thorough analyses in order to be confirmed.

Moreover, the use of earthen material could serve as an evidence for environmental conditions. Earthen materials are able to record activity in their microstructure or in form of specific pedo-features, different changes in humidity levels and water. A correlation of pedo-features between micro-layers of the same sample can point to high or low moisture on the floor and thus it is considered as an environmental indicator of seasonal changes during the occupation instead of a post-depositional effect which is expected to affect micro-layers as a whole. Also, biological activity could be an indicator for exterior or interior spaces, although it is usually stronger in open areas. In the case of Malia, the indicators used for studying the environmental conditions such as porosity, biological activity, oxide features, dusty clay coatings as well as the absence of runoff and rain-drop features, show that some rooms did not have walls but were more likely covered by a light roof. Therefore, micromorphology constitutes a valuable approach, in combination with more traditional methods, to refine the interpretation of spaces, especially when the archaeological evidence is not straightforward.

The earthen material used in construction comes from the vicinity of the site, like most of architectural material of the site (Schmid and Treuil, 2017;129). The red color clayey sediments observed in Area Pi were collected from terra rossa formation. Moreover, they used high amount of sediments already on the site. For example, for the construction of the leveling floor in Room 19, sediments are, on the one hand, backfills containing older archaeological levels and debris of human activity (pottery sherds, charcoals, bones, ashes) and, on the other hand, the well- prepared surfaces are made of red clayey sediments of terra rossa formation.

Further micromorphological analyses in other Spaces and Rooms of the Area Pi would shed light on the use of space in different rooms and allow better defining micro-facies regarding the nature of activities and the density of the use of space. Micromorphology can also contribute to the characterization of the *chaîne opératoire* of earth building materials both of mudbricks and earthen floors from the same Area, as a *continuum* to the study conducted by Marta Lorenzon (Devolder and Lorenzon, 2019). Finally, it is desirable to compare our results with micromorphological data from other Minoan sites, like the neighboring site of Sissi (currently under study), for a more thorough understanding of the behavior of communities in Bronze Age Crete.

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