Urban Soil Micromorphology at Bronze Age Palaikastro, Crete: A Geoarchaeological Investigation of Site Formation Processes

by

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A thesis submitted in conformity with the requirements for the degree of Doctor of Philosophy
Graduate Department of Art
University of Toronto

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Abstract

Across the Mediterranean region, human-environment interactions constitute a major research focus, often concerned with issues of sustainability, both past and present. The Aegean region shares many environmental features and often direct cultural interactions with this larger, encompassing region. While broader Mediterranean research questions are also applicable at the local Aegean level, there are some surprising gaps in inquiry, particularly in studies of the Bronze Age Aegean civilizations. Although narratives of the emergence and collapse of civilizations—such as that of Minoan Crete—do invoke environmental factors, whether catastrophic events (e.g., Theran eruption, tsunami) or anthropogenic processes (e.g., soil erosion, overintensive agriculture), there are few multi-scalar investigations of how urban centres interacted with their environments. This dissertation aims to address the aforementioned shortcoming.

This project (part of the Palace and Landscape at Palaikastro Project) evaluates epistemological issues concerning the roles of geoarchaeological research and environmental science in archaeological research and applies an urban archaeological soil micromorphology approach to help understand the issues surrounding the episodes of occupation and disturbance at the Minoan
urban centre of Palaikastro, in East Crete. The study demonstrates that varied types of socio-
natural transformations are visible via different scales of data and analysis. Micromorphological
differences are observed between sediments related to urban abandonment and transformation
processes. This micro-scale evidence indicates the influence of coastal sediments on the site;
however, occupation of the urban structures appears to be related to the sustainability of the
surrounding slopes.

These findings illustrate that information garnered on ‘micro’ processes occurring in and
between buildings in the urban settlement completes the punctuated dataset in which one
typically encounters archaeological contexts produced by events (such as destructions and
abandonments). The micromorphological data connects discrete, small-scale processes that
occurred leading up to, and after, specific events and relates these processes to cycles of growth
and decay, construction and abandonment, in the context of larger-scale social and
environmental transformations.
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I was initially drawn to environmental research in the Mediterranean largely by my undergraduate research in the Cornell Tree Ring Laboratory, under the direction of Dr. Sturt Manning, which introduced me to archaeological and dendrochronological field work in the Mediterranean region. Through my MPhil research in soil micromorphology at the University of Cambridge, supervised by Dr. Charles French, my interest in developing methodologies for understanding human-environment interactions was further motivated. I would like to express my gratitude to these former mentors, as well as to Dr. Thomas Finan, Dr. Thomas Volman, Dr. Peter Kuniholm, Dr. Tomasz Wazny, Dr. Kathleen Sterling, Dr. Sebastien Lacombe, Dr. Margaret Conkey, and Dr. Patrice Bonnafoux, who have encouraged me to persevere in this research, and who have challenged me to become a better scholar and person.

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Chapter 1: Geoarchaeology in the study of Environments and Societies

**Premise:** This dissertation research employs geoarchaeological methodologies in a novel way in a Minoan urban area, resulting in archaeological interpretations that integrate geoscientific information. This chapter will discuss the epistemological issues concerning the role of geoarchaeology in archaeological research in general. In addition, this chapter will explore the relationship between geoarchaeology and environmental science—a relationship which has in broad terms been characterized by temporal, spatial, and scalar divisions.

1.1 Defining Geoarchaeology

“[G]eoarchaeology must be an essential component of inter-disciplinary landscape archaeology, it cannot by itself move from defining the 'resource-cape' and thence the 'task-cape' to understanding the human landscape in all its complexity.”

The interdisciplinary relationship between the geosciences and archaeology has been fundamentally important in understanding archaeological sites and patterns of human behaviour. However, the extent to which geological data have been incorporated in “final archaeological interpretations” has varied greatly. Often, geoarchaeological data have been included only in appendices to project reports, despite the essential support that they provide to the archaeological interpretations. Partly, this has been due to the incorporation of geological studies after the establishment of the initial archaeological project design, when geoarchaeology has been

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1 Barker and Bintliff 1999: 209.
3 Data integration is a problem not only for geoarchaeology, but for other disciplines of archaeological science. While Voutsaki and Valamoti (2013: 1) state that archaeological science in Greece has “moved beyond the stage of placing scientific results in an appendix at the end of an archaeological publication,” there is still an understandable tendency to ignore or fail to analyze critically other scientific data that may be useful to one’s research due to the overwhelming array of other scientific techniques.
employed to answer specific questions that studies of the archaeological materials cannot solve. Geological studies prepared and carried out in this manner have been termed ‘archaeological geology’—“geology that is pursued with an archaeological bias or application.”⁴ Suggested definitions of ‘geoarchaeology’ differ from ‘archaeological geology’ based on the extent to which geological information is incorporated into the initial project design and in subsequent archaeological interpretations. In contrast to ‘archaeological geology’ research, geoarchaeological research is generally integrated with archaeological questions from the outset of the project, and, consequently, geoarchaeological data is generally well incorporated in the project’s archaeological conclusions.⁵

According to Kevin Walsh, geoarchaeology may “usually [be] defined as the study of sedimentary processes, which affect the archaeological record, the study of past landforms and their associated geomorphic processes.”⁶ Others define geoarchaeology based on the methodologies that it employs; for example, Rapp and Hill define geoarchaeology as “any earth-science concept, technique, or knowledge base applicable to the study of artifacts and the processes involved in the creation of the archaeological record” and as “the application of laboratory methods used in geology and prehistory to archaeology.”⁷ Nevertheless, a comprehensive definition of geoarchaeological research is lacking; varied definitions of ‘geoarchaeology’ exist due to the diverse methodologies, both scientific and theoretical, that geoarchaeological research (and archaeological geology) employs, as well as to the varied applications of shared geological methodologies among geological and other environmental research.⁸

The overall purpose of geoarchaeology has been generally delineated as developing an understanding of the relationship between humans and the landscapes they inhabit.⁹ Generally

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⁴ Butzer 1982: 35. Often, applications of ‘archaeological geology’ are employed to simply test a working archaeological hypothesis.

⁵ Ibid.

⁶ Walsh 2004: 225.

⁷ Rapp and Hill 1998.


⁹ e.g., Renfrew 1976.
viewed in the broader context of landscape archaeology, geoarchaeology is important because it provides different information on past societies from that of other landscape archaeological research methods. Geoarchaeology reveals both the superficial and sub-surface landscapes that influenced past human activities, and the past human activities that may have impacted or transformed the landscape. While data obtained from landscape surface survey or large-scale site excavation assist in the elaboration of settlement and landscape histories, geoarchaeological data can additionally identify buried landscapes and land-use practices. However, the effectiveness of such geoarchaeological data in answering social, economic, and political questions ultimately depends on the fit and scale of the methodologies employed both to the archaeological questions asked and to the other methodological approaches used in interpretations.

The geological disciplines employed in geoarchaeology include “geomorphology (the study of landform origin and morphology), sedimentology (the study of the characteristics and formation of deposits), pedology (the study of soil formation and morphology), stratigraphy (the study of the sequence and correlation of sediments and soils), and geochronology (the study of time in a stratigraphic sequence).” Each of these disciplines and its respective methodologies provides geological information at different scales of resolution. The actual utility of geoarchaeological methodologies, their effectiveness in archaeological research, and the scope of information obtainable through such approaches, as well as their respective limitations, depends on how these geological methodologies are applied to archaeological questions; for example, taking metres-deep sediment cores along a transect of an alluvial plain may assist in

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10 Landscape archaeology may be defined as “the study of individual features including settlements seen as single components within the broader perspective of the patterning of human activity over a wide area” (Renfrew and Bahn 2000: 568-569).
11 Kulick 2013: 78.
12 The other methodological approaches that impact the effectiveness of geoarchaeological data include palaeoenvironmental research methodologies, as well as approaches to integrating environmental and excavation data, that can similarly provide information about past environmental changes, landscape use, and human activities (e.g., palynology, stable isotope analysis, dendrochronology, archaeobotany, malacology, petrology, biomolecular archaeology, spatial analysis, etc.).
13 Kulick 2013: 80-84.
14 Waters 1992: 3-4.
understanding potential anthropogenic impact due to agricultural practices on the plain but will not assist in understanding how different rooms were used in an archaeological site on this plain.

To answer broader archaeological questions of landscape transformation (under the wider indication of environmental change), geological research has focused on applications of geomorphology, which itself, as noted by Fouache et al. 2010, has been divided into (1) studies of ‘dynamic geomorphology’ and (2) geomorphology as applied to specific disciplines, including archaeology. While the former studies have concentrated on identifying the anthropogenic impact on natural physical processes, such as human impacts on deltas and catchment areas, the latter studies—as applied to archaeology—have attempted to identify the nuances and mutual influences of natural physical transformations and anthropogenically-driven landscape changes, and the social reasons influencing them.¹⁵ As will be discussed in subsequent sections, being able to differentiate anthropogenic from natural processes has been a popular, and challenging, goal of geoarchaeological research and one that requires the addition of multiple lines of environmental and archaeological evidence.¹⁶

1.2 Environmental Science in Archaeology

“Perhaps the greatest challenge for inter-disciplinary landscape archaeology in the coming years, however, will be to bridge the divide between the ecological approaches of the natural sciences to past landscapes, on the one hand, and the concerns of social archaeologists on the other with the interface between human actions and landscape...”¹⁷

According to Colin Renfrew¹⁸, the first objective of geoarchaeology is to provide spatial and temporal context to archaeological sites through stratigraphic and absolute dating

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¹⁶ Leveau et al. 1999.
¹⁷ Barker and Bintliff 1999: 209.
¹⁸ Renfrew 1976.
techniques; the second objective is to understand the processes of site formation; the third objective is to reconstruct the ancient landscape. In order to accomplish these objectives, geoarchaeology relies not only on methodologies of geological science but also on the amalgamation of other environmental science and archaeological methodologies. The geological methodologies used in geoarchaeological research may themselves be classified as part of the larger discipline of environmental science.

Since environmental science may be defined as the study of the relationship between organisms and their environment, ‘environmental science’ approaches are not strictly limited to the study of relationships between humans and their environments. Similarly, through geoarchaeology, geological sciences can be used to understand interactions between different natural forces and the impact of other organisms, such as earthworms, burrowing animals, and microorganisms, on archaeological sites. Such non-anthropogenic information is key in understanding the objectives that Renfrew set out.

Difficulties do arise, however, in using the geological sciences, or other environmental sciences, to answer archaeological questions because such methodologies are not necessarily designed to differentiate between environmentally- or anthropogenically-related effects or events. ‘Environmental science’ and ‘geological science’ approaches specific to archaeological applications (‘archaeological science’ and ‘geoarchaeological’ approaches) have not yet been fully developed due to the fact that the techniques and approaches were designed for multidisciplinary research in disciplines outside of archaeology.

Furthermore, applying scientific techniques to archaeology does not necessarily establish archaeology as a ‘science’ that may be applied to understanding the human past. Therefore, while the environmental and geological sciences certainly provide additional data, the value of these data is only useful if it

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19 Although Renfrew (1976) focuses on understanding ‘natural’ processes of site formation, Schiffer (1972) differentiates transformation processes as resulting from either ‘cultural’ (human) or natural processes; contemporary geoarchaeology is typically responsible for identifying both types of processes.

20 Renfrew 1976.

21 Although extensive ecological research has been carried out in the Mediterranean region (e.g., Grove and Rackham’s (2001) “The Nature of Mediterranean Europe: An Ecological History,” palaeoenvironmental records are difficult to establish beyond historical records, and the integration (and applicability) of palaeoenvironmental evidence has not yet been fully tested or examined.

22 Johnson 2010: 37.
can be used to develop our understanding of the past – to bridge the ‘gulf between past and present’.  

Due to environmental science researchers tailoring methodologies to answer discipline-related questions about environments, issues with the temporal, spatial, and scalar applicability of environmental science methodologies to archaeological questions arise. These issues of time, space, and scale are themselves common topics of archaeological debate due to the lack of scholarly agreement upon not only how to define temporal, spatial, and scalar boundaries in the archaeological record, but also on how to approach the tasks of interpreting temporal, spatial, and scalar constructs within varying theoretical and empirical frameworks. The issue of temporal resolution is most often the focus of environmental science applications in archaeological research, since scientific techniques are capable of providing a general temporal framework, or even suggest specific dates, for environmental or societal changes.  

It is through the use of proxy environmental science records, in conjunction with geoarchaeological studies of stratigraphic relationships, that geoarchaeological approaches can provide the most accurate information on spatial and temporal contexts at archaeological sites. Fundamentally, geoarchaeological research requires the application of environmental science methodologies and their respective analyses to be conducted by researchers in disciplines outside of archaeology (e.g., geology, pedology, micromorphology, palaeobotany, climatology, etc.). Such divisions within geoarchaeological research, whereby geologists may specialize in interpretations on regional scales, pedologists on more localized bedrock and soil parent material, and archaeologists on site-specific, micro-scale anthropogenic deposits, make it  

24 Here, the terms ‘temporal, spatial, and scalar constructs’ are used to refer to systems created by researchers to analyze temporal, spatial, or scalar data, whether qualitative or quantitative. A temporal construct could be particular ‘periods’ defined by specific architectural styles, a spatial construct could be site catchment zones defined by ceramic distributions identified in survey, and scalar constructs could be designations of towns versus cities defined by numbers of buildings. Different constructs, whether qualitative or quantitative, are valuable for answering different questions. Wagstaff (1987: 1) contrasts these constructs in geography and archaeology, stating that the two disciplines “are concerned with two dimensions of a single field” – geography is focused on spatial dimensions and archaeology with temporal dimensions.  
26 Hedges 2001: 3.  
difficult to merge applications of environmental science and archaeological theory to answer archaeological questions.\textsuperscript{28} The scientific techniques of geoarchaeology are such that environmentally-focused results may not be readily or easily applicable to archaeological research. For instance, challenges persist in the amalgamation of data from macro-scale, environmentally-focused geochronologies and geomorphologies with that from micro-scale archaeological records. When these data – independently obtained at different levels resolution (based both on varying temporal, spatial, and scalar constructs and on different disciplinary interests) and through different techniques – are combined, the results are not as effective in assisting in the understanding of ancient human-environment interactions in the landscape.\textsuperscript{29}

Ultimately, divisions of scale in geoarchaeology persist due to both the research questions asked and to the methodologies used. For example, the notion that studying archaeological records over a long time scale is the best method for understanding social history downplays the importance of evidence for short-term events.\textsuperscript{30} While subsumed within long-term environmental processes, short-term environmental events—due to their immediate impact on built and natural environments—typically can have far greater impact on social change than can longer-term transformations.\textsuperscript{31} Small-scale, short-term environmental events are often only made apparent through environmental science methodologies.\textsuperscript{32} Despite the acknowledgement that scientific disciplines can provide this finer temporal resolution of these environmental, and

\textsuperscript{28} Haggett et al. (1977) demonstrate how working at different scales creates problems of integration in geography. Haggett et al. (1977: 7) observe that many geographical projects aim “to identify a regional unit appropriate to the spatial analysis of the cultural landscape.” However, comparisons between regional units studied at different scales can result in analytical problems because comparable samples and “inferences about spatial patterns are scale dependent” (Haggett et al. 1977: 10). Haggett et al. (1977:10) explain that “[a]s we change the spatial resolution, say the relevant size of the collecting grid, so the results we obtain vary: findings at one level of analysis may be misleading at another.” This concept can also be applied to changing scales of geoarchaeological units studied.

\textsuperscript{29} Moody 2004: 247; Jusseret 2010: 676.

\textsuperscript{30} Fernand Braudel (1970) presented the idea of focusing on ‘the long term’ records. This concept—that long term changes (the longue durée) are more significant in understanding social and historical transitions—has been perpetuated by the Annales School. (Braudel also recognized the importance of middle-term processes and the short-term event.)

\textsuperscript{31} Horden and Purcell 2000: 301, 307.

\textsuperscript{32} For example, most environmental science dating techniques provide indications of specific events (within years or hundreds of years) through radiocarbon dating, dendrochronology, ESR, TL, OSL, Uranium-series dating, obsidian hydration dating, etc.
often artifactual, changes, archaeological research faces challenges in integrating or relating multiple timescales. This challenge stems from the tendency to divide periods artifactual – in Mediterranean archaeology periods are frequently divided into three separate phases: short-, medium-, and long-term. However, archaeological timescales created on the basis of artifactual phases may not effectively integrate multiple environmental (or socio-natural) changes within or between these phases.

1.3 A ‘Social’ Geoarchaeology?

“The full potential of cultural geoarchaeological approaches in Mediterranean archaeology has yet to be fulfilled. Such an approach comprises a more extensive interpretation of landscape processes and moves beyond the orthodox analyses of geomorphic cause and effect.”

Geoarchaeology, as an archaeological science, involves the application of environmental scientific techniques to study archaeological landscapes. Geoarchaeology may also be considered inherently social, in the sense that it is a methodology employed to attain answers to archaeological—and thus social and cultural—questions. However, in practice, not all geoarchaeological investigations have been successful in answering social questions; many investigations, such as the environmental science studies mentioned earlier, have focused on purely geological or environmental inquiries. Nevertheless, geoarchaeology can provide very useful social information that is sometimes inaccessible via other archaeological methods; this ability is due to the fact that geoarchaeology has the potential, as do other proxy methods, to merge (1) environmental science data and (2) notions of social theory. The societal information provided through geoarchaeological studies differs from that of other archaeological research

33 Bintliff’s (1991) Annales School approach is unable to integrate the separate temporal scales of the environmental and archaeological records, noting that humans generally only recognize and respond to short-term events.

34 The term “social geoarchaeology” comes from the concept presented in a paper by Simon Jusseret (2010), “Socializing geoarchaeology: Insights from Bourdieu’s theory of practice applied to Neolithic and Bronze Age Crete.” I thank Dr. Margaret Conkey and Dr. Lisa Maher for their insight on the ‘social’ nature of geoarchaeology.

35 Walsh 2004: 225.
methods in that geoarchaeology enables the identification of past land surfaces as well as human activities outside of normal excavation areas and at scales not visible via excavation. It reveals surfaces and activities that may have been concealed by naturally- or anthropogenically-caused erosion and aggradation. However, establishing connections between scientific geological data and transformations in the archaeological record (i.e. ensuring that the geoarchaeological findings answer social questions) requires that the scientific data match the scales of the scientific methodology applied, as well as the scale of the social- or landscape-related question(s) being asked.

Geoarchaeological research has been applied across a variety of scales, but the research generally has been considered as fitting into two scales of archaeological questions: (1) macro-scale and (2) micro-scale.\textsuperscript{36} The factors determining the scale include the geographic research interests of the projects, i.e., whether the interests are local or regional, and the methodologies employed when studying specific sites or single site features (micro-scale) versus several sites or activities across much larger, geographically-defined, regions (macro-scale).\textsuperscript{37} On the macro-scale, geoarchaeology has been able to define global- or regional-scale interactions of environmental processes at the ‘gross level’, such as identifying widespread droughts and episodes of erosion.\textsuperscript{38} On the micro-scale, it has been able to differentiate between, and elucidate upon, small-scale environmentally- and anthropogenically-induced on-site activities, such as anthropogenic alteration (trampling/foot-traffic, sweeping, etc.) and post-depositional transformation of deposits (such as localized flooding events).\textsuperscript{39} However, both macro- and micro-scale approaches encounter challenges when attempts are made to use the primarily scientific, geoarchaeological data to answer specific archaeological questions.

Issues in answering archaeological questions arise when researchers have attempted to extend interpretations of localized areas, generally based on micro-scale geoarchaeological approaches, to answer broader archaeological questions; these localized interpretations have

\textsuperscript{36} Kulick 2013: 78; Goldberg and Macphail 2006: 2; Stein and Linse 1993.

\textsuperscript{37} Kulick 2013: 78; Goldberg and Macphail 2006: 9.

\textsuperscript{38} e.g., Goldberg and Bar-Yosef 1990.

\textsuperscript{39} e.g., Betancourt and Hope Simpson 1992; Matthews et al. 1997; Butzer 1980: 133; Butzer 2005.
served as poor models for larger phenomena.\textsuperscript{40} In contrast, studies focused on broader areas—which generally apply macro-scale geoarchaeological approaches—have focused on answering pedological, geomorphological, and environmental questions but, in doing so, have failed to sufficiently address social questions.\textsuperscript{41} Difficulties have been particularly apparent in trying to break down geological time frames established by macro-scale research into temporal frameworks applicable to archaeological timescales.

Disparities in the scales of the questions being asked and the areas being studied via geoarchaeology have inhibited the full effectiveness of geoarchaeological methodologies in broaching social questions. This is due to the fact that geoarchaeology typically has been employed as an ‘environmental science’ tool of landscape archaeology in determining whether climatic or human factors resulted in landscape change or stability. The focus on this cause-and-effect relationship in geoarchaeological questions has inhibited the application of the data it produces from answering the social questions that archaeologists pose. In order to understand the reasons for these difficulties in using geoarchaeology to answer social questions, one needs to consider the questions specifically being asked of geoarchaeology, as well as the ways in which scientific geoarchaeological data and archaeological data are amalgamated, in conjunction with other environmental science data.

1.4 Geoarchaeological and Archaeological Questions

“There will always be a need for imagination and evaluation of a range of probabilities in interpreting the past...”\textsuperscript{42}

While geoarchaeology plays an integral part in answering social, economic, and political questions, it has not, until recently, regularly been used to answer the broader questions of when, why, and how changes in human society, activities, landscapes, or the environment occurred.\textsuperscript{43}

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\textsuperscript{40} e.g., French and Whitelaw 1999: 161.
\footnotesize
\textsuperscript{41} e.g., Morris 2002.
\footnotesize
\textsuperscript{42} Brothwell and Pollard 2001: xviii.
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\end{flushleft}
The reason that such questions have not been answered by geoarchaeological methodologies has not been technological restrictions. Rather, researchers have been hesitant to make the interpretive assumptions required to compensate for incongruities in the scales of ‘social’ questions asked and geoarchaeological methods applied.44

Due to the ability of geoarchaeology to aid in both understanding the processes of site formation and in reconstructing the ancient landscape,45 archaeological projects with primary queries revolving around questions of agriculture and production have more closely involved geoarchaeology in the preliminary stages of research and hypothesis-formation. This is due to the fact that agriculture and production are two main anthropogenic processes by which sites can experience significant physical transformation, e.g., through the management of terraces and field systems. Notably, the scales of the geoarchaeological methodologies used in these projects have generally corresponded to the large scale of the landscapes in question. These studies have typically involved techniques such as systematic coring, which normally require the expertise of a geologist. Thus, geologists have typically provided the information on large-scale landscape transformation, while archaeologists have been faced with connecting the evidence from the settlement to these greater processes of transformation.

In contrast, in tightly site-centred archaeological projects—i.e., projects with queries encompassing use of space within rooms, episodes of habitation and abandonment, etc.—questions have been generally addressed by archaeological techniques and proxy methods producing immediate data; these projects typically have used geoarchaeological techniques only as a secondary approach, usually to test already-established hypotheses.46 In these projects, geologists have not been commonly called in to deal with the archaeological sites—only

44 For example, new GIS and DEM technologies integrated into geomatic approaches that are capable of producing detailed landscape reconstructions are limited by the disparities in the ‘choice of the geographic scale of study’ between archaeologists and geographers/earth science specialists, including geologists (Ghilardi and Desrulles 2009: 6).

45 Renfrew 1976.

46 The geoarchaeological techniques employed to answer site-centred (room- or area-specific) questions typically involve micro-scale methodologies, such as soil micromorphology and soil thin-section analysis. The areas to be analyzed via micro-scale techniques are chosen based on queries raised through macro-scale evidence (evidence that is visible to excavators). The information that is subsequently provided by soil micromorphology is usually only available during the post-excavation phase, after preliminary hypotheses have been formulated. This will be further discussed in Chapter 4.
geoarchaeologists, who are normally trained first in archaeology, have been typically involved. Notably, projects focusing on use of space within rooms or episodes of occupation are often still interested in extending their discussions to consider the effects on the site of agriculture or production or transformations of the larger landscape. Significantly, geoarchaeologists’ backgrounds in geology are usually largely confined to the Holocene; geoarchaeologists typically do not deal with earlier geological periods, despite the need to consider these earlier periods in order to understand the longer-term processes of transformation that may have affected the sites.47 Using site-based geoarchaeological data alone to understand large-scale landscape transformations and questions of agriculture and production is indeed problematic.

Published evidence for land management practices across regions demonstrates that a geoarchaeological approach restricted to single sites will not produce answers to broader social questions of regionally-spread land-use trends. However, such answers can be reached by reevaluating the temporal and spatial aspects of geoarchaeological approaches. If researchers strive to understand how specific environmental characteristics and land-use practices differed across regional contexts, it will be necessary to delineate the appropriate temporal and spatial scales required to investigate these human-landscape interactions. Additionally, it will be essential to consider the social evidence that the geoarchaeological studies convey (e.g.: are land-use changes and practices indicative of typical or atypical behaviours?).

Significantly, the main questions—often triggered by contemporary interests in human demand and sustainability—that archaeologists analyzing the Mediterranean ancient landscape have asked have revolved around matters of agriculture and production.48 For example, in the Late Minoan period in central and eastern Crete, the potential extents and limitations of ‘palace’ production have framed approaches in landscape research. Specifically, if the potentially large population of Knossos might have been supported by ‘palace’ storage supplies,49 how would the

47 This will be discussed further in Chapter 4.
48 In contemporary land-use research, “human-induced change to the landscape is [considered] a function of demand” (Gribb and Czerniak 2016: 3). Thus, in the ‘hierarchical’ view of land-use systems (Gribb and Czerniak 2016: 2), it is apt for agriculture and production to have been viewed as the processes of largest impact on the ancient landscape. Increasing human demand on the ancient landscape may have also manifested itself in the form of road systems and urban centres, but these physical changes were generally not of sufficient size to have greatly impacted ancient landscapes or coastlines. In contrast, inputs from ancient agricultural systems may have been great enough to have contributed to landscape transformations, including the formation of deltas, etc.
49 Warren 2004: 164-166.
agricultural intensification necessary to generate such food surpluses\textsuperscript{50} have impacted the landscape?\textsuperscript{51} In answering such archaeological questions through landscape and environmental research, it is necessary to reevaluate the temporal and spatial aspects of the archaeological record that landscape research approaches explicitly expose. Was agricultural over-intensification ever a concern in Minoan Crete and, if so, was it a concern in some areas but not others? In exposing possible evidence for agricultural practices, or over-intensification, are communal or individual practices being studied? How should studies of human-environment interaction in Minoan Crete be conducted and presented in order for the data to be used to answer such interregionally-involved questions? Evaluating evidence for agriculture and production at spatially and temporally delimited sites alone will not produce answers to the question of whether the landscape was over-exploited on a regional basis.

In addition to addressing key archaeological issues related to agriculture and production, Renfrew notes (see section 1.2) the second objective of geoarchaeology is to understand the processes of site formation,\textsuperscript{52} and the third objective is to reconstruct the ancient landscape. While reconstructions of the ancient landscape have often been integrally tied to the establishment of ancient agriculture and production practices, developing an understanding of site formation—how the archaeological site came to be in its current (often fully or partially buried) condition—has often been omitted by archaeological projects. Knowing how the site was physically transformed and came to be buried has not always been considered important to understanding how the inhabitants functioned or why the site was abandoned. However, comprehending the processes of site formation may be integral to understanding agricultural and production practices, among other social behaviours, as well as overall landscape transformation. Do on-site phenomena relate to off-site practices? Were certain areas of a site abandoned temporarily or for specific periods due to issues with management of off-site erosion (whether

\textsuperscript{50} Tomkins and Schoep 2010: 72; Haggis 1999.

\textsuperscript{51} Whitelaw (2011) estimates the likely extent of Knossian territory based on growing population size by period. Significantly, Gribb and Czerniak (2016: 1) state, “The expanding spatial dimensions of the urban-metropolitan area can be three times larger than the actual population increase.” While modern ‘land consumption rates’ frequently take the form of ‘urban sprawl’, this was not necessarily the case for Bronze Age Cretan urban centres. Additionally, human demand for land may increase faster than population increases necessitate (Gribb and Czerniak 2016: 2).

\textsuperscript{52} Although Renfrew (1976) focuses on understanding ‘natural’ processes of site formation, Schiffer (1972) differentiates transformation processes as resulting from either ‘cultural’ (human) or natural processes; contemporary geoarchaeology is typically responsible for identifying both types of processes.
natural or human-induced)? How might the physical impact of landscape transformation have psychologically affected the population or have impacted subsequent land-use practices or re-use of specific settlement areas? These questions make apparent the need to view on-site smaller-scale social and natural transformations alongside off-site, broader environmental processes. Understanding and reconstructing these processes requires the amalgamation of multiple techniques in geoarchaeology, as well as other archaeological and proxy studies.

As will be discussed below, developing an accurate picture of the environmental factors affecting the landscape and of the development of agricultural/economic practices of Minoan Crete is a challenging endeavor, especially when modern/contemporary environmental evidence suggests that variations occurred on both local and regional scales. In general, landscape research on Crete has involved two main approaches: (1) surveys of exposed-landscape features and (2) geoarchaeological research. In both of these approaches, with few exceptions, the research focus has been on either micro-scale (site-based) or macro-scale (regionally-based) questions, and further subdivided between chronological or environmental questions. Chronological questions have been mainly focused on the dating of archaeological materials or geological deposits, which is problematic in itself. Environmental questions generally have not been well-delineated temporally, and research results have not been broadly applicable on regional bases. Consequently, differentiations between anthropogenic and naturally-caused landscape transformations have not been readily apparent in the current, stand-alone applications of the aforementioned geoarchaeological and scientific approaches.

53 e.g., Betancourt and Hope Simpson 1992.

54 Dating site deposits (to determine site burial and episodes of abandonment) often involves dating colluvial deposits, which is challenging since these deposits contain reworked material. Proxy methods used to date these deposits (e.g., radiocarbon dating, artifact typology, OSL, etc.) may not produce accurate results. For example, in OSL dating, one cannot determine whether the grains being dated are fully bleached during deposition. OSL could thus produce a wide range of dates and/or much older dates than those actually associated with site burial episodes. Normally, non-colluvial deposits or features associated with in situ archaeology layers are those that may be considered accurate.
1.5 Approaches and Integration of Geoarchaeology, Environmental Science, and Multiple Hypotheses

“Archaeological deposits are often complex and illustrative of an intricate interplay between geogenic and anthropogenic inputs and formation processes.”

How can geoarchaeology, in conjunction with other techniques of ‘environmental science’, help us understand social behaviours and answer theoretical archaeological questions? Since geoarchaeology incorporates environmental science approaches, geoarchaeology can provide quantifiable data, which we may then consider alongside other environmental science datasets that are applied to similar archaeological questions. By analyzing multiple types of environmental science datasets, through the systematic study of predictable and quantifiable data, it may be possible to separate environmental ‘interference’ and establish social connections. How can environmental and landscape studies provide information on the ‘culture’ of ancient societies? Geoarchaeology can assist in establishing whether a certain behaviour was repetitive, and thus related to the result of engrained cultural choices, or was more ad hoc and contingent. Despite the long-standing archaeological practice of differentiating ‘natural’ from ‘social’ site formation processes, differentiating the ways in which, or degrees to which, these processes are represented in different environments, with varying scales of visibility, has been less frequently deliberated. Some social or cultural processes may only be apparent in particular environments, when analyzed at specific scales; in environments and at scales in which these processes are typically less visible, the processes may be considered ‘unique’ or natural in nature, simply due to their sporadic occurrence.

Using tools of contemporary social science, landscape studies and urban studies can aid in understanding these ‘natural’ and ‘cultural’ processes, and thus to answer social questions about ancient societies. For example, Gribb and Czerniak divide the contemporary ‘global landscape’ into four types of environment: the natural environment (areas with minimal visible

55 Goldberg and Aldeias 2015: 1.
56 Schiffer 1975.
57 For example, Ober (2015) applies contemporary social and political theories to the study of the ancient Greek world.
human impact), the urban environment (areas with the maximum amount of visible human impact), the rural environment (areas with low-intensity human impact, normally used for agriculture or forestry), and the transitional environment (‘the space between the other three levels of development’).\(^5^8\) In the ancient landscape, determining which areas were used as natural, rural, and transitional environments is confounded by post-depositional processes, but attempting to understand how groups based in urban centres used these areas is integral to, and would benefit, our understanding of ‘natural’ and ‘cultural’ site-formation processes at the urban centres.

Considering the visibility of these four types of global environments in the ancient context—based on human-made landscape features—broaches the underlying issue of both chronologically- and environmentally-focused geoarchaeological research: matters of scale. Exposed-surface features—whether buildings or landforms—have generally served as the major determining factors in formulating geoarchaeological research agendas. However, the landscape data that most merit analysis are not necessarily visible on the exposed surface. The challenge for geoarchaeologists is to be able to work across both spatial and temporal contexts and scales, which extend beyond the immediate urban environment and may be discrete (in the form of rural or transitional environments), to produce meaningful interpretations of human-environment interactions.\(^5^9\) The main distinguishing factors determining the applicability of individual landscape and geoarchaeological research investigations to particular archaeological research questions lie in the temporal and spatial scales established in their approaches.

Moreover, in archaeological projects the integration of various forms of environmental science data can be challenging, since varying types and scales of environmental science data can frequently provide conflicting results. Rather than attempting to develop social conclusions directly from geoarchaeological evidence (or another single form of proxy data), it is more fitting to consider geoarchaeological information as just one form of data to be used in conjunction with the rest of the archaeological and proxy environmental record. In addition, environmental and archaeological data may be viewed as ‘multi-stranded’ since there is frequently more than one alternative explanation to account for geoarchaeological observations. Rather than viewing

\(^{5^8}\) Gribb and Czerniak 2016: 4-5.

\(^{5^9}\) e.g., Butzer 1982: 9, 13, 123.
geoarchaeological and environmental proxy data as links on a chain, one could alternatively view the multiple strands of evidence as a series of cables in which no one line of argument is sufficient on its own to secure an explanatory or interpretive conclusion, but the cumulative, multi-dimensional information, data, and arguments can be ‘rationally decisive’. Some strands may have more limited flexibility, but in contrast to a chain relationship, the argument would not collapse based on any one weak link. Thus, in answering archaeological questions, the amount of confidence in, or strength of, the particular multiple strands of geoarchaeological and environmental evidence would first need to be determined.

Additionally, in multi-stranded reconstructions, different archaeological questions would result in the various evidential datasets having fluctuating ‘levels of confidence’. The goal of multi-stranded reconstruction would be to take comparable types of evidence and fit them together in a ‘cable’ or ‘web’ construction in order to form a composite of archaeological information that builds a picture of past human societies and environments. Common issues persist in developing consistent and accurate pictures of the past environment, landscape, and human activity due to the generally restrictive nature of the data acquired—the missing strands in the cable. Simply applying new scientific or archaeological data, which do not fit the unique ‘gaps’, is not helpful in reconstructing this picture. However, by “weighing in” on the amount of confidence that one can have in each particular strand of data, a solid picture may be developed from the composite of archaeological data. As different forms of geoarchaeological and environmental data are utilized as reconstruction starting points—depending on the particular questions asked—slightly different reconstructions of the past society and environment will be developed. However, if at the beginning of any investigation or analysis, plans are made to integrate the starting data with other forms of environmental and archaeological data, an overall

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60 This reasoning follows the notion set forth by Peircean theory: “the formation of hypotheses [is] a distinct and important phase of a method that include[s] a repetitive, cyclical process of induction and induction,” also termed abduction (Moxley 2003: 151). In applying the Peircean model to geoarchaeology, the conjectures/hypotheses/abductions may be viewed as the perceived past events, which are reflected in changes in the geoarchaeological record (the consequences), and, in turn, affect the existing facts/perceptions/new inductions—the perception of the cultural landscape transformations. The role of deduction in (geo)archaeology is quite limited.

61 Wylie 2002.

62 Moxley 2003: 152.

63 Wylie 2002.
reconstruction and archaeological answer may be accomplished. It is the differences in initial research design and approach that will enable multiple archaeological interpretations to reconstruct and elaborate upon multiple hypotheses to create better overall images of past societies and environments.

Geoarchaeology performed on the micro-scale level is integral to evaluating landscape transformation and site formation processes, both ‘natural’ and cultural’. When incorporated from the start of archaeological projects, micro-scale geoarchaeological investigations are able to produce, with a great level of confidence, data that can fill ‘gaps’ in archaeological data. Micro-scale geoarchaeology may be considered “geoarchaeological research that attempts to answer questions about a limited spatial feature or temporal frame, such as site-based research.” It is these micro-scale geoarchaeological methods (microstratigraphic and micromorphological studies) that may be applied to ‘urban’ archaeological sites—archaeological sites labeled as ancient urban centres—and may produce the fine-resolution contextual information desired. When used in conjunction with other forms of archaeological and environmental science data, microstratigraphy and micromorphology can serve as the ‘missing strands’ that can increase the level of confidence in interpretations of sediments and their associated archaeological objects.

64 Kulick 2013: 84.
65 Goldberg and Berna 2010: 57.
Premise: As discussed in Chapter 1, geoarchaeology has been implemented, for diverse reasons and via various approaches, in the study of environments and societies. Similarly varied are the ideas that have been formulated about ancient Mediterranean urban and natural environments, and humans’ behaviours in relation to these environments, due to the lack of existing hard evidence for human-environment interactions. In order to better understand the development of these human-environment interactions, research has often focused on island and coastal environments, where the last Aegean hunter-gatherers mostly concentrated. Although development certainly extended beyond the coastlines with the neolithicization of the Mediterranean (7000-5500 BC), a “proliferation of islanders” (Neolithic settlements) in the Aegean and central Mediterranean followed. Within these sub-regions, Bronze Age societies serve as a focal point for research as they provide some of the earliest evidence for cross-Mediterranean trade and interaction during the ensuing rise of the first superpowers: Egypt and Mesopotamia. Archaeological and proxy methods have revealed much about these Bronze Age settlements and environments; however, much work is still needed, particularly in the realm of geoarchaeology, to understand how the island peoples interacted with one another and sustained their urban and natural environments. Geoarchaeology can identify socio-natural processes between occupational and transitional phases that may be used to recognize both broader interactions and networks as well as the local variances that may exist in material culture and local environment.

67 Broodbank 2013: 181.
68 Ibid.: 184.
69 Ibid.: 212-214.
70 Ibid.: 269.
This chapter will discuss the broader environmental processes that need to be considered in research on Mediterranean archaeological sites and how micro-scale geoarchaeological research (specifically soil micromorphology) has been used to identify and separate natural and social processes, and can be used to better understand continuity and change in human behaviours at Minoan ‘urban’ sites. It will first consider how processes of continuity and change have been studied on different scales (spatial and temporal) in Mediterranean geoarchaeology and in studies of Bronze Age Crete. Second, this chapter will discuss how soil micromorphology has been applied to examine these processes at different types of urban sites, not strictly Bronze Age Cretan sites—where such studies have largely been limited. Finally, this chapter will consider how soil micromorphology at urban archaeological sites may specifically help to identify various socio-natural processes of transformation that are not visible on the macro-scale, as well as to address interpretative challenges may be addressed.

2.1 Scale and Process in Mediterranean Geoarchaeology

“A social interpretation of sedimentation is just as necessary as a social view of the artifacts contained in the soil.”

Butzer states that the Mediterranean “problem” in understanding past urban and natural environments is that model-based reconstruction approaches fail to address larger-scale, cyclical changes in environments, and rather are focused on forming linear models that can determine correlations and causations between natural and cultural transformations. Hill also notes this issue of differing theoretical scenarios applied to subjects at different temporal scales: “we should not expect to see evidence of people adapting to environmental conditions at the scale of individual or even group management”; rather, researchers need to focus on


73 Noted by Grove and Rackham 2001.
centennial/millennial-scales. While understanding these bigger questions of resilience over the *longue durée* is certainly important for formulating an understanding of larger urban and environmental questions of Mediterranean sites, these larger-scale models are not so helpful for trying to understand individual behaviours or micro-scale or meso-scale changes. Small changes (which may be considered trivial relative to massive transformative processes) could very well be indicative of society- or landscape-wide transformations.

This scalar consideration is an important one because, although one can attempt to articulate general social and environmental processes based on macro characteristics of anthropogenic and environmental systems, one needs to look at the micro features (both natural and anthropogenic) to understand the local agents of these processes and to see how humans fit in with these natural processes. Neither Butzer nor Hill addresses the question of how to resolve this “scalar-disjunction” to move from individual events, to seasonal/annual, to decadal, to the *longue durée*.

While Butzer notes that many of the “better” projects are those involving “small-scale but intensive collaboration”, many of these projects, even those involving micro-scale archaeological methods, still fail to address the gaps in knowledge that constitute the Mediterranean “problem.” Observations made at the micro-scale are often compared to those made at the macro-scale; perhaps this scalar problem would be resolved by the introduction of meso-scale observations. One is not even necessarily going to understand all of the variables influencing archaeological outcomes, even with multidisciplinary processes, but micro-scale approaches, such as soil micromorphology, may get us closer to identifying trends in socio-natural processes at site or regional levels; these trends, beyond the local variables that may exist in material culture and local environment, may relate to macro-scale processes.

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74 Hill 2004: 126.
75 After Bintliff 1991.
76 Knappett et al. 2011.
77 Similar to the C- and N-transformations as proposed by Schiffer 1975.
79 Butzer 2005: 1774.
80 contra Butzer 2005: 1798.
There have been many geoarchaeological and landscape studies that have been conducted to study longer-term, macro-scale processes in the Mediterranean. However, these studies often lack the detail necessary for understanding short-term processes. For example, Devillers’ detailed mapping of landforms in Cypriot flood plains, integrating some micromorphological analysis, identified alluvial terraces and determined possible relations to human activity on Cyprus from 4000 BP.\(^{81}\) However, the results were inconclusive in the Bronze Age, likely because of issues with variations in microclimates.\(^{82}\) Moody compared analyses of deep-sea cores and palynological cores from around Crete to make general climatic observations for Bronze Age Crete.\(^{83}\) However, only three sites supplied this climatic information and, while noting certain events (e.g., aridity) that would have most affected eastern Crete and the Mesara,\(^{84}\) other local conditions, topographies, and social-political aspects were not incorporated—factors that need to be considered to understand the actual local processes and observed (versus perceived) changes.\(^{85}\) In another study of broader Aegean climatic trends, Finné et al. propose on a general scale three main climatic periods in the eastern Mediterranean for the past 6000 years, but the data and dating (± 200 years) are very poor for the Aegean region.\(^{86}\)

In terms of smaller-scale studies, for the Bronze Age sites in the Mediterranean region, settlement or ‘urban’ sites are at the centre of most research efforts to understand human behaviours, which fall between these micro- and macro-processes. Human behaviours are generally witnessed at smaller-scale levels, including that of the neighbourhood\(^{87}\)—which may be considered meso-scale level.\(^{88}\) While Bronze Age Mediterranean archaeologists have been

\(^{81}\) Devillers 2003.

\(^{82}\) Contra Devillers 2003.

\(^{83}\) Moody 2009.

\(^{84}\) Ibid.

\(^{85}\) Contra Moody 2009.

\(^{86}\) Finné et al. 2011.

\(^{87}\) Smith and Novic 2012: 1.

\(^{88}\) In this dissertation, meso-scale is used to refer to an entity larger than the level of an individual person or family unit, or an individual room or structure, and below that of an entire society (e.g., Bronze Age Cretan).
asking questions revolving around how and why the people behaved as they did throughout the occupation(s) of the sites, the resolution of analyses of micro-scale behaviours has not yet matched that of the analyses conducted at the tell sites in Western Asia nor the urban sites in Northern Europe.\textsuperscript{89} Conclusions about social behaviours of a site’s population cannot be based on events in a single household or on overall settlement or landscape transformations; however, these behaviours may have significantly impacted the social fabric of the settlement or landscape. In order to evaluate human behaviours at this meso-scale level, one could turn to the spatial relationships in urban centres—the neighbourhoods of practice—which certainly vary across time.\textsuperscript{90} These relationships have frequently been studied via artifactual and architectural evidence in studies of Bronze Age Cretan societies.\textsuperscript{91} However, certain networks of (social) relationships may not be comprehensible in architectural and artifactual evidence. Understanding human behaviours and these relationships beyond the level of the single room/structure and between the major occupational (or “cultural”) periods may be possible if microstratigraphic analyses can recover missing micro-scale processes and discern meso-scale and neighbourhood-level information.

Often in investigating these archaeological processes, researchers tend to focus on the same ‘triggers’ to explain social change: climate fluctuations, sudden shifts in human-environment interactions, or shifts in human societies.\textsuperscript{92} In these cases, ‘trigger’ events (i.e. short-term processes), such as single environmental events or single occupation sequences, are the focus of micromorphological sampling and analysis. Such sampling strategies focused on finding single ‘triggers’ have their limitations: first, one must determine how to selectively sample in order to go about finding whether these ‘trigger’ factors exist in the stratigraphic

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\textsuperscript{89} Reasons for these resolution issues are discussed in Sections 2.2 and 2.3.

\textsuperscript{90} Smith 2010.

\textsuperscript{91} e.g., Renfrew 1972; Manning 1994; Laffineur and Niemeier 1995; Driessen and Macdonald 1997; Knappett and Schoep 2000; Letesson 2014. Spatial relationships in urban centres based on artifactual and architectural evidence will be discussed in Section 2.2.

\textsuperscript{92} Bar-Yosef and Belfer-Cohen 2002.
record; second, this information on short-term processes must be considered alongside unknown factors: regional data; local environmental shifts; correlating dates of cultural materials; testing correlations between larger systems and vegetation. Most interpretations of the micromorphological data obtained from ‘trigger’-focused studies are left to retrospective comparisons to answer the behavioural questions. Nevertheless, studies of these short-term processes are valuable in determining how small variations (short-term changes) in urban or landscape maintenance varied across different parts of the site and across occupation and transitional periods; in turn, this micro-scale information can inform researchers not only about what sort of social practices and investment went into these sites, and thus about meso-scale processes within the settlement (and all of its various phases), but about human-environment interactions as well, such as the socio-natural transformations that may have occurred after the Theran eruption.

2.1.1 Macro-scale processes: environmental systems

Broader macro-scale environmental processes do unite every archaeological site in the Mediterranean region, yet each site also possesses unique, local patterns. While researchers of Mediterranean environments have largely established that major landscape changes have occurred in the Mediterranean region throughout the Quaternary period, historical records, climatological analysis, and modern fieldwork demonstrate the high degree of variability and unpredictability of regional, as well as local, environmental trends that characterize, and affect settlements in, the Mediterranean region – trends that include unstable environmental conditions (including severe droughts, wet periods, temperature fluctuations, and natural resource transformation) in this climatically sensitive region. In fact, Horden and Purcell

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95 e.g., Horden and Purcell 2000; Wainwright and Thornes 2004. This notion of the importance of identifying the unique spatial and temporal context in understanding a particular environment relates to the particularist idea of Kroeber (1948) who stated the need to consider both temporal and spatial aspects of culture areas in order to understand why different cultures might adapt or react differently to environmental scenarios.

96 Fouche 2003.
stress the importance of microecologies (and microclimates) as the basis for establishing site histories in the Mediterranean. What did the Bronze Age environment of Palaikastro, and other sites, actually look like, and what processes created and have actively affected this landscape? How might this environmental setting have affected the geoarchaeological/micromorphological records of urban sites?

Research on the characteristics of recent Mediterranean environments and climatic patterns is valuable in understanding how past cultures may have successfully or unsuccessfully responded to similar climatic conditions; however, the unpredictability of influential environmental events occurring in the Mediterranean region makes reconstructions of the environment and landscape understandably challenging for researchers of both past and present conditions. Untangling these physical landscape and climatic events from human-induced changes in urban settings is necessary, however, to distill the social behaviours impacting urban transformations.

In terms of climate, the Mediterranean region lies in a transitional zone between competing influences of both tropical and mid-latitude climatic forces, and thus is sensitive to larger-scale climatic factors. Jennifer Moody uses this large-scale data to illustrate that the eastern Mediterranean must be considered in the context of Mediterranean-wide processes and, subsequently, that the entire Mediterranean must be considered in the context of global weather systems (e.g., North Atlantic Oscillation (NAO), El Niño–Southern Oscillation (ENSO)). However, problems in understanding how the Mediterranean-wide processes apply to particular ecological and cultural systems become quickly apparent when considering across scales the effects of the NAO and ENSO. For example, on Crete, the effects of these systems vary locally; the eastern and western ends of Crete experience their own, independent, microclimates.

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97 Horden and Purcell 2000: Chapter 4. An entire Chapter (4) is dedicated to microecologies and discussion of how environmental patterns, like precipitation, and microclimates vary drastically among Mediterranean regions (also 2000: 152).
98 For example, the impact of short-term climatic events on modern erosional processes is being analyzed through geomorphological studies (Maas and Macklin 2002; Macklin et al. 2010).
100 Moody 2005.
Thus, palaeoenvironmental data indicating that conditions changed significantly in the Mediterranean in the second half of the Late Bronze Age (LBA) (1400-1100 BC), with a possible widespread drought, might be complicated by conflicting evidence for flooding events in western and north-central Crete if strong NAO patterns were in effect. Actual multi-scalar research on the Aegean landscape by Moody demonstrates that, while the present Mediterranean climate may roughly be described as a xeric climate, in which the typical annual weather cycle consists of a moist and cool winter season and a dry and warm summer season, climatic events are reflected in dramatically different manners within specific locales on the same island.

Rather than looking at macro-scale environmental processes, which it may or may not be possible to correlate with social systems at the site-level, one may approach both of these systems together at the micro-scale. Furthermore, micro-scale studies enable consideration of both social and natural systems features simultaneously, providing a more nuanced view of the resiliency and reactivity of Bronze Age societies with respect to both environmental and anthropogenic change—viewing these processes as a combined socio-natural system.

### 2.1.2 Micro-scale processes: socio-natural systems

As noted above, using broader environmental data in order to understand more localized social systems presents scalar problems. Yet, broad environmental information, however generalizing, may be able to establish some meaningful correlations with site-specific social-natural systems, if considered through appropriate models. Wainwright and Thornes assess three levels of features (not specifying natural or social) that can influence social systems: local

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102 Moody 2005: 462. The North Atlantic Oscillation (NAO) is generated by pressure differentials in the North Atlantic and determines the velocity of westerly winds and storms, which can affect the Mediterranean region. Research has demonstrated that the NAO has a great influence on Mediterranean winter precipitation; a positive NAO generally leads to drier Mediterranean winter conditions (Mariotti 2011: 2). The El Niño–Southern Oscillation (ENSO) originates as atypical variations in winds and sea surface temperatures in the tropical eastern Pacific Ocean. Research has shown that there is an association between ENSO and precipitation in the Mediterranean region (e.g., Shaman and Tziperman 2011: 124; Ropelewski and Halpert 1987; Dai and Wigley 2000).

103 Rackham and Moody 1996: 35
features, pan-Mediterranean features, and features outside of the Mediterranean Basin. They suggest conceptualizing these features as “a hierarchy of mechanisms of change, some driven internally, some externally, and operative on a range of spatial and temporal scales.” Additionally, they suggest that human actions only impact the former two levels (local features, pan-Mediterranean features), while natural processes only impact the last level (features outside of the Mediterranean Basin). Thus, in order to establish a meaningful correlation between broader environmental processes and a social system, a hierarchy of mechanisms would need to be reassembled for each socio-natural system under study since the weight (degree of influence) of social and natural features among each of these systems would likely vary.

Establishing the social and natural features of each system, however, requires that these features be considered on a finer scale than that of the pan-Mediterranean, or even regional scale. Social features, such as agricultural practices (terracing, plowing, etc.), pastoralism (animal husbandry, fire regimes, etc.), and building construction, do not exist in isolation but are integrated with features of their surrounding natural systems. Through micro-scale analyses of archaeological sites, archaeologists can view both of these systems together, as socio-natural systems, rather than polarizing social and natural systems, and, in doing so, can assist in establishing the significance of broader social and environmental processes on specific socio-natural systems.

Connections between broader environmental processes and social and natural systems in the Bronze Age Mediterranean have been noted with regard to the development of technologies, such as terracing, that enabled societies to cope with larger landscape changes primarily affecting soil stability and fertility. Wainwright and Thornes label the evidence of land-use practices from this period onwards as an “exploitation of the Mediterranean landscapes” and as “a continual struggle to grow crops on an often inhospitable soil that is impoverished of water and

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104 Wainwright and Thornes 2004: 12.
105 Ibid.: 12.
106 Ibid.: 12.
Using the term ‘exploitation’ gives human land-use an unnecessarily negative connotation, insinuating a lack of understanding of how to manage a resilient landscape (ecosystem), which, as seen in Minoan water-management systems, for example, was not the case.

Evaluating these social and natural features on smaller scales, however, suggests that the actual environmental situation may not have been necessarily as dire throughout the Mediterranean region as Wainwright and Thornes suggest; viewing social and natural systems on these smaller scales demonstrates that they are fundamentally tied and may have been more about finding balances between local land-use practices and land self-rejuvenation. Considering whether “exploitation” even occurred requires an understanding that social and natural systems are codependent, rather than joint socio-natural systems. When focusing on micro-scale studies of socio-natural systems, it is important to recognize that local sites (and their socio-natural systems) are interconnected, and these individual sites and site networks are also tied to broader socio-natural processes.

Identifying the broader impacts on, and of, socio-natural systems has been challenging even in current studies because most studies, despite advances in recent research technologies, focus on differentiating (rather than viewing as codependent) “natural ecosystems and anthropogenically altered ecosystems”. This focus on separating social and natural systems, in order to understand them, is an increasingly complex task when attempted on the macro-scale level: “…the entire Mediterranean basin, including maquis (stunted forest), garrigue (low brush)

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109 The use of the term “exploitation” insinuates a relationship in which only one-side (the society) benefits, to the detriment of the other side (the environment).
110 e.g., Pseira: Betancourt 2012.
111 Wainwright and Thornes 2004.
112 van der Leeuw and Redman (2002: 601) recognize that environmental crisis itself is based on perception of inability to adapt to changing environmental conditions.
113 van der Leeuw and Redman (2002) discuss the history of the how these systems have been considered as separate entities, as well as the value of bridging studies of social and natural systems, in socio-natural studies.
114 LaFreniere 2007: 18.
and steppe (grasslands), is essentially [seen as] a human artifact produced over thousands of years of selective hunting and gathering, herding, burning, and farming."\textsuperscript{115}

Contemporary researchers have frequently turned to the Mediterranean islands as an approach to separate these social and natural variables by more closely analyzing the resiliency of early socio-natural systems; there has been a more restrictive input of variables in island environments, which have made the studies of these variables more manageable.\textsuperscript{116} Islands also serve as a valuable avenue through which to study socio-natural systems since, as noted by Papayannis and Sorotou, islands have “places and features of cultural significance [that] definitely persist as powerful expressions of the way that the Mediterranean islanders perceived, shaped and interacted with their topography and resources."\textsuperscript{117}

However, developing an accurate understanding of island socio-natural processes requires consideration of what island environments actually entail. More commonly than on the continent, the landscapes of the Mediterranean islands have been perceived (since the 16\textsuperscript{th} and 17\textsuperscript{th} centuries AD) as ‘Ruined Landscapes’—landscapes that have deteriorated in their resource production capacities and aesthetics due to human-caused deforestation, overgrazing, and general mismanagement of the land and resources. However, recent historical research and environmental data have discredited this Mediterranean narrative of ‘Ruined Landscapes’.\textsuperscript{118} New studies have suggested that island environments were codependent with social systems, and that humans actually contributed to the maintenance of landscape diversity, despite the generally semi-arid conditions on the islands.\textsuperscript{119}

Islands, as a field of study (i.e. island studies), developed largely in the 1970s with the notion of islands as laboratories closed to external influences,\textsuperscript{120} making attempts at studying the social systems of islands useful for case studies of inductive modeling. However, also in the

\textsuperscript{115} LaFreniere 2007: 18.
\textsuperscript{116} Vogiatzakis et al. 2008: xiii.
\textsuperscript{117} Papayannis and Sorotou 2008: 83.
\textsuperscript{118} Horden and Purcell 2000: 298-241 (Mediterranean catastrophes); e.g., Pseira—Betancourt 2012.
\textsuperscript{119} Grove and Rackham 2001.
\textsuperscript{120} Evans 1973.
1970s, the concept developed of islands as constructs that were not purely geographical, but could be social as well. This idea that islands could be culturally open systems was furthered by Cyprian Broodbank’s reevaluation of islands that differentiated between analytical islands (geographically or physically defined) and perceived islands (experientially defined), proposing insularity as a cultural construct. Paul Rainbird also acknowledges the importance of connections, rather than isolating practices, in island systems. While these ways of thinking could possibly assist in establishing models of ancient perceptions of the environment, and while considering insularity as a cultural construct could assist in defining features of social systems, identifying perceptions and constructs based on experiences, which may or may not leave physical evidence, would be challenging. Ina Berg notes that, despite new concepts in islands research, there is still a tendency for all Mediterranean island surveys and studies to end at the coastline; “island archaeology” has not truly been realized. Since island systems do not exist in a state of “edenic equilibrium” but rather have experienced “dynamic histories,” whether or not they are influenced by human actions, determining internal and external variables affecting island socio-natural systems is challenging.

In order to better understand island cultural systems, Broodbank, mainly focusing on anthropogenic influences on these systems, suggests perceiving the external contacts of island systems as a “sliding scale,” shifting back and forth between “complete independence” from and “complete integration” with the rest of the world. Although raising the significant point that individuals or groups within a large society could have different positions on the scale at any

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122 Broodbank 2000: 16; 20. Papayannis and Sorotou (2008: 84) and Dawson (2013: 262) support Broodbank’s notion that distinct geographic boundaries should not limit an understanding of the extent of island cultural systems.
123 Rainbird 2007.
125 Berg 2010.
127 Ibid.: 11.
128 Ibid.: 8.
time,\textsuperscript{129} his proposal does not reflect on how to differentiate individuals or groups operating on completely different scales, with varying degrees of isolation and connection between their perceptions and actions. Rather, identifying in island socio-natural systems actual physical evidence of human actions across different temporal frameworks will be necessary when considering external anthropogenic influences on these systems; in other words, multiple “sliding scales” will be necessary. Possibly, studying these systems on the micro-scale level will elucidate these meso-scale behaviours and processes.

2.2 Scale and Process in Bronze Age Crete

“[E]ach polity [and process] needs to be studied individually in order to observe this variability and to explain it.”\textsuperscript{130}

As a Mediterranean island, Crete has historically been studied according to the aforementioned wider narratives on island systems, whether along the narrative of a ‘Ruined Landscape’, or the sociopolitical narratives of an island-wide, Knossian-focused culture. However, with its many microecologies and nuanced local cultures, Crete does not actually behave like an island system; rather, its environmental and cultural diversity is comparable to that of the Mediterranean region as a whole. Crete should, therefore, be studied on the basis of its microecologies and local cultures, such as those of Bronze Age East Crete, or even subregions within East Crete, in order to understand its local societies and to build a picture of continuity and change of Crete’s wider meso-scale environmental processes and sociopolitical narratives.

Thinking about processes of continuity and change in ancient societies is nothing new.\textsuperscript{131} Identifying these processes in human behaviours requires information from various types of material cultural, settlement, and landscape practices. Early research, starting over a century ago, on Cretan Bronze Age palatial centres and urban sites did not produce the resolution of data,

\textsuperscript{129} Ibid.
\textsuperscript{130} Nakassis et al. 2010: 247.
\textsuperscript{131} e.g., Goldberg and Macphail 2006: 237; Renfrew 1972; Manning 1994; Laffineur and Niemeier 1995; Driessen and Macdonald 1997; Knappett and Schoep 2000.
particularly palaeoenvironmental data, necessary to understand human-environment interactions; broad generalizations were made about past environmental and climatic conditions. More recently, archaeologically-aimed intensive surveys have contributed significantly to the contextualization of the Minoan palatial centres and settlements through the investigation of some of the centres’ surrounding towns and hinterlands, with the potential to understand the corresponding micro-environmental contexts (Figure 3.6). Additionally, the regional and local environments of Crete and the overarching Aegean region have been studied through landscape, climatological, and geological research. In many of these studies, the integration of innovative environmental and proxy data has improved the conceptualization of these processes of continuity and change at both the material cultural and site-levels.\textsuperscript{132}

However, despite this integration of environmental and proxy data, evaluations of stratigraphic contexts, as they relate to continuity and change, are still based on artifact and architectural typologies, with few exceptions.\textsuperscript{133} While artifact (predominantly ceramic) and architectural typologies have been comprehensively examined and refined, and have provided valuable information in period-to-period comparisons, the traditional\textsuperscript{134} Mediterranean archaeological approach of assigning activity- and period-designations to contexts based on these artifact and architectural typologies generates gaps in studying transitional phases that occur between these strictly artifactually-defined activities or periods.

New approaches to understanding processes of continuity and change have been considered in Minoan archaeology.\textsuperscript{135} These periods of continuity and changes have been studied at two general scales: (1) regional issues of competing power centres\textsuperscript{136} and (2) single-
site studies, based on material-cultural typologies. Often, information from the site-scale supplies the evidence for continuity or change at the regional scale (in a bottom-up approach\textsuperscript{137}); thus, site-level information on continuity and change has been essential to understanding both local and regional behaviours.

Within particular periods, however, the continuous nature of change may not be apparent as we only base these understandings on archaeological snapshots of phase destructions (e.g., in the Protopalatial period we see a snapshot of MM IB, a snapshot of MM IIA, a snapshot of MM IIB, etc.). This creates gaps in our understanding of the continuous nature of transformations within periods. Therefore, with these gaps, a bottom-up approach to understanding broader behavioural trends in Bronze Age Cretan societies may similarly be missing information on more gradual transformations, which may be unique to particular sites. How can human behaviour within these periods (in-between these materially-defined snapshots) be observed and consistently identified? How does one identify gradual change versus transitional phases of construction, destruction (human-induced or natural), abandonment, construction, and re-construction?

2.2.1 Architecturally- and Artfactually-defined Phases

Analyzing urbanism on Bronze Age Crete has been a popular avenue through which investigations on social behaviours have been conducted, but high-resolution investigations of human-environment interactions in urban centres have been limited.\textsuperscript{138} Studies of Minoan settlement sites have established regionally-based as well as locally-based artifact typologies for occupation periods from the Early through Late Bronze Age.\textsuperscript{139} Research on the built environments of urban centres has provided insights into site functions and periods of occupation.\textsuperscript{140} Recent analyses of built environments in relation to social transformations also

\textsuperscript{137} Knappett (2011) discusses “bottom-up” and “top-down” approaches used in archaeology, noting specifically the lack of ability to move vertically between scales.

\textsuperscript{138} e.g., Aegean: Branigan 2001.

\textsuperscript{139} Manning 2010: 15-16.

\textsuperscript{140} Todd and Warren 2012.
have been considered in case studies on Late Bronze Age Crete. These analyses have provided snapshots of specific events that may then be correlated with particular phases of occupation, and thus socio-natural transformations. Nevertheless, analyses of transitional periods between phases of occupation at Bronze Age urban sites remain rare. Finer-scale analyses are necessary to determine potential micro-scale events that led up to, and followed, these coarser, macro-scale snapshots.

Furthermore, conclusions about community behaviours—meso-scale processes—of a site’s population can be based neither on events in a single household nor on overall settlement/landscape transformations; however, these behaviours may have significantly impacted the social fabric of the settlement or affected the landscape. In order to evaluate community behaviours at this meso-scale level, it is necessary to evaluate the spatial relationships in urban centres—such as the relationships between neighbourhoods—which certainly vary across time. “Neighbourhoods of practice” may be defined as ‘practice-based communities’, rather than communities only defined by spatial extent, in the geographical sense. Many recent archaeology projects on Crete acknowledge that, despite identifiable typological trends, not all urban activities need to have been contemporaneous, but may have occurred decades or more apart; these projects have focused on integrating environmental and proxy studies to supplement the material cultural evidence for processes that may have affected temporally- and spatially-varied meso-scale behaviours.

Nevertheless, analyses of transitional periods between phases of occupation remain challenging to interpret at Minoan urban sites. However, detailed examination of the sediments present in these transitional stratigraphic sequences can potentially complete these gaps in understanding of how and when sites transition from one occupation phase to another. For example, one may conclude that indications of “[c]o-operation, consensus and communal decisions are evident where neighbouring buildings were destroyed and reconstructed at the

141 Letesson 2014.
142 This “snapshot” term and concept has been used and critiqued by others, e.g., Smith (2011: 80).
143 Smith 2010.
144 Knappett 2011: 102-103.
145 The issues of time and scale are also discussed by Goldberg and Macphail (2006: 217).
same time;” being able to identify the temporal relationship and exact nature of these transitional periods of destruction, abandonment, or other processes is essential in forming these interpretations, and has not been systematically practiced at Bronze Age Cretan sites to date. Briefly considering how occupation contexts have been studied at two urban Minoan settlement sites demonstrates how these Minoan transitional periods have not been systematically identified or compared, due to the traditional focus on identifying phases or periods based on material culture.

2.2.1.1 Zakros

The site of Zakros, and the settlement of Kato Zakros, are located on the southeast coast of Crete, approximately 12 km south of Palaikastro (20 km by modern road). While the architectural evidence for a ‘palatial’ structure at Zakros suggests that the ‘palace’ was smaller than those at Knossos, Phaistos, and Malia, the ‘palace’ may have served significant functions for the Minoan population; evidence of storage areas, paved courts, and cultic materials was present in the ‘palace’, and the settlement contained items such as *rhyta*, offering tables, a metal production workshop, a wine press, about 500 sealings, and a Linear A tablet. In addition to the on-site archaeological research results, the evidence from landscape survey conducted around the site has indicated, according to Judith Reid, that the population at Kato Zakro was able to produce surplus resources due to ‘specialised pastoralism’ and, in turn, was also able to prosper due to the utility of surplus goods as tradable commodities. Reid’s view that Kato Zakros was the ‘centre of an autonomous political unit’ controlled by pastoralists and entrepreneurs is in contrast to that of many other scholars who have viewed Kato Zakros as a trading centre, governed by ‘exploitative elites’ who functioned under orders from Knossos.

Recently, select pottery styles at Zakros, originally assigned to universal Minoan ceramic designations from the Evans-Mackenzie system, have been connected with new, locally-

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146 As has been demonstrated for the Neolithic cave site of Makri (Karkanas and Efstratiou 2009: 964).
148 Reid 2007: 156.
149 Reid 2007: 138.
identified styles. This has led to the recent development of a new system of relative chronology for some of the Zakros material, which is noted to be based on stratigraphy, rather than on ceramic typologies. The new study also notes that “five stratigraphically confirmed phases have been identified for the district of Kato Zakros and a total of seven for the wider Zakros area.” However, while five stratigraphical phases are defined for the Kato Zakros site, there is no discussion as to the nature of transitions between these phases, other than suggestions of abandonment, etc. Other events that may have occurred during these abandonments and between specific phases has not been discussed due to the focus on the occupation periods themselves. Particularly since activities do not necessarily persist during an entire phase—for example, only the final activity may be present—these transitional phases call for further evaluation.

Platon does point out the problematic nature of consistently labeling and correlating types of deposits (whether fill, destruction, etc.), particularly between sites, and attributes some of this to the lack of publications and detailed descriptions of comparable material at Zakros since those created by Dawkins in the early 1900s. Additionally, Platon critiques the “confused terminology” used by Minoan researchers at Zakros, stating that “the terms ‘MM IIIB’, ‘MM IIIB-LM IA’ and ‘early LM IA’ may well represent essentially the same chronological phase, placed around the beginning of the 16th century BC, equated to that which on Thera represents the so-called ‘Seismic Destruction Levels’ of the local settlement.” Additionally, an understanding of the transitional processes that led to LM III period reoccupation after

150 Platon 2010b: 513-514.
151 Ibid.: 513-514. Platon (2010a: 243-244) does emphasize the problematic nature of Cretan ceramic assemblages as well.
152 Platon 2010b: 513-514.
153 It is stated by Platon (2010b: 517) that abandonment occurred after site destruction around the end of the LM IB period, and a portion of the settlement was occupied until it was again abandoned the end of the LM IIIA2.
154 As noted by Platon (2011: 155).
155 Platon 2010a: 244; Dawkins 1903: 248-254. Part of the problem in comparing phases is that one phase, such as the MM IIA at Palaikastro, might be defined/identified at some sites largely through fill deposits; while another phase, such as the MM IIIB at Palaikastro, might be defined/identified largely through primary destruction deposits.
Neopalatial destruction and abandonment – beyond the material evidence for reoccupation in the LM III period – is lacking. At least for Zakros, it seems that when focusing only on the artifactually-defined occupation phases one cannot completely understand socio-natural systems within these periods due to the lack of (non-ceramic) information on the processes that occurred leading up to, and occurring after, these occupations.

2.2.1.2 Malia

The site of Malia is located on the north-central coast of Crete, approximately 75 geodesic km west of Palaikastro (about 115 km by modern road). The site of Malia was discovered by S. Xanthoudides in 1915, and, since 1920, excavations and studies have continued in conjunction with the French School at Athens and local archaeological service. The Malia region appears to have been occupied since Early Minoan times, and possibly even earlier in the Late Neolithic period; occupation continued through the end of the Bronze Age, with major construction phases at the main settlement site occurring during the Middle Minoan Period. Architectural evidence indicates a ‘palace’ complex, as well as an extensive settlement including workshops, storage buildings, houses, and elite burials (e.g., the Chrysolakkos building).

Although at a distance from both Palaikastro and Kato Zakros, Malia serves as an excellent comparative site for Palaikastro as extensive excavation and survey data are available for both large Minoan towns. Concepts of continuity and change have also been considered surrounding the site of Malia, and the Malia-Lasithi State. Although detailed documentation exists for the extensive

157 Zoitopoulos 2012.
158 In this way, Zakros serves as one of many examples of the problems of establishing local sequences that may or may not fit neatly into wider chronologies.
159 Effenterre and Tzedakis 1977; Driessen 2010: 557.
161 Driessen 2010.
163 E.g., Knappett 1999.
excavations at Malia, there remains some uncertainty surrounding the actual processes of transformation and transitional phases at the site. Briefly comparing the terminology and evidence used at Malia for these occupations (termed as “occupations,” “traces of occupations,” and “reoccupations”) and transitional periods makes this apparent. For example, Late Neolithic “occupation” at the site is defined, based only on the presence of surface finds on Arkovouno hill, located to the east of Malia. “Traces of [Neolithic] occupation” are noted in Villa A, Block Nu, as well as “[t]races of mixed LM IB–LM II deposits” in Blocks Epsilon and Nu. Farnoux recognizes the problematic gap in understanding the true nature of these “traces of occupation”—whether they “represent continuity or reoccupation by other groups.” Driessen also acknowledges the complexity in differentiating continued building usage and/or “destruction” in certain building areas in the LM IA, LM IB, and beyond, due to the “reoccupation” of the building. However, to date at Malia, no stratigraphically-standardized definition—based on non-material cultural evidence—of what specifically constitutes an “occupation” or “destruction” has been suggested. Thus, the material evidence provides information on particular events, but not necessarily on the processes that could define these events in relation to the socio-natural transformations affecting, and affected by, these events.

Additionally, Driessen states that “there is an ongoing discussion among archaeologists digging at Malia on the chronology of the different deposits.” Notably, these discussions revolve around artifactualy-based period classifications. Interpretations on the “rapid

164 Driessen 2010: 558.
168 Farnoux 1997; Driessen 2010: 566.
169 Driessen 2010: 566.
expansion” and subsequent “destruction” of the settlement during the MM II phase have been based on material evidence (artifactually-defined), while transformations within the period (and in-between other periods), beyond material differentiation, remains unclear. For example, discerning subdivisions in the MM II period based on pottery types has been possible, but these data do not necessarily provide information on the processes that led to possible socio-natural subdivisions or transformations in the MM II settlement at Malia. As another example of issues in understanding processes of transition due to the focus on architecturally-defined transitions and phases, Driessen notes that the exact organization of the Protopalatial palace is unclear due to uncertainty in its stratigraphical relationship to the Neopalatial palace and to other areas with unknown construction and “clearing” dates. Further noted is that raised sandstone slab walks are the “clearest sign for urbanization, apart from the buildings and courts.” It is interesting to observe that in all of these mentions of evidence for abandonment, occupation, reoccupation, and destruction, there is no emphasis on the potential (material cultural or sedimentological) evidence of the socio-natural processes that may have contributed to these events. However, higher-resolution data from the transitional periods between these materially-based snapshots could perhaps clarify the socio-natural processes occurring in-between these events.

2.3 Urban Micromorphology

From the aforementioned cases of Zakros, and Malia, one must consider: what, other than architecture and material culture, can indicate in site and urban contexts particular processes of

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171 After MM IIB destructions at Malia, evidence for MM III has generally been considered a bit poor, although evidence for MM IIIA is now apparent in Quartier Pi.

172 Driessen 2010: 560.

173 Knappett et al. in press.


175 One must also consider the issue of comparing a phase defined by in situ destruction deposits (MM IIB, Quartier Mu) with one defined, currently, by secondary fills (MM IIA, Quartier Pi).

176 Driessen 2010: 561.

177 Ibid.; Driessen 2009.
socio-natural change or continuity in occupation activities? A lack of differences in, or absence of, material culture or architectural types does not necessarily equate to a lack of change in periods/phases. How then may these phases, occupational and transitional, be more closely analyzed? For example, can one determine differences in the spatial use and site maintenance of Late Minoan contexts versus Middle Minoan contexts to understand potential behavioural changes? At sites outside of Bronze Age Crete, including sites without such well-developed artifactually-based relative chronologies, differences in occupational activities and transitional phases have been identified in settlements/urban contexts through fine-resolution analysis of sediment stratigraphy. Potentially, conducting such micro-scale studies at Bronze Age Cretan settlement/urban sites would greatly assist in understanding difficult stratigraphic contexts—whether or not material culture is present—and in determining activities and transitional phases that may be connected to behavioural changes or continuities in a society.

Micromorphology has been used as an inter-scale tool to understand the microcosm of the settlement and human behaviour at research sites outside of Bronze Age Crete. In studies of “household archaeology,” Beaudry discusses the role of micromorphology in revealing the different time scales of household cycles, life courses, and site life histories. Beaudry acknowledges the multiple time scales revealed in a household, between exterior architecture (general continuity, outward appearance) and internal practices (household economics), but observes the issues with hidden aspects (personal choices). Boivin also acknowledges the significance of floor cycles, normally not closely studied by archaeologists, who focus on the material resting on floors. Through analyses of microstratigraphic sequences of these households and other buildings, Boivin and Matthews have clearly demonstrated the ability of micromorphology to analyze “uses of space and behaviour during the birth, life and death of the

178 At the Late Neolithic (sixth millennium BC) of Makri, near Alexandroupolis, Greece, Karkanas and Efstratiou (2009) were able to differentiate via micromorphology between two different types of floors surfaces (not visible during excavation) and conclude that these different floor types were related to different types of social behaviours (individual versus communal behaviours). At Bronze Age Mitrou, in central Greece, Karkanas and Van de Moortel (2014) identify different floor construction and maintenance practices with possible shifts in larger social (settlement-level, meso-scale) organization.

179 Beaudry 1999.

180 Ibid.

building and its occupants, which may not be represented in the architecture.”

The additional challenge, however, is to then be able to correlate this micromorphology of households and of buildings to access human behaviour across urban centres, at the meso-scale level.

In addition to using micromorphological studies of households to understand neighbourhoods of practice at urban sites, another option for understanding these meso-scale processes to look at urban-rural connections and consider ‘atypical’ urban land-use for Bronze Age urban contexts. This involves additionally looking at the spaces outside of households and buildings and considering urban sites as ciphers for environmental information. Identifying the effects of the rural environment and urban microclimate on urban form can possibly assist in understanding meso-scale behaviours. In this sense, rather than dichotomize social and natural processes, micromorphology can investigate these urban transformations as socio-natural processes.

Urbanism in Bronze Age Crete has been a popular topic of discussion. However, in his survey of studies on Minoan urbanism, Branigan has emphasized three “neglected aspects of Minoan urbanism.” Notably, he does not consider in his discussion the micro-scale stratigraphic analyses that have been neglected in many Bronze Age Cretan urban studies. One issue acknowledged by Branigan is the disadvantage of constructing definitions of settlements (as “urban” or “town”) based on architectural (or estimated demographic) size alone. Micro-scale stratigraphic analysis may, however, be utilized to better differentiate between “urban” and “town” settings. While architectural studies certainly provide insight into site function and periods (based on typologies), micro-scale analyses may reveal more specific “neighbourhoods

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183 Davies and M'Mbogori 2013.
184 after Irger 2011.
187 Ibid.: 38, 40-41.
of practice” at Bronze Age sites. Such information may reveal whether “urban” or “town” sites with possibly varying demographic populations have distinct “neighbourhoods of practice.”

“Neighbourhoods of practice” have been noted to vary for modern urban centres, but such analogies have not been made in relation to Bronze Age Cretan urban sites. For example, comparisons of modern cities in the United States and Canada have illustrated that respective governmental authorities have utilized the “democratic grid” system in distinct manners. United States authorities have tended to utilize the “democratic grid…at a more intimate scale, laying out urban blocks on a cardinal axis, ten chains long and five chains wide.” The uniformity of land parcels supported social uniformity and equality, and only community-shared, public buildings might exhibit architectural dominance. Condon observes that, “The scale of the city building enterprise did not influence this ethos [of social uniformity/equality], as the plan for Seattle demonstrates.” In the absence of knowledge of the exact contemporaneity and maintenance of Bronze Age urban structures and the phasing of streets, observations of individual buildings and other urban areas can potentially aid in understanding the varying “neighbourhood of practices” within the site, and possibly differentiate areas of increased social cohesions and social (public) significance.

Soil micromorphology has been used at many different types of settlement sites to access these processes and to understand human behaviour, although not on Crete. Notably, the accessibility of the micro-scale information, in terms of timescales and behaviours visible, varies at these different types of sites (cave, coastal, mountain, tell; arid, temperate, tropical, tundra, etc.) due to the processes that have shaped the sites. Due to depositional and post-depositional

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188 Branigan 2001: 46-47.
190 Ibid.: 4.
192 Ibid.: 4.
processes, at some types of sites only long-term, overall settlement processes across entire sites may be identified while at other sites only single events/actions may be detected in specific spaces. As already observed by Karkanas and Efstratiou,\textsuperscript{195} outside of western Asia, where tell sites remarkably preserve stratigraphic sequences,\textsuperscript{196} micromorphological research is not normally employed to provide detailed information on human behaviours in-between occupation periods, nor across sites and larger regions.\textsuperscript{197} At urban sites in Northern Europe, micromorphological analyses have consistently identified Dark Earth deposits, which contrast with the typically fine, well-stratified deposits of tell sites. As noted by Borderie et al., “Dark Earth are thick dark layers, which appear to be homogeneous and constitute the main archaeological documentation of towns from the 4th to the 11th c. [A.D.].”\textsuperscript{198} Dark Earth is not necessarily indicative of abandonment, but is formed in spaces both inside and outside of buildings by anthropogenic and natural depositional and post-depositional processes.\textsuperscript{199} While Dark Earth has been applied to Bronze Age and Iron Age contexts in Britain,\textsuperscript{200} similar observations have not been made for Bronze Age Mediterranean urban sites. In fact, there has only been one urban site on the Cretan mainland, other than the study site of this dissertation, that has been studied via soil micromorphology—Sissi, which has been studied by Carpentier.\textsuperscript{201} Micromorphological research has been conducted on Pseira, an island in the northeast of the Gulf of Mirabello off the northern coast of eastern Crete, as part of a larger geoarchaeological

\textsuperscript{195} Karkanas and Efstratiou 2009: 955.


\textsuperscript{197} Macphail and Crowther 2007; Macphail et al. 2007; Milek 2005; Milek and French 2007. Recently, Karkanas and Efstratiou (2009: 955) have acknowledged the potential utility of micromorphology serving as an “indicator of social change at the household and settlement level,” across phases and spaces.

\textsuperscript{198} Borderie et al. 2015: 213.

\textsuperscript{199} Ibid.: 220; Macphail 1994; Cammas et al. 1998; Cammas 2004; Devos et al. 2009, Devos et al. 2011; Nicosia 2012.

\textsuperscript{200} French 2003.

\textsuperscript{201} Carpentier 2015.
survey; however, most micromorphological analysis focused on off-site samples from terraces.\textsuperscript{202}

In studies of other geographic regions and time periods, micromorphological studies of urban contexts have been able to identify the temporal and depositional nature of evidence indicative of occupation activities (e.g., site maintenance, storage, food processing/cooking, and industrial activities)—which are not readily visible at the macro-scale—through analyses of occupational features of building constructions (floors, roofs, and walls) and open urban spaces (middens and gardens), as well as transitional features (abandonment sequences and collapse sequences).\textsuperscript{203} Furthermore, while macro-scale research has focused on particular features of purposefully constructive human behaviour (active building construction/maintenance and creation of urban activity areas), the in-depth micro-scale analysis of negative human behaviour (via collapse debris, building decay, animal management, etc. that subsequently form dark earth\textsuperscript{204} and other transitional features) supplies valuable information on transitional and site formation processes, as well as allowing for possible interpretations of the broader environment.

The following sections (2.3.1 and 2.3.2) will consider several different types of urban-related contexts that may be studied via micromorphological analysis and will discuss the ability of each of these types of contexts to yield human behavioural information on the meso-scale (or on their respective scales). It is important to note that micromorphological sampling is not usually done systematically, in every site setting/context, due to research reasons including lengthy processing times and funding.\textsuperscript{205} Rather, specific contexts are sampled with particular short-term and/or long-term questions in mind—questions which have been formulated based on previous or concurrent archaeological and proxy research, as well as on the site setting. Additionally, each context—and each sample—needs to be individually analyzed as sediment/soil conditions and human activities may change over minute distances and very

\begin{thebibliography}{9}
\bibitem{202} Goldberg 2005a; Goldberg 2005b; Clark 2004; Hope Simpson et al. 2005; Noted in Kulick 2013.
\bibitem{204} Macphail 2010: 161.
\bibitem{205} Some reasons why micromorphology has not been regularly implemented in archaeological research are discussed by Goldberg and Valdeias (2016).
\end{thebibliography}
different inputs can result in similar-appearing outcomes. Finally, one aim of the following examples will be to demonstrate how micromorphology can provide more nuanced information on transitional phases (those between “occupation” phases) that not readily accessible via artifactually-based research methods.

2.3.1 Occupational phases

Human activities during occupational phases often produce or influence material that is preserved in the micro-scale archaeological record. As noted in Section 2.1, human activities/behaviours at the meso-scale level (communal-level or neighbourhood-level behaviours) may provide significant information on social transformations. Depositional and post-depositional processes that occur after such activities may obscure the materials indicative of these activities, and thus create challenges in interpreting the original activities, as well as social behaviours. However, analyzing the components of occupations and their levels of transformation micromorphologically can inform us of these original activities, their possible meso-scale significances, and overall urban history of the site.

2.3.1.1 Buildings and Structures (floors, roofing, wall plaster)

Building construction and maintenance activities produce many components that are visible in the microarchaeological record: floors, roofs, wall plasters, mortar, mud-brick, evidence of sweeping activities, etc. In addition to being able to identify floors that have been missed during excavations, micromorphological analyses of the nature of floor surfaces has been demonstrated to reflect individual/family and communal (social) behaviours at sites including the Neolithic tell of Makri in Greece, the Bronze Age site of Mitrou in Greece, the

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207 Refer to Table 2.1 for examples of depositional and post-depositional processes.
208 Karkanas and Efstratiou 2009: 964.
Neolithic site of Çatalhöyük in Turkey, and at various Roman and Medieval sites in Britain. For example, different cyclical processes in floor maintenance of specific types of formal, thick floor layers versus informal, thin floor layers may reflect site-wide communal practices in contrast to individual or familial practices, respectively—the former perhaps occurring occasionally but consistently across a neighbourhood or site and the latter perhaps occurring more frequently and/or only in specific contexts. At Neolithic Makri, Karkanas and Efstratiou were able to conclude that “overall construction practices in the Makri tell mirror structurally-coherent cultural preferences,” based on the differences in upkeep of two different types of indoor floors (formal and informal) versus outdoor areas.

Extensive micromorphological research has been conducted on floor sequences at Neolithic Çatalhöyük by Matthews and recently García-Suárez, enabling interpretations of different types of floor surfaces associated with specific activities. For example, thick mud plaster floors in “Shrine 10, Space 159” were correlated with storage activities. Additionally, studies of floor sequences from early Medieval London (No. 1 Poultry, the London Guildhall, Spitalfields) have demonstrated that micromorphology can relate transformative processes that bulk soil analysis alone can miss; floor layers, which can vary on the millimetric scale, may be obscured in macro-scale observations due to activities such as sweeping or trampling, which can introduce exogenous materials and cause heterogeneity of the sediments.


212 Karkanas and Efstratiou 2009: 965.


214 Courty et al. 1989; Matthews et al. 1996; Goldberg and Macphail 2006: 246.
2.3.1.2 Open Areas (middens, animal pens, gardens, roads)

Micromorphological analyses of areas outside of buildings at urban sites, such as middens, animal pens, and gardens, are also capable of providing valuable information on human activities and behaviours, as well as on environmental settings. In general, the micromorphological observations of samples from open areas outside of buildings may provide valuable contextual information against which to compare samples taken from within buildings and structures. Additionally, they may provide information on changes in environmental conditions including changing water levels, broader landscape transformations (such as vegetation changes, deforestation, etc.), and depositional and post-depositional site processes.

For example, extensive micromorphological research on middens has been conducted at Neolithic Çatalhöyük and has supplemented the minimal in situ evidence of activities from within buildings. Micro-scale analysis of middens from Çatalhöyük has also been able to differentiate the fine layers common in middens—something not typically visible during excavations—and reveal behavioural and perhaps environmental information, such as the various fuel types from midden ashes, based on wood charcoal data, etc.

Additionally, studies of Dark Earth contexts from medieval sites in Belgium, such as the Hôtel d'Hoogstraeten in Brussels, have identified these contexts as middens; this research has demonstrated that, when analyzed micromorphologically, midden deposits also may reveal components of destruction debris, such as mortar and brick fragments, wall plasters, floors, as well as domestic and animal waste and food preparation activities. Other micromorphological studies of middens have clarified chronological uncertainties, such as studies conducted on Viking/early medieval

\begin{itemize}
  \item Shillito and Matthews 2013; Shillito et al. 2011; Macphail et al. 2004; Hubbard 2010; difficult to resolve middens at macro-scale: Simpson and Barrett 1996; Shillito et al. 2008.
  \item Shillito and Matthews 2013: 28; Matthews 2005.
  \item Hodder and Cessford 2004; Shillito et al. 2011: 1025.
  \item Yeoman 2005; Shillito et al. 2011: 1025; Shillito and Matthews 2013.
  \item Canti 2003; Matthews 2010; Shillito and Matthews 2013: 46; Asouti and Hather 2001; Asouti 2003.
  \item Devos et al. 2011: 66-67.
\end{itemize}
middens in Quoygrew (Orkney), which aided in interpreting temporal phasing related to marine-resource exploitation and agricultural production in different areas.\textsuperscript{221}

Micromorphological analyses of other open area spaces at urban sites have provided evidence of practices and changes in animal management (animal stabling/penning).\textsuperscript{222} For example, research has demonstrated spatial separation between animal penning areas and human quarters at the Middle Chalcolithic settlement of Tel Tsaf, Israel,\textsuperscript{223} and has also indicated increased prevalence of animal management in urban spaces at (Roman, Dark Age, Saxon, and medieval) sites including Canterbury and Staples Gardens, Deansway, Tours, Whitefriars, Winchester, and Worcester.\textsuperscript{224} Micromorphological evidence from urban gardens has also been detected at Northern European sites in later Roman and Medieval periods,\textsuperscript{225} including the site of Hôtel d'Hoogstraeten, where secondary anthropogenic materials (construction materials, waste products, and domestic refuse) have been noted – components that appear to be common in other urban gardens.\textsuperscript{226}

Other open area features of urban sites that have been studied in order to understand continuity and change in social behaviour have been roads and trackways.\textsuperscript{227} The deposits that fill the roadside gullies and dumps in many Roman towns supply significant behavioural information when analyzed micromorphologically, rather than at the macro-scale. Micromorphological analyses of these roadside gullies have demonstrated that these gully fills are typically dominated by sand-sized sediments which have washed from the road surfaces, and

\textsuperscript{221} Simpson et al. 2005.
\textsuperscript{222} Hubbard 2010; Macphail 2010.
\textsuperscript{223} Hubbard 2010.
\textsuperscript{224} Macphail 2010: 157.
\textsuperscript{225} Macphail et al. 2003; Nicosia et al. in press; Galinié 2010; Macphail and Crowther 2007; Macphail 2010: 157.
\textsuperscript{226} Devos et al. 2011: 67.
\textsuperscript{227} Goldberg and Macphail 2006: 236.
additionally contain indications of secondary phosphate deposition as well as anthropogenic materials (mainly waste products) that have washed in from the road surfaces.

2.3.2 Transitional phases

Urban environments are not static; they may change dramatically throughout the occupation(s) of the site. As noted above, challenges exist in identifying these changes based on their unknown scale and nature. Thus, it is essential in micromorphological studies to be aware that, in addition to multiple activities occurring simultaneously at urban sites, activities at sites may continue along multiple, different temporal and spatial frames. Particularly in Dark Earth contexts, evidence of multiple activities may be present, or—alternatively—only the final activity/inputs may be readily visible. Through micromorphological analysis, short-term, but significant, changes in urban life have been identified at Roman sites in Britain.

Furthermore, while the components of urban archaeological contexts are primarily reflective of anthropogenic activities, the pre-depositional, depositional, and post-depositional processes that affect their formation and preservation are varied and complex, thus making it essential “to continually bear in mind the principle of equifinality when interpreting soil micromorphology.” Some key depositional and post-depositional processes—both anthropogenic and natural—that may affect urban archaeological contexts are noted in Table 1. The identification of these transformative processes is significant because they may provide information on the events/actions that occur in-between phases of urban occupation, whether human-induced or naturally-occurring—or both. The ability of micromorphology to identify these processes significantly advances understandings of human behaviours and environments at urban sites.


229 Devos et al. 2011: 68.

230 Notable short-term changes in urban life have been noted at Roman Colchester and London, after their purposeful destructions in the Boudiccan revolt in AD 59-60, prior to more standard Roman urban life being re-established (Macphail 1994; Goldberg and Macphail 2006: 237).

231 Goldberg and Macphail 2006: 356; also noted by Devos et al. 2011: 68-70; Macphail 2010: 158.
Table 2.1: Site transformation processes (after Devos et al. 2011: 57; Table 2).

<table>
<thead>
<tr>
<th>Depositional/Post-depositional transformation processes affecting urban contexts</th>
<th>Anthropogenic processes</th>
<th>Environmental processes</th>
<th>Selected References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixing/homogenization</td>
<td>Agricultural activities (e.g., ploughing); sweeping, washing, trampling</td>
<td>Bioturbation (by plants and animals)</td>
<td>Goldberg and Macphail 2006; Macphail 2003c; Macphail et al. 1995</td>
</tr>
<tr>
<td>Accumulation</td>
<td>Anthropogenic additions (e.g., waste inputs; industrial waste); animal/human traffic</td>
<td>Aeolian, alluvial, colluvial inputs</td>
<td>Cammas et al. 2011; Goldberg and Macphail 2006; Cammas 1994; Cammas et al. 1996; Macphail 1994, 2003b; Matthews et al. 1997</td>
</tr>
<tr>
<td>Erosion/truncation</td>
<td>Anthropogenic sediment removal (e.g., pit creation, building demolition/reconstruction)</td>
<td>Slope processes, water-based erosion, mass wasting events, etc.)</td>
<td>Cammas et al. 2011; Macphail 2003c; Macphail et al. 1995</td>
</tr>
<tr>
<td>Mineralization/degradation/decomposition/humification</td>
<td>Influenced by inputs of calcareous building debris (e.g., mortar, plaster); burning</td>
<td>Faunal and microbiological activity; burning</td>
<td>Devos et al. 2009; Duchaufour 2001; Gobat et al. 1998; Goldberg and Macphail 2006: 65; Courty et al. 1989: 107</td>
</tr>
<tr>
<td>Pedogenesis</td>
<td>Influenced by dissolution of alkaline materials (e.g., mortar, plaster, bone, ashes, shell)</td>
<td>Wetting and drying; waterlogging</td>
<td>Devos et al. 2011: 63</td>
</tr>
</tbody>
</table>

2.3.2.1 Abandonment and Collapse sequences

As noted for the Bronze Age urban sites of Zakros and Malia, the lack of accuracy in identifying the specifics of transitional periods in-between major occupation phases can inhibit interpretations of the sites and environments. Research at other urban sites has demonstrated the capability of micromorphology to aid in the interpretations of these transitional phases. As Macphail cautions, abandonment (“negative demographic phase”) does not necessarily equate with a “greater depositional signal, compared to use,” because “structures collapse, and once-swept floors accumulate deposits through casual occupation,” such as via squatters.\(^{232}\) Case studies from Roman and Iron Age Britain have demonstrated that occupation-period activities such as floor sweeping, road cleaning, and livestock movement, in fact, also result in

deposition. For sites in Northern Europe, it has also been observed that “All occupation deposits, given time, will develop dark earth soils…” However, micromorphological studies of these seemingly uniform (at the macro-scale) Dark Earth sediments have been able to reveal transitional phases in site occupation sequences, such as episodes of low-intensity use, pedogenic interruptions, and short-term weathering—at a resolution of years and decades. In other cases, Dark Earth formation has been attributed to site abandonment.

At Çatalhöyük, abandonment has also produced “fill”; multiple depositional episodes have been identified micromorphologically within this fill—features not visible at the macroscale—and typical micro-scale features of abandonment fill in this area are now identifiable. For example, micromorphological analysis of a sample (BACH 2238 S1) collected from an area of possible collapsed roofing in the BACH Area demonstrated water-laid crusts and deposits, which suggest that the sample may be representative of “uncovered roof deposits.” In contrast, another site area in Space 511, micro-scale observations of the “absence of water-laid crusts” in the abandonment fill suggests that this space was roofed during this transitional phase. From these observations and interpretations, it is apparent that various types of transitional-phase features have been identified micromorphologically, and these transitional phases, which may only be identifiable as “fill” on the macro-scale, can be more specifically defined with nuance as particular types of abandonment, occupation, reoccupation, and destruction deposits and transitions. In turn, these nuances in transitional phases can reveal

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233 Studies at Roman Southwark have demonstrated floor sweeping and road cleaning as contributing to depositional processes (Macphail 2010: 148). At Southwark and Roman/Iron Age Heybridge, also in Britain, Dark Earth deposits formed as a result of “urban activities and not because of abandonment” (Macphail 2010: 148).

234 Macphail 1994; Macphail 2010: 152.

235 Examples of this transitional period resolution are from late antique St. Julien, Tours; Southwark, London; and the London amphitheatre (London Guildhall) (Macphail 2010: 153-154).

236 E.g., at Pauvre Claires (Devos et al. 2011: 67-68).


238 Alternatively, these features may have been formed by anthropogenic activities involving intense water use; the necessity for further research has been noted (Ibid.: 268).

239 Ibid.: 267.
much more about societal transformations than is currently known for these Bronze Age Cretan urban sites.

2.3.2.2 “Urban Earth”

As noted earlier, micromorphological analyses have consistently identified Dark Earth deposits at urban sites in Northern Europe. While the present definition of Dark Earth: “thick dark layers, which appear to be homogeneous and constitute the main archaeological documentation of towns from the 4th to the 11th c. [A.D.]” \(^{240}\) does not include the context of Bronze Age urban sites, Dark Earth has been noted at Bronze Age and Iron Age contexts in Britain. \(^{241}\) Micromorphological analyses of Dark Earth have been able to supply valuable information on human behaviours and processes of transformation, as mentioned above. The only notable feature that possibly disqualifies Bronze Age Cretan sediments as also being termed Dark Earth is the lack of presence of a significant portion of organic material (humic content), which creates the dark colour of Dark Earth. \(^{242}\)

One suggestion of this dissertation will to establish a new terminology for Bronze Age Cretan sediments—“Urban Earth”—which also share the following qualities of Dark Earth: thick layers, which appear homogeneous and which comprise the majority of Bronze Age Cretan urban sites. Like Dark Earth, this seemingly well-homogenized Urban Earth similarly demonstrates some internal structure, including pockets or areas of quite well-sorted grains; there are ‘pockets’ of similarly-sized sand grains, as well as inclusions of anthropogenic materials and previous bedding and slaking crusts. Also, like Dark Earth, it seems probable that Urban Earth can assist in identifying transformational processes at urban sites, particularly between occupational phases.

\(^{240}\) Borderie et al. 2015: 213.

\(^{241}\) French 2003.

\(^{242}\) This finding was confirmed by F. Carpentier (pers comm. July 2016).
2.3.3 Experimental Urban Micromorphology

One of the challenges in forming conclusive interpretations in archaeology, geoarchaeology, and soil micromorphology (and in other studies of the past) is that no hypothesis is ever truly testable. Mainly we rely on induction. While micromorphological observations may provide detailed descriptions of micro-scale stratigraphic records, the interpretations of these records may vary, and must be compared with other archaeological and proxy evidence, as noted above. Additionally assisting in the interpretation of these urban archaeological contexts, as well as other post-occupation processes, have been experimental and ethnographical micromorphological studies.

Studies by Miller et al. have provided experimental micromorphological comparisons for activities of burning, sweeping, and trampling of experimental fireplaces containing anthropogenic materials. Several large experimental studies have been set up in Britain, such as the experimental Iron Age and Romano-British farms at Butser (1975) and Umeå (1986–1998). Micromorphological analyses of floor sequences from Butser farm have identified micro-scale characteristics of stabling floors and domestic floors, respectively.

Friesem et al. have conducted ethnoarchaeological studies of an abandoned mud brick village in northern Greece and have been able to identify particular micromorphological characteristics for different phases of mud brick decomposition; these identifications have been able to differentiate mud brick from natural soils, which can be particularly valuable in understanding urban contexts that lack stone architecture. In another ethnoarchaeological study by Milek on an abandoned 19th and early 20th-century group of turf buildings at Thverá farm in Iceland, micromorphological observations of floor sequences with known accounts of the uses of space of the buildings allowed Milek to differentiate between the social constructs of

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244 Miller et al. 2010.
245 Goldberg and Macphail 2006; Macphail and Goldberg 1995.
246 Goldberg and Macphail 2006: 258-262.
247 Friesem et al. 2014a, 2014b.
248 Milek 2012.
building maintenance (perceptions of “dirty” versus “clean,” etc.) and the actual result of these constructed behaviours on the micro-scale structure and components of occupation surfaces.\textsuperscript{249} In the future, experimental and ethnoarchaeological micromorphological comparisons of contexts relatable to Bronze Age Cretan urban sites would greatly benefit the interpretations of these micro-stratigraphic sequences by being able to relate them to known meso-scale behaviours and macro-scale processes.

\textsuperscript{249} Ibid.
3 Chapter 3: Palaikastro in its Mediterranean, Aegean, and East Cretan Contexts

**Premise:** As demonstrated in Chapter 2, the ability of urban micromorphology to provide information on human behaviours and human-environment interactions has the potential to be applied to Bronze Age Cretan urban sites, and would be valuable to understanding micro-scale processes unique to Mediterranean local microecologies and cultural systems. This urban micromorphological approach has been implemented in the Phase 4 Palaikastro excavation and research project, Palace and Landscape at Palaikastro (PALAP), and aims to identify Bronze Age urban behaviours and human-environment interactions that macro-scale research has not been able to detect. This chapter will describe the setting of Palaikastro by examining its urban character in the context of its East Cretan environment. It will summarize the archaeological research that has been conducted at Palaikastro, the main features of its environment and geological setting, and the recent PALAP excavations. The research opportunity provided by the new PALAP excavation campaign (2013-2015) to consider meso-scale urban behaviours that have previously not been accessed at Palaikastro or in East Crete, and that have only been studied micromorphologically at the Bronze Age settlement sites on Pseira and at Sissi, will then be considered. Finally, the aims of the micromorphological project—and premise of this dissertation—will be outlined in relation to the new study area of the recent excavation campaign.
3.1 Palaikastro

“The intervening country is…a region of desolate kärsten descending on the east to the rich inland basin of Upper Zakro and on the north to the maritime plain of Palaikastro.”

Excavations at Palaikastro (1902-1906; 1962-1963; 1986-2003; 2013-2015) in East Crete have uncovered an extensive settlement area, occupied from Early Minoan IIA to Late Minoan IIIB. The site is considered urban due to its organization and size, spanning some 15 ha. While the excavated structures in the urban centre are generally perceived as residential, ‘elite’ buildings, it is unknown if the site contains a central ‘palace’ or monumental public building. Although one has been postulated, no such building has been located. Additionally, the socio-natural processes leading to changes in on-site and off-site activities during the occupation of the site are unclear. That Palaikastro also has an accessible, surrounding landscape largely untouched by modern development makes it an ideal case-study site to investigate both on-site and off-site data related to human activities and landscape transformation—providing an opportunity to understand the socio-natural interactions between Minoan townspeople and their landscape.

Nevertheless, issues of scale and process that apply to all Mediterranean archaeological sites (discussed in Chapter 2), also apply to Palaikastro, as an urban site in East Crete. Bronze Age East Crete—roughly corresponding to the modern-day prefecture of Lasithi—has been extensively studied through landscape survey and excavations. It has been demonstrated that a network of Minoan palatial centres (Gournia, Petras, Zakros) and towns (Palaikastro, Karoumes, Mochlos, Papadiakambos, Pseira, Vrokastro, Choiromandres), and even regional ‘roads’ existed, although the social, economic, and political relationships between these communities are unclear.

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250 Bosanquet 1901/1902: 286-287.
251 MacGillivray and Driessen 1989.
252 Whitelaw (2017, in press) the label of what it means to have an ‘urban’ setting in prehistoric Crete, beyond the contemporary qualification of ‘urban’ as being a size-based designation that correlates increased size with increased social complexity.
253 Based on survey calculations from recent PALAP survey.
Bronze Age material remains from East Crete and other Mediterranean regions indicate that the area was involved in larger regional trade networks. As in other Mediterranean regions, research has also established that East Crete exhibits certain local social and micro-environmental systems. Marina Gkiasta has attempted, with partial success due to varying data formats, an integration of data from surveys and excavations conducted in Lasithi with the aim of understanding social transformations on the macro-scale. Jonathan Flood, acknowledging the importance of understanding micro-environments, has attempted a study of Neopalatial water management, specifically focusing on Palaikastro as a case study. Both studies have demonstrated that, while it is possible to make generalizations about Bronze Age climate and site habitation in East Crete, the spatial and temporal resolution of human activity-types and their relation to the ‘physical landscape’—and subsequent societal relations—is apparent neither through current diachronically focused landscape survey data nor through question- or site-specific archaeological data. Clarification of the past micro-environmental conditions and human activities is essential in understanding these East Cretan relationships, as well as those of other Bronze Age Cretan societies.

Bronze Age East Crete is different from the rest of Crete in several respects. Geographically, surrounded by the Sea of Crete to the north and Libyan Sea to the south, East Crete is isolated from the central and western areas of the island by the Sitia Mountains which consist of two separate ranges—the western Thripti (Aori) range and the eastern Zakros range.

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256 Moody 2005; Reid 2007: 6-8.

257 Gkiasta 2008: Ch.6:1.

258 Flood 2012.

259 Gkiasta 2008: Ch.6.6: 21
It remains a one- to two-hour, 70-90 km drive around the mountains from the Bronze Age settlement of Gournia to Bronze Age Palaikastro, although the settlement sites are only 45 geodesic km apart. Culturally, East Cretan Bronze Age settlements sites demonstrate different trends.\textsuperscript{260} For example, the types of transitions from Protopalatial to the Neopalatial period (MM IIB to MM III) vary across sites.\textsuperscript{261} Additionally, the destructions in the LM IB period appear to have occurred in multiple (discontinuous) phases at some sites, such as Zakros.\textsuperscript{262}

Nevertheless, indications of landscape use and environmental and climatic conditions at the time of Bronze Age occupation have been largely determined by structural and material remains, as well as by preserved faunal and archaeobotanical remains from urban sites. Although limited socio-economic and political information on urban-based authorities can be gained from studying rural or hinterland sites alone,\textsuperscript{263} geoarchaeological investigations of the hinterland landscape in combination with that of the urban settlement provides a much more accurate view of the entire urban-based authority. Geoarchaeological and palaeoenvironmental methods incorporated in initial research design or urban centres can go beyond simple ‘contextualization’ and strict ‘cause-and-effect’ interpretations of urban centres.

To establish and apply a geoarchaeological approach on a scale appropriate to answer particular urban archaeological questions at Palaikastro, in their Bronze-Age East Cretan context, it is first necessary to approach the region through site-specific analysis. This fine-scale analysis will elucidate human activity and environmental changes in the context of a temporally- and spatially-specific Bronze Age urban society. Subsequently, this site-specific data may be used to make preliminary archaeological and environmental comparisons with interpretations from other regional sites (discussed in Chapter 5). While comparisons will be inter-scalar, due to the lack of micromorphological evidence from other sites, and will initially be among the sites located in the closest geographical proximity to Palaikastro, it is duly noted that geographical proximity may not have been the main determining factor in past settlement relations.

\begin{itemize}
\item \textsuperscript{260} E.g., Knappett and Cunningham 2003: 183.
\item \textsuperscript{261} Macdonald and Knappett 2013: 2.
\item \textsuperscript{262} Brogan and Hallager 2011: 595, 609; Barnard and Brogan 2003, 46–7, 107–9; Soles 2002: 128.
\item \textsuperscript{263} Whitelaw 2013: 71.
\end{itemize}
3.1.1 Archaeological (urban) setting

At Bronze Age Palaikastro [Figure 3.6], evidence for occupation in EM IIA (c. 2650-2450 BC) has been found in Block Δ, Block Ξ, and on Kastri, beneath the subsequent Middle and/or Late Minoan structures in these areas. In MM IIB, the settlement became a “well-planned town.” Although destruction events occurred at the end of the Protopalatial Period (MM IIB, 1760 BC), rebuilding followed in some areas of the settlement zone, including the construction of a “Minoan Hall” in Block M in MM IIIA. There is evidence suggesting that seismic damage may have occurred subsequently at the end of MM IIIB; some site areas, such as Block M, had minimal evidence of subsequent occupation, possibly ‘squatter’ occupation, in LM IA. Nevertheless, major construction and occupation in other zones of the site persisted in the LM IA period. Evidence of tephra and pumice fallout from the Theran eruption in LM IA (c. 1640-1600 BC) is present at the site; however other site-wide environmental impacts from this event have not yet been conclusively determined. Despite the potential impact (direct or indirect) of the eruption, major construction at the settlement—which followed detailed urban planning schemes—in the form of ashlar structures, occurred in the LM IB period (c. 1490–1460/40 BC). A series of fire-related destructuons—interpreted as human-induced—occurred during LM IB (c. 1460–1440 BC). Unlike other settlements in East Crete, rebuilding immediately followed these destructions in the LM II and LM IIIA1 periods (c. 1440–1400


265 The main street was first noted in Bosanquet et al.: 278; Knappett and Cunningham 2012: 5; MacGillivray and Sackett 2010: 574.

266 MacGillivray and Sackett 2010: 574; Knappett and Cunningham 2003: 194.

267 Knappett and Cunningham 2012: 319.


269 There are varying accounts of the degree of impact that the Theran eruption had on Palaikastro. Knappett and Cunningham 2012: 27; Driessen and Macdonald 1997; Bruins et al. 2008; Kulick 2015 (unpublished conference paper). Here, the “high” chronology is being used for the date of the Theran eruption (cf. Manning et al. 2014).

270 MacGillivray and Sackett 2010: 574.

271 Ibid.
Another fire-related destruction event followed in the early LM IIIA2 period (c. 1320 BC), although rebuilding took place in LM IIIA2 and LM IIIB. Finally, the urban centre in Roussolakkos valley was abandoned in the middle of LM IIIB (c. 1250 BC); whether an earthquake preceded this abandonment is uncertain. A small settlement continued on the top of Kastri during LM IIIC (c. 1200–1100 BC). Palaikastro provides a unique opportunity to analyze a well-planned urban centre, lacking any indication of a “palatial” structure, with evidence of organizational continuity in respect to certain streets and blocks being maintained across periods, particularly during its MM III to LM IIIA occupation. The overall temporal span of the EM to LM III occupations, furthermore, enables the study of longer-term behavioural processes. However, the behavioural (and possibly environmental) processes affecting the individual occupation periods need further clarification—part of the aim of the recent PALAP project. Earlier research has suggested that the site layout and architecture—the arrangement of the Palaikastro houses and their rooms in relation to street alignments—indicates different practices of spatial segregation (public v. private) across the site throughout its occupation periods. The material and architectural evidence from Block M, for example, suggests the importance of varying social processes (possibly “neighbourhoods of practice”) within the larger site during the Proto- and Neopalatial periods, including distinct “familial or clan holdings of the most important residents of the town.” Simultaneously, these urban transformations reflect ties to regional social processes, such the development of a regional ‘elite’ political culture, with shared administration, architectural forms and techniques, seal iconography, and wall paintings. Understanding the balance between a potential local hierarchy of public and private

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273 MacGillivray and Sackett 2010: 574.


275 Ibid: 344-345; MacGillivray and Sackett 2010: 574.

276 Cunningham 2007; MacGillivray and Sackett 2010: 576-577. This is in contrast to other towns, such as Gournia, where the towns demonstrate more organic growth patterns (Watrous et al. 2015).

277 Knappett and Cunningham 2012: 5-6.

needs is essential to understanding urban transformations since changes in this hierarchy would have different effects on urbanization trends. Public needs, such as the maintenance of “urban corridors,” would not necessarily provide information on private needs, which may only be visible via activities in individual buildings or at the neighbourhood level. Separating these local social needs from larger regional trends requires delving into the evidence for the actual activities and socio-natural processes affecting these particular spaces within and across periods.

While recent survey research raises questions about the extent of the Bronze Age settlement and organization of the local landscape in supporting a larger, centralized community or individual communities, the research has still been focused on architecture and period-specific material culture and does not address the behavioural processes in the settlement. Further research on the occupation periods and the possibility of multiple phases of occupation, within particular site structures and areas (via techniques such as soil micromorphology), needs to be considered in relation to the urban architecture and material culture in order to develop a more complete picture of potential behavioural and environmental transformations. Without being able to differentiate the processes surrounding occupational phases by identifying the particular types of transformative processes (e.g., natural sedimentation, anthropogenic fill, destruction or decay, etc.), it will be difficult to accurately designate – without this socio-natural

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279 Establishing these local dynamics, rather than simply following broader regional narratives, follows the logic of establishing microecologies, as laid out by Horden and Purcell (2000).

280 Gribb and Czerniak (2016: 6) use the term “urban corridors” in relation to linking different areas of contemporary and future megacities; however, the concept that some form of governance or public agreement is implied in the maintenance of these corridors can, in this case, be applied to publically-maintained roads in Palaikastro.

281 Driessen’s (2010) main research goal for a particular study of Palaikastro was to reconstruct the political geography and settlement hierarchy in Proto- and Neopalatial periods based on urban survey data. However, he reaches the conclusion that “site numbers and sizes do not suffice to reconstruct a persuasive political geography.” Instead, Driessen recognizes the need to look beyond the site, into the surrounding landscape to truly understand how the society was functioning.

282 Early surface surveys and geophysical surveys of the Palaikastro landscape have had primarily descriptive aims (MacGillivray et al. 1984; Boyd et al. 2006). Recent surface and geophysical surveys of the Palaikastro urban area have revealed more of the extent of the urban centre beyond the present coastline and currently excavated areas (MacGillivray et al. 1984; Boyd et al. 2006). This recent work includes the surface survey conducted through the on-going PALAP project, which has also indicated evidence of activities and possible habitations in areas of the landscape which are not directly next to the main urban centre (Orengo and Knappett forthcoming).
information – *any* behavioural trends as socio-economic- (public v. private) or status-based (elite v. non-elite), for *any* site area—regardless of the (still unknown) spatial extent of the site.\(^\text{283}\)

Certainly, developing a complete reconstruction of these potential behavioural and environmental transformations is challenging because the full extent of the ‘urbanized’ area and of off-site activities is not yet understood. However, the micro-environmental features that are unique to Palaikastro merit further investigation in order to establish a more holistic understanding of Palaikastro’s role in East Crete and on the rest of the island; this investigation would elucidate the inter-island systems and correct broader Mediterranean assumptions. While there has indeed been a general call to look locally, to the micro-environments of Bronze Age Crete, this approach has not necessarily been implemented in practice.\(^\text{284}\) Recognizing the role of settlement sites in their environments necessitates a detailed understanding of the characteristics of both the specific local urban trends and the micro-environmental features.\(^\text{285}\) Furthermore, as discussed in Chapter 2, an understanding of local socio-natural systems is necessary to understand how the Bronze Age towns operated and interacted with their larger

\(^{283}\) Issues with terminology used to define phases has largely been due to the lack of fine-scale resolution applied to analyses prior to the recent excavations. For example, multiple terms have been used, but never clearly defined or used with consistency, to describe the site phases/contexts at Palaikastro that are primarily composed of sediments. For example, in the Block M (Knappett and Cunningham 2012) publication, the term “fill” is used frequently but is not correlated with any particular process—whether anthropogenic fill, a mix of anthropogenic material and sediments, just sediments, etc. Micromorphological analysis will hopefully be able to identify the processes responsible for these “fills” and possibly be able to separate categories of fill and other events (e.g., identify how Proto-palatial fill differs from Neopalatial fill, or define different types of destruction events, etc).

\(^{284}\) Whitelaw (2001b: 145) notes that “relatively small scale climatic variations during the fourth and third millennia (Wright 1972; Rackham 1982; Bottema 1985; 1994; Allen and Katsikis 1990; Moody et al. 1996) are likely to have affected individual areas in different ways, given different geologies, vegetation patterns, histories of human settlement, and micro-climatic conditions (van Andel et al. 1990).”

\(^{285}\) There are many issues with understanding the effect of landscape on a society and vice versa, particularly as the built environment would not have necessarily corresponded directly to the environmental setting nor to the political authority. Smith (2003: 71) states that most of the built environment has been constructed by political regimes rather than individuals. Although advocating for a multi-scalar understanding of space and landscape/environment, Smith does not necessarily consider what might be perceived as the demonstration of authority outside of a political regime. However, certain scholars in Near Eastern Bronze Age archaeology have now come to the conclusion that private individuals also played significant roles in the functioning of the economies that incorporated both private and public economic endeavors (Monroe 2000, Garfinkle 2005, Bell 2006, Crewe 2007, Sherratt and Sherratt 1991). Instead of operating within the confines of definite public and private spheres in which individuals performed their respective tasks, the people of these societies appeared to “pursue an advantage for several households simultaneously, and to do so in a manner that institutionalized the kind of conflicts of interest that our system [of public versus private] will not tolerate” (Garfinkle 2005: 390). In this context, understanding the power relations behind material culture in relation to environment is more challenging since these objects and interactions may have been caught up in a web of institutional and personal networks. By identifying micro-scale trends in a particular urban setting, trends specific to Palaikastro will hopefully become apparent.
environments.\textsuperscript{286} Beyond counting sites to understand the larger political geography and settlement hierarchy of Bronze Age Crete,\textsuperscript{287} an examination of the specific micro-scale elements of these urban sites would be advantageous to developing a more discursive approach to understanding these behaviours.

3.1.2 Environmental and Geological Setting

In order to answer questions about the urban site of Bronze Age Palaikastro and its environment, it is necessary to be able to explain the aspects of the site environment that influenced the occupational and post-occupational processes impacting site preservation, or lack thereof. Despite the absence of significant post-Bronze Age occupation, various processes obviously occurred that did result in the Bronze Age site being covered with sediments—some areas more so than others. How did the environment look in the Bronze Age, and how did it come to look as it does today? What aspects of the environment might have affected the materials that are seen in the urban soil micromorphological record?

3.1.2.1 Environmental setting

Opening to the east to the Aegean Sea, the modern-day coastline of the alluvial basin that contains modern-day and Bronze Age Palaikastro is topographically delimited by surrounding hill ranges to the north, west, and south [Plate 2]. To the north, hill ranges lead into the plateau area of Vai. Forming the western edge of the Palaikastro basin are the hills of Kaminia and Aspromouri (c. 190 m), leading towards Toplou.\textsuperscript{288} To the south and southwest of the basin is another upland plateau range, including Petsophas (c. 250 m)—a Bronze Age sanctuary to the south of the Bronze Age Palaikastro settlement site, and the peaks of Simodi (c. 390 m), and

\textsuperscript{286} For example, Schoep (1999) discusses the Neopalatial Linear A tablet and sealed document evidence as suggesting the lack of an overall island-wide administrative system.

\textsuperscript{287} Driessen (2001) attempts to reconstruct political geography and settlement hierarchy in Proto- and Neopalatial periods based on survey data (counting sites); local environment and geopolitical reasons are assumed to be a cause for settlement divergences, but the local environmental evidence is unclear.

\textsuperscript{288} Height designations of peaks from Google Earth noted in Cunningham 2012: 4.
Modi (c. 500 m) to the south and southwest.\textsuperscript{289} The modern coastline is divided into two sandy beaches, Kouremenos—the northern strand, and Chiona—the southern strand [Plate 3]. Together, the strands are approximately 2.5 geodesic kilometres in length, divided by Kastri (c. 80 m)—a trapezoidal/conical hill which is gradually eroding into the sea on the east and actively contributing (colluvially) to the sedimentation of the alluvial plain to the west. Also contributing to this active sedimentation is the eroding hill of Rizoviglo (c. 30 m), located approximately 200 m inland from the centre of the bay/beach of Kouremenos.\textsuperscript{290}

Bronze Age Palaikastro is located approximately 200-300 m from the modern-day coastline of Chiona beach and its seasonally-wet salt flat. North of Bronze Age Palaikastro, a seasonal river (in winter and spring) passes from the area of the modern town, ending at Kouremenos beach. Located below the north-facing slopes of Petsophas, the Bronze Age town (15 ha)\textsuperscript{291} has been in a low-lying topographic position with the potential of being significantly affected by colluvial and alluvial processes, as noted in 3.2.1.2 [Plate 4]. The coastline south of the sandy beach of Chiona consists of rough inlets and vertical cliffs of up to approximately 5 m in height [Plate 5]. These cliffs and inlets continue to the southeast to Ta Skaria (the Bronze Age quarries).\textsuperscript{292} The eroding Bronze Age structures at Chiona [Plates 6-7]\textsuperscript{293} and the vertical cliff features, as well as the evidence of walls (unconfirmed whether Bronze Age or more recent) visible underwater, suggests that this area of East Crete has subsided since Bronze Age times—something not attributable to sea-level change alone [Plate 8].\textsuperscript{294}

Roussolakkos valley is presently scattered with olive orchards, a few small agricultural plots, one paved road running from the modern village of Palaikastro to Chiona, several small

\textsuperscript{289} Height designations of peaks from Google Earth and as noted in Cunningham 2012: 4.

\textsuperscript{290} Height and distance measurements from Google Earth and as noted in Cunningham 2012: 4.

\textsuperscript{291} MacGillivray et al. 1984: 135-137; Bosanquet 1901/1902: 287.

\textsuperscript{292} Ta Skaria quarries noted by MacGillivray et al. 1984: 143-149.

\textsuperscript{293} MacGillivray et al. 1984: 137-140.

\textsuperscript{294} The Mediterranean region is generally microtidal, i.e., sea-level variation is not dramatic (Stiros and Blackman 2014: 114-115). Furthermore, Price et al. (2002: 178), although focusing on their research on Sphakia and West Crete, note that, “The current consensus is that the tectonic uplift at active plate margins, such as the Hellenic subduction arc, occurs in discrete and rapid events.”
dirt roads, a few one-story structures, and a few agricultural or pastoral sheds. The most heavily-trafficked dirt road near the current PALAP excavations runs from Chiona beach along the coastline and over the remains of Bronze Age structures that are actively eroding into the sea, to Ta Skaria [refer to Plate 7]. The landscape in the early 1900s also contained olive orchards, although other crops, such as wheat and barley, were grown as well. Comparisons of photographs from the early 1900s and from the present demonstrate that olive trees are now more predominant in the valley and that many of the terraces and field walls visible in the early 1900s have either fallen apart or have been disassembled [Plates 9-10]. Some of this transformation of the valley may be attributable to the sporadic archaeological excavations, changing agricultural practices, and to the occupation of this part of the island by the Italian military during World War II; an Italian guardhouse on the promontory extending from Chiona, several gun implacements, and evidence of related military items are occasionally present, the latter less than half a metre above Bronze Age archaeological materials in the new PALAP area of excavation.

Other transformations not comprehensively considered in surface surveys have been the extensive erosion and aggradation processes near the urban centre. For example, an eroded earth slump area, identified by its stepped crescentic scarp, has changed somewhat since the early 20th century and similar Bronze Age erosion processes have not been considered in terms of their archaeological impact [Plate 11]. For example, a mass event (such as a debris flow) may have caused “deep burial in a single event, [and there may be buried,] rotated and offset structures.” Understanding the post-Bronze Age erosion of the depositional zone (below the source zone)

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295 Recent roads, the beach road which had destroyed House A (excavated in 1902), the coastal structures, modern and ancient terraces and field walls, and recent structures (“two nineteenth-century houses on the central town ridge (50 m south of Blocks Z, Y) both demolished in the 1940s, a Second World War Italian guardhouse on the Promontory (still identifiable by its fasces in plaster relief), and a number of gun implacements, small shepherds' shelters or lean-to's and enclosures, and possibly a cheese-house (or mitato) at the gravel ridge” are noted in PK Survey (MacGillivray et al. 1984: 132-133).

296 MacGillivray et al. 1984: 137-140.

297 Bosanquet 1901/1902: 287.


would aid in reconstructing buried landscape; depositional features will be considered later in the micromorphological study (Chapters 4 and 5).

Indications of landscape use and environmental or climatic conditions at the time of Bronze Age occupation have been largely limited to structural and material remains from excavations, as well as to preserved faunal and archaeobotanical remains. Evidence of olive and grape production has come in the form of charred and preserved seeds/stones/pips, olive- and wine-presses, and olive wood. Storage areas and the LM IB-LM IIIA wells, the latter containing faunal (dog, sheep/goat, cow, pig, and fish) and archaeobotanical (olive, grape, barley, wheat), and almond) remains, may also provide some indication of the Bronze Age landscape and land-use practices surrounding the site. The simple presence of the LM IB wells is believed to provide environmental information, indicating an increased need for local water sources; however, whether this need was due to climatic change, a specific circumstance causing increased water demand, or a combination of climate change and demand, is not clear based only on these well constructions (see Section 5.1.5 and 5.2.3 for further discussion). Understandably, a full grasp of the landscape, and pastoral and agricultural practices that may have affected landscape transformation, cannot be developed from this on-site information alone.

3.1.2.2 Geological setting

It is important to recognize the general geological characteristics of East Crete and the tectonic processes affecting this part of the island so as to understand the types of geological material (rocks and sediments) present and the natural transformative processes that may have


301 MacGillivray et al. 2007.

302 MacGillivray and Sackett, in MacGillivray et al. 2007: 223-224.

303 This region, with a prevalence of phyllite and quartzite, would be ideal for future subsurface studies of potential springs to understand such hydrological changes, as springs are commonly associated with such rock types (Rackham and Moody 1996: 42; Flood 2012: 13).
changed the landscape, and that may be visible during micromorphological analyses. The landscape of the Bronze Age is strongly related to the Quaternary sedimentation that has occurred in the past 12,000 years, which consists mainly of alluvial sediments. The types of sediments present in the Palaikastro basin will be the focus of this summary, rather than the formation processes of the pre-Quaternary geological formations.

Crete was formed in two general episodes: the pre-alpine and alpine orogenesis (mountain-creating events) that occurred in Greece in the Late Oligocene/Early Miocene, approximately 23 million years ago, and the Neogene and Quaternary geological formations that formed subsequently, from ca. 23 million years ago to the present. Thus, a series of underlying nappes are present in varying degrees across the island, but are located beneath younger (Neogene and Quaternary) sedimentary formations and alluvial deposits formed more recently. The Neogene sediments of Eastern Crete are comprised of Late Miocene sandstones, clays, and marls near Moni Toplou, as well as Tripolitza limestones and Pleistocene colluvium near Kato Zakros. Quaternary marine terraces and limestones and terrestrial, reddish conglomerates and sands, were caused by sea-level fluctuations in the Pleistocene. These younger formations and deposits comprise the landscape visible today in Eastern Crete and the topographically-delineated basin surrounding modern and Bronze Age Palaikastro.

Research by Gradstein supplies information on two main Neogene sources of Quaternary sediments that have likely impacted Bronze Age Palaikastro (Fig. 3.1): (1) the Kastri Formation (ca. 100 m thickness), consisting of “reddish-brown silts and reddish-violet clays alternating with ill-sorted conglomerates” and marine deposits of the Palaiokastron Formation on top and (2) the Toplou Formation (ca. 200 m thickness), consisting of “well-stratified and well-sorted

304 Fassoulas 2017; Fassoulas 2000: 14, 21. Neogene period extends from ca. 23 mya until start of the Quaternary, ca. 2 mya.
305 Nappe may be defined as “a body of rock that has undergone considerable horizontal, tectonic transport in an orogenic zone” (Fassoulas 2000: 101); Fassoulas 2017.
308 Fassoulas 2000: 22; Fassoulas 2017.
309 Limestones and fossiliferous marls and sands are noted on Cape Plaka (Gradstein 1973: 540), and the author has observed a prevalence of fossils in Tenda Bay with the potential for future study.
conglomerates, sands, silts, clays, and some limestone intercalations.”  

The coarse conglomerates in the Kastri formation include dark limestone, red and grey schists, and green, igneous rocks; above the base contact with preneogene rocks (which include reddish-brown or violet schists and shales, or recrystallized limestones) are “grey and white silt and clay beds with lignite lenses with gypsum crystals and small, Viviparous-like gastropods.”

In terms of differentiating the conglomerates, which laterally transition (gradually) to the west, the Kastri silts and clays have a distinct reddish colour, whereas sandy intercalations become more frequent in the Toplou Formation; Toplou conglomerates are also generally less coarse and exhibit a greater degree of stratification than Kastri conglomerates. The overlying Palaikastron formation (ca.40 m thickness) consists of “organo-clastic or reefal limestones and Clypeaster and Heterostegina sands, breccias, and conglomerates.”

Figure 3.1 Lithostratigraphic schematic of Neogene formations in East Sitia district (after Gradstein 1973: 531, Fig. 2).

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311 Ibid.: 532-533.
312 Ibid.: 537.
313 Ibid.: 539.
Figure 3.2 Geologic Map of Crete, Eastern Section, 1:50,000 (Institute of Geology, 1959) Kastri formation illustrated to consist of marly limestone (Mi-mk). The new area of excavations is located on the boundary of recent alluvial deposits (al) and yellowish marly sandstone (Mi-ms).

Previous surface and geophysical surveys have noted areas of “red clay,” “stony,” “rocky,” and “fine-grained and compact” surface sediments and subsoil, as well as areas of “shallow soil”—primarily on ridges—across unexcavated areas of the Roussolakkos valley;\(^\text{314}\) however, detailed maps of these geological features do not exist, other than those supplied by Gradstein (1972) and the Institute of Geology (1959) (Fig. 3.2). In terms of rock types present, field observations of the immediate surrounds of Bronze Age Palaikastro (Palaikastro and Kouremenos Beach) have identified dolomite, quartzite (phyllite-quartzite), phyllite/schists (phyllite-quartzite), sandstones (Tripolitza), marbles (including dolomitic marble), and lava.\(^\text{315}\) Preliminary photogrammetric plans have compiled a topographic map of the Roussolakkos

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\(^{314}\) E.g., Bonsanquet 1901/1902: 287, 303, 305; Bosanquet et al. 1902/1903; Dawkins and Currelly 1903/1904: 207, 214, 231; Dawkins et al. 1904/1905: 286, 293.

\(^{315}\) Observations made by field surveys conducted as part of the PALAP 2012-2016 project.
valley; combined with future landscape analyses of the field systems and terraces, some previously described in earlier reports, a reconstruction of geological zones susceptible to erosion/aggradation processes and those likely used for Bronze Age activities will benefit subsequent discussions and research.

3.1.2.3 Tectonic setting

Crete is located in the central part of the Hellenic Arc—which stretches from the Peloponnese to the Taurus Mountains in Southwest Turkey. Neotectonic studies have demonstrated that the relative sea level has changed within the past 2000 years; however, Crete has not acted as a single unit in relation to these changes. West Crete has risen approximately four metres in the past 1000 years; Central Crete has experienced relatively little change; Northeast Crete has experienced submergence, and Southeast Crete has experienced uplift. While tectonic activity has been generally low during the Quaternary period, occasional earthquakes have occurred, and have been observed to have produced coastal uplift or subsidence on Crete, such as those noted in relation to the Early Byzantine tectonic paroxysm (EBTP), which occurred between the middle of the fourth and the middle of the sixth century A.D.

317 Alluvial deposition is likely to have preserved undisturbed habitation sequences; however, the modern vegetation and surface features mask any indications of the archaeological features beneath. Landscape research conducted by the PALAP project under the direction of Orengo (Orengo and Knappett, forthcoming) and Riera (Cañellas-Boltà et al., in prep.) will aid in building this environmental history.
318 Farrand and Stearns 2004.
319 Ibid.: 17.
320 Ibid.
321 Stiros and Papageorgiou 2001: 381. Uplift events have been determined based on the observation of uplifted marine sediments of the Last Interglacial and Late Holocene shorelines (cf. Stiros and Papageorgiou 2001: 381; Pirazzoli et al. 1982; 1996)
Two main methods have been used to identify these general tectonic changes: (1) the coring of unconsolidated sediments at/below sea level and subsequent mineralogical and microfossil analyses of these cores, and (2) the analysis of physiochemical features of coastal limestone outcrops. At Palaikastro, as at other sites, such as Kommos and Mochlos, “the net effect of neotectonism combined with eustatic sea level rise is less easily disentangled.”

Gifford has stated that Palaikastro was originally on the coastline, but that subsequent alluvial aggradation has separated it from the beach. However, excavations of structures on the shoreline, as well as recent coring and underwater observations have demonstrated that may not be accurate and that the actual geologic events may have been more complicated; the Minoan shoreline may have been lower and more distant from the Bronze Age archaeological site than the present one. Future coastal and underwater studies will be essential to determine the exact processes, such as earthquakes and uplift or subsidence events, that have affected the Palaikastro basin, Roussolakkos valley, and coastline since Bronze Age times. (See 5.2.3.3 for further discussion of tectonism).

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325 Ibid.: 28.


327 Coring has been conducted by the PALAP project under the direction of Orengo and Riera.

328 Basic underwater observations made during recreational snorkeling have identified walls of unknown date and evidence of land-based vegetation (an in situ tree stump [Figure 5]) approximately 30 metres east of the present shoreline of Kouremenos Beach.

329 Research by the PALAP palaeoenvironmental team will hopefully clarify this situation.

330 Researchers give differing amounts of trust to the historical earthquake record: Stiros and Blackman (2014) place a good amount of trust in historical earthquake evidence, while Sintubin (2011) and Ambraseys (2006) question their validity.

331 E.g., Stiros and Blackman 2014: 114-115; Stiros and Papageorgiou 2001: 381.


3.1.3 Recent PALAP excavations (2012-2016)

What more can be accomplished in studying the urban settlement to understand the socio-natural systems impacting Bronze Age urban behaviours? Excavating a much larger area of Roussolakkos valley is not necessarily going to assist in answering the types of questions that remain about the meso-scale (public versus private/neighbourhood level) urban behaviours that have been difficult to understand at Palaikastro, as well as at other Bronze Age Cretan sites. Rather, in order to develop an accurate foundation from which to answer these questions, the fine-scale, temporal and spatial resolution of settlement transformations must be achieved. Applying micro-scale geoarchaeological techniques to study the urban contexts, as noted in Chapter 2 and as applied in the PALAP excavation project design, is necessary to attain the degree of resolution essential for making period-specific interpretations of behavioural/settlement changes. This micromorphological data, when analyzed in context with site areas and on-site remains (discussed in Chapter 4), will provide more precise contextual (spatial and temporal) information on urban stratigraphical sequences.

3.1.3.1 PALAP Archaeological evidence

The 2012-2016 PALAP project involved one year (2012) of surface survey within select areas of the Palaikastro basin and one year of post-excavation study (2016) of the materials and information garnered from the three years of excavation (2013-2015). As noted earlier, the 2012 landscape surface survey provided indications of Bronze Age activities in various parts of the Palaikastro basin, not immediately adjacent to the main urban centre, and further analyses of this survey data are currently being compiled for publication [Plate 12]. Simultaneously in 2012, a geophysical survey by ground-penetrating radar (GPR) and fluxgate gradiometry was conducted in a portion of the area that had been geophysically surveyed by electrical resistivity and fluxgate gradiometry in 2001. Although results from the

334 Orengo and Knappett (forthcoming).
335 PALAP BSA Report 2013.
2012 geophysical study indicated certain anomalies, more confidently suggested the possibility of a palace or other large structures in this area.

Prior to the PALAP project, a magnetometry survey covered some 13,000 m², from the known Bronze Age town blocks to the Chiona salt flats, in addition to the 2001 study, which used electrical resistivity and fluxgate gradiometry on an unexcavated area of the Roussolakkos valley—to the southeast of the previously excavated urban centre, between the lower slopes of Petsophas and the salt flat at Chiona. The results from this survey were interpreted as providing evidence for sub-surface structures in seven surveyed zones, including the extension of the main urban area to the East that including a possible, large sub-surface structure [Plate 13].

The first PALAP excavation campaign (2013) involved the excavation of two fields to the East of the three structures subsequently found in the new excavations, which was partially surveyed by the geophysical projects and separated by a modern field wall [Plate 14]. Excavations of a trench in the field on the upper terrace—the Papadakis plot—demonstrated a significant accumulation of sediments devoid of architectural materials. Similarly, initial exploration in the west of the field on the lower terrace—the Argyrakis plot—demonstrated a lack of architecture and significant accumulation of alluvial/colluvial sediments, a portion of which were micromorphologically analyzed and will be discussed in Chapter 4. However,

336 Ibid.: 1.

337 While, the PALAP BSA Report 2013 notes that the opinions of L.H. Sackett and M.S.F. Hood and various other archaeologists supported the idea that there might be sub-surface Bronze Age structures in this area, the Boyd et al. 2006 report (discussing the 2001 study) made confident claims about the geophysics suggesting a palace.

338 MacGillivray et al. 1984: 134.

339 Boyd et al. 2006: 89. The geophysical survey used a Geoscan RM-15 resistance meter with twin probe array and 0.5 probe separation and a Geoscan FM-36 fluxgate gradiometer (Boyd et al. 2006: 96).

340 Boyd et al. 2006: 132. Zones 1-4 and 7 were interpreted as having structures approximately 1 m beneath the modern surface; zone 5 was believed to be under deeper sediments due to modern field terraces preventing sedimentation of zone 4 but causing the accumulation of sediments in zone 5 (Boyd et al. 2006: 132).


342 The lack of architectural and other materials in this area supports observations by J. Peterson (2000) (cited in BSA Report 2013), who noted that there was a “shallow gully” in this area. This was also observed to be a zone devoid of archaeological material in the 1983 survey (MacGillivray et al. 1984: 135, n. 12). Possibly then, this gully also existed during Bronze Age times; this conjecture will be discussed further in Chapters 4 and 5.
architectural features and a greater quantity of artifacts were discovered upon moving the excavations to the eastern end of the Argyrakis plot, immediately next to a modern stone boundary wall that runs perpendicularly (north-south) to the modern terrace wall (running east-west) dividing the Argyrakis from the Papadakis plots [Plate 15].

Using the architectural features that were discovered during the 2013 season as starting points, the 2014 and 2015 excavation campaigns expanded these excavation zones further east into the Mavrokoukoulakis plot as well as more extensively in all directions in the Argyrakis and Papadakis plots [Plate 16]. By the conclusion of the 2015 campaign, the general architectural foundations of three buildings, typologically dated to various phases between the MM and LM III periods, were revealed: Buildings AP1, AM1, and MP1 [Fig. 3.7, Plate 17].

It is curious that, although these three buildings occur in close proximity, and share a particular location separated (possibly by a Bronze Age ‘gully’) from the previously excavated urban area. The buildings may not have been constructed or used simultaneously, nor may they have served similar purposes to those in the urban core. As noted in Chapter 2, it is difficult to begin to form conclusions about urban areas based on architecture and material culture alone, and even more difficult to understand the varying transitional phases between these occupation periods based on such material evidence. Therefore, the aim of the PALAP soil micromorphological study (and this dissertation) is to address the depositional processes and anthropogenic inclusions that can contextualize the urban activities and natural environmental processes affecting the site’s inhabitants, and, subsequently, to possibly develop an understanding of the site’s meso-term, neighbourhood-level processes. The following chapter (Chapter 4) will discuss in more detail the specific areas of the buildings and related areas that were sampled for micromorphological analyses, as well as the observations that are additionally apparent at the micro-scale level.

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343 PALAP BSA Report 2013.
3.1.3.2 PALAP Geoarchaeological/Micromorphological Research

Prior excavations and sub-surface surveys at Palaikastro revealed extensive architecture and evidence for occupation from Early Minoan IIA to Late Minoan IIIB, but little geoarchaeological research has been conducted.\(^{345}\) As noted earlier, three geophysical surveys have been conducted to date: one via electrical resistivity and fluxgate gradiometry in 2001 and one via ground-penetrating radar (GPR) and fluxgate gradiometry (as part of the PALAP project) in 2012.\(^{346}\) It has been challenging to correlate interpretations of the anomalies indicated by the data with actual sub-surface materials, as demonstrated by the failure to correlate such anomalies with architectural structures in the 2013 excavations.

Geological observations made during the 2001 geophysical survey led researchers to hypothesize that “[t]he dense clay layer in the [Roussolakkos] valley could have been deposited suddenly, gradually or spasmodically.”\(^{347}\) However, sub-surface research to test these specific observations in the Roussolakkos valley has not been conducted. While the recent PALAP excavations provide some information on sedimentation rates and processes, these findings are primarily associated with archaeological materials and, therefore, do not necessarily provide information on the natural transformative processes impacting the valley.

Understanding the impact of recent land use and subsequent transformations may help in reconstructing past transformative processes, but, as noted earlier, the Bronze Age environment may not have looked or responded to changes in ways similar to those of our modern environment. Also noted in the 2001 geophysical survey were indications that parts of the valley were actively being plowed,\(^{348}\) which—like the World War II constructions and use of the area as agricultural land—would certainly impact sedimentation and erosion rates. Present-day Palaikastro residents have also indicated that a portion of the Roussolakkos valley excavated in


\(^{346}\) Boyd et al. 2006; PALAP BSA Report 2013.

\(^{347}\) Boyd et al. 2006: 132.

\(^{348}\) Ibid.: 95.
the 2013 campaign (the Argyrakis plot) had been used for viticulture—a practice that could impact sedimentation and erosion rates differently than would certain types of plowing.

Obviously, not all recent variables affecting the previous landscape surfaces and conditions of sub-surface finds may be identified at this time; earlier excavation publications themselves did not record all of the modern landscape uses, including some significant field walls present onsite in the early 1900s [Plate 18]. However, urban micromorphological research can provide a starting point to understand these transformative processes, particularly when connected with palaeoenvironmental research on-site and near the site.

Limited soil micromorphological research was conducted on-site at Palaikastro during the excavation campaigns in the early 2000s. Sediment blocks were obtained during excavations from Building 4, Area 6, Building 7, Street BM, and from the east beach, the last as control samples. The samples were subsequently prepared into thin sections, and are awaiting formal study. Some of these thin sections were, however, previously used in a study with the specific aim of understanding the stratigraphic contexts relating to tephra from the Theran eruption. This research analyzed the Palaikastro promontory and coastal profiles in comparison with select on-site samples from Street BM (east of Building 6). Other analyses of the thin section samples have been paused due to the research restrictions noted above. Nevertheless, the preliminary information from these thin sections have provided a starting point for subsequent comparative analyses of the basic components of these sections with those from the new area of the PALAP excavations.

The goal of the current PALAP soil micromorphological investigations, which are detailed in Chapter 4, is to sample the rooms and spaces being excavated in order to achieve a high-resolution record of the depositional processes and anthropogenic inclusions that can contextualize the urban activities—and thus behaviours—and natural environmental processes

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350 This micromorphological study was conducted in 2003.
351 A future goal is to formally study these samples, as well as to use the samples as comparative controls for the new area of PALAP excavations that also contains tephra (the 2015 samples awaiting export and study permits).
352 Bruins et al. 2008; 2009.
353 Ibid.
affecting the site’s inhabitants. The integration of this micro-scale data with the other auxiliary projects analyzing the human-landscape interactions both on-site and off-site will contribute to an understanding of the nature of human activities and transformative processes at Palaikastro. Moreover, this will open the possibilities for filling in the gaps in our comprehension of the meso-scale processes at Palaikastro, which may assist in understanding the broader trends in East Crete, as well as the environmental sustainability of East Cretan coastal settlements and landscapes over the short and long terms.

Figure 3.3 The Eastern Mediterranean region, showing the location of Crete.
Plate 3.1: Aegean region, showing Bronze Age sites of Tiryns and Pylos (NASA).\textsuperscript{354}

\textsuperscript{354} NASA 2003.
Figure 3.4: Crete, showing locations of some of the major Bronze Age sites.\textsuperscript{355}

\textsuperscript{355} Hamilakis 2014: 322, Fig. 18.1, adapted from Rehak and Younger 1998.
Figure 3.5: Locations of noted Bronze Age sites in East Crete.\textsuperscript{356}

\textsuperscript{356} Rehak and Younger 1998: 102, Fig. 3.
Plate 3.2: Location of Palaikastro within a 30 km basin, surrounded by upland areas (Google Earth).

Plate 3.3: Location of Bronze Age Palaikastro in relation to the beaches of Kouremenos and Chiona, and modern Palaikastro.
Plate 3.4: The Roussolakos valley (centre), in 2014, the location of Bronze Age Palaikastro, with Petsophas (230 m) on the left in the background and the coastal cliffs of Chiona beach (up to approximately 5 m at greatest height from sea level) in the right foreground. This location makes the archaeological site of Palaikastro susceptible to both coastal flooding and inland colluvial and alluvial processes.
Plate 3.5: Coastal cliffs of Chiona beach, up to approximately 5 m at greatest height from sea level (note the 2 m stadia rod; arrows mark top and bottom). View from South, in 2014.
Plate 3.6: Structures eroding (due to wave action) on promontory at Chiona, in 2014. (Stadia rod is 2 m).
Plate 3.7: Stadia rod (2 m, running East-West) highlighting structural stones at the edge of the coastline and Chiona, in 2014.
Plate 3.8: Underwater photo of an *in situ* tree stump, approximately 30 m from the beach of Kouremenos, demonstrates that the shoreline at some time extended farther east than the modern one, in 2014.
Plate 3.9: Field walls and terraces in the Roussolakkos valley ca. 1900 (SPHS 9290). View towards the north with Kouremenos Bay in the centre and the western edge of Kastri on the right side.
Plate 3.10 (A/B): View from the lower slopes of Petsophas, looking northeast towards Kastri. Note the greater presence of open fields in the early 20th century photo as opposed to olive trees and shrubs (A: PK4, ca. 1900, versus B: 2015).

Plate 3.11 (A/B): View over old/current excavation areas looking towards earth slump. Note the horseshoe-shaped earth slump is more defined (has undergone additional erosion) in the recent photograph (A: PK 52 / 7088, ca. 1900 (Entrance of Palace, #C early megaron, in Delta; B: 2015).
Figure 3.6: Plan of Bronze Age Palaikastro (including inset Block M) (Knappett and Cunningham 2003: Fig. 17.1).
Plate 3.12: Locations of surface surveys in survey phase of PALAP project.
Plate 3.13: Locations 2001 geophysical survey (Boyd et al. 2006) and PALAP 2013 excavation areas.
Plate 3.14: Palaikastro excavation areas (prior to excavation) in 2013 season (PALAP BSA Report 2013: 3, Fig. 4).
Plate 3.15: (A): View towards the southwest from the 2013 excavations (July 22), showing the modern stone boundary wall (running north-south), perpendicular to the stone terrace wall that supports the Papadakis plot, which is at a higher elevation than the Argyrakis plot (the latter actively being excavated in this photograph). (B): View towards the southeast from the 2013 excavations (July 22), showing the stone terrace that supports the higher-elevated Papadakis plot.
Plate 3.16: Site overview of 2014 excavation areas (PALAP BSA Report 2014: Figure 1).
Figure 3.7: Illustration of architectural layouts of Buildings AP1, AM1, and MP1 (including locations of 2014 micromorphological samples from buildings).
Plate 3.17: Aerial photographs of Buildings AP1, AM1, and MP1, taken in 2015.
Plate 3.18: Photos of early Palaikastro excavations from ca. 1900. (A): In the background, a modern wall with what appears to be windows is visible. (B): Interior of Block Γ from Block E (PK 46), showing modern field walls in the background. Such substantial modern constructions would recently have impacted sedimentation and erosion rates affecting the Bronze Age site.
Chapter 4: Archaeological Soil Micromorphology
Methodology and Observations

Premise: As advocated in Chapters 2 and 3, necessary to understanding human-environment interactions at Palaikastro is a micromorphological methodology that both reduces survey and study biases attributable to differential erosion and aggradation processes and elucidates environmental influences within the urban settlement. While it may not be possible to account for all depositional biases across the different settlement zones at Palaikastro, the information garnered from micromorphological samples from multiple urban contexts and control areas across the site serves to provide multiple lines of comparable evidence essential to answer broader sociocultural and environmental research questions.

While members of the PALAP Project seek to investigate the overall settlement in its surrounding local and regional landscape, in this dissertation project I aim to fulfill the on-site, urban geoarchaeological component, which I will subsequently compare to off-site research results. The following micromorphological data will provide the degree of resolution essential in making period-specific (and intra-period) interpretations of the anthropogenic urban activities and natural environmental processes within the rooms and spaces being excavated. This micromorphological data, when combined with detailed on-site excavation contexts and off-site palaeoenvironmental data, will provide a more precise and accurate scale of spatial and temporal resolution than can be accomplished from material data alone.
4.1 Micromorphological Methodology

“[G]eoarchaeology stands in contrast to other fields within the archaeological sciences, such as zooarchaeology and paleoethnobotany, which have explicit research objectives that, while complementing the overall agenda of a multidisciplinary project, stand on their own as legitimate research goals.”357

The goal of the soil micromorphological investigations conducted as part of this dissertation research has been to sample the rooms and spaces being excavated in order to achieve a high-resolution record of the depositional processes and anthropogenic inclusions that enable the contextualization of the on-site human activities and the natural environmental processes affecting the site’s inhabitants. As the micromorphological research process was affected by the findings in the active excavations, the micromorphological methodology employed was one of purposive sampling and post-excavation hypothesis-testing based on the actively changing areas of interest and developing research questions; the micromorphological investigations themselves did not have an initial research objective outside of these aims.

The approach used to determine the on-site areas that were sampled for micromorphological analysis was largely determined by the individual trench/area supervisors, thus not following a ‘microfacies approach’ for the micromorphological study from the beginning. A ‘microfacies approach’, which would have been employed to study a particular microfacies unit—“a discrete stratigraphic entity that can be distinguished based on its microscopic characteristics”—laterally across a site,358 would have been appropriate to apply to this initial study had a particular stratigraphic unit of interest been identified across the site. Due to the fact that the buildings in the new area of excavation may not have been used during the same periods, selective micromorphological sampling was employed to answer questions about use of space and transitional phases within individual rooms and spaces,359 in line with

357 Miller and Mentzer (pers. comm. 2016).
358 Ibid.
359 In the 2015 season, one microfacies type was sampled across the site—the tephra microfacies—which is currently being processed, and thus not included in this study.
the goal of achieving a high-resolution record of the depositional and anthropogenic processes affecting individual rooms and spaces.

During the three years of excavations and study at Palaikastro by the PALAP Project (2013-2015), the developing nature of the archaeological research questions affected the questions that the micromorphology project has attempted to answer. The micromorphological study served as a tool to answer other archaeological questions over the course of the excavations. Research questions changed because of several factors: 1) the finding of a potential gully separating the new area of excavations from the main urban area to the west, which raised questions of site development and maintenance, and micromorphological aims of assessing sedimentation sources and rates; 2) the finding of LM I material immediately beneath the modern surface in one area (Building MP1 area) and LM III below the surface in others (Building AP1 area, some of the Building AM1 area), which raised questions of the effects of post-Theran eruption-related events and micromorphological aims of assessing post-depositional processes and “abandonment” and “collapse” sequences; and 3) the preliminary observations of the micromorphological thin sections after their production, which raised questions of intra- and inter-period transitional phases (the formation of these hypotheses was only possible after observing the thin sections, after excavations had ended).

The fact that micromorphological questions were not fully developed until the post-excavation micromorphological research had commenced led to the subsequent implementation of a ‘microfabric approach’ during the organization of observational data during initial thin section analysis. In this study, the term ‘microfabric’ is employed because it is being used to define similar types of soil ‘fabrics’ in site sediments, which do not necessarily occur along the same horizontal plane. Furthermore, many of the micromorphological samples, such as the

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360 The idea that micromorphology differs from other proxy studies by nature of its technique in that observations cannot necessarily be made when sampling, nor particular hypotheses tested until initial thin section analysis is conducted, is noted by Miller and Mentzer (pers. comm. 2016).

361 It has been considered acceptable practice to utilize a particular approach in the initial geoarchaeological analysis of a site (e.g., microfacies approach) and to subsequently decide to communicate the date in a different format (e.g., semi-quantitative frequency/description tables) (Miller and Mentzer (in press); Goldberg and Macphail 2006).

362 Soil ‘fabric’ may be defined as “the organization of a soil, expressed by the spatial arrangements of the soil constituents, their shape, size, and frequency, and considered from a configurational, functional and genetic
gully (Trench A2) and Trench A3 samples, are composed of texturally homogeneous sediments without distinct contact boundaries, and so are not suitable for the ‘microfacies approach’. Furthermore, the multiple time periods represented in the PALAP samples negate the applicability of identical horizontal correlation, but rather similarities in practices and processes may be identified by particular microfabric types (e.g., floor types, abandonment types, debris flows, etc.). Nevertheless, the purpose of establishing microfabrics types is the same as establishing microfacies types—to aid in separating observations from interpretations and to “help reduce complexity and help identify patterns.”

4.1.1 Sampling Technique and Processing

The micromorphological sampling involved the collection of undisturbed soil monoliths, approximately 10 - 15cm x 10 - 15cm x 10 - 40cm (soil stability conditions necessitated the removal of smaller and larger samples to ensure intact preservation of the monoliths), and the additional collection of 200 - 300 g of bulk soil associated with each monolith, in the site excavation areas. The monolith samples were collected by encasing them in plaster and plastic PVC tubes. The monoliths were dried, prior to shipment, outside at the PALAP apothiki under upturned ceramic vessels. For shipment, the samples were wrapped in bubble wrap, and securing them with tape (for more stability for shipment). The bulk soil samples were then placed in plastic bags and double-bagged. The samples were then shipped to Spectrum Petrographics, Inc (Vancouver, WA) for further processing.

In order to be analyzed microscopically, samples were first embedded in epoxy resin and dried (prior to trimming into thin sections); this embedding stage of the process was completed by Spectrum Petrographics, Inc. Second, the embedded blocks were trimmed and ground to size, while preserving the rest of the block for future reference; this stage was also completed by viewpoint)” (Bullock et al. 1985, in Stoops 2003: 34). ‘Microfabric’ is use to described the microscopic observations of these features.

363 In a ‘microfacies approach’, distinct ‘facies’ are characterized by their common occurrence over particular horizontal trajectories (Miller and Menzter, pers. comm. 2016).

364 Miller and Mentzer (pers. comm. 2016).
Spectrum Petrographics, Inc. The thin sections were then trimmed from all of the monolith samples and were processed into petrographic thin sections 50 x 75 mm and 30µm thick by Spectrum Petrographics, Inc. After preparation into thin sections, the samples permanently preserved the archaeological stratigraphy, in contrast to the rest of the associated soils removed during the excavations.

### 4.1.2 Data Collection and Analysis

Subsequently, the thin sections were analyzed by the author at the University of Toronto and the University of Tübingen. A preliminary analysis was conducted by making an assessment of all of the thin sections with the naked eye and by binocular microscope with limited magnification (10x - 60x). The thin sections were also scanned at high-resolution, and the scanned images were used to observe potential differences and boundaries between different microfabrics. Subsequently, the thin sections were analyzed with a petrographic microscope in plane-polarized (PPL) and cross-polarized (XPL) light at magnifications ranging from 10x to 400x. After identification of the different types of microfabrics, systematic description of all of the thin sections followed.

Only after the micromorphological observations were made, and microfabric types confirmed, were interpretations of the data made in relation to their immediate geoarchaeological contexts, to archaeological (anthropogenic) data from excavations, and to palaeoenvironmental studies. In the following sections (Sections 4.2 and 4.3), the contexts of the micromorphological samples will be described in terms of their floor/fill sequence descriptions, which will be organized by site area/building and space/room, followed by general observations and interpretations. A brief summary of all of the microfabric types follows (Section 4.4), and a more detailed discussion of the results is presented in Chapter 5.

Due to the small size (stratigraphic dimensions) of the sections, the finite thickness of each section (30 µm), and the small overall sample size, which is characteristic of soil

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365 This approach is recommended by Mentzer and Miller (pers. comm. 2016) in the microfacies approach and in Stoops 2003: 131-132.

366 These systematic descriptions follow the terminology and protocols outlined by Stoops (2003), Courty et al. (1989), and Bullock et al. (1985).
micromorphological thin section studies, subsequent interpretations will need to be reconsidered with the inclusion of additional samples from new contexts as well as other archaeological and proxy data, as this becomes available. Percentages listed for the various components of the thin sections are estimates of abundance and should be read as such; thus, all percentages are indicated with a ‘~’ symbol. For quantities ≤ 10%, approximations are within 1% (e.g., ~2% signifies 2±1%); for quantities ≥10%, approximations are within 5% (e.g., ~15% signifies 15±5%). Estimates of grain sizes are likely lower than actual grain sizes due to the two-dimensional observations made of the three-dimensional grains. Where single or very few occurrences of materials—particularly bone, charred organic material, ceramic, and shell—were observed, these observations are noted as <1% of the matrix or groundmass.

### 4.2 2013 Excavations: Argyrakis Plot

Twenty-two sediment samples, in two trenches in the Argyrakis plot, were taken during the 2013 excavations at Palaikastro in order to analyze the depositional context of the archaeological stratigraphy (Plate 4.1). The samples were obtained from two different trenches, Trench A2 and Trench A3. The samples were taken from the trench walls and baulks, ensuring that the samples overlapped the indistinct unit boundaries. Sixteen samples were collected from the excavated area A2, covering thirteen unit contexts (#2003, #2004, #2006, #2007, #2008, #2009, #2010, #2011, #2012, #2013, #2014, #2026, and #2028) (Table 4.1, Plate 4.1, 4.2, Fig. 4.1). Bulk soil samples of approximately 200 - 300 g were also removed from this trench. Six samples were collected from the Trench A3, covering five unit contexts (#3008A, #3008B, #3009, #3010, and #3013) (Table 4.2, Fig 4.2, Plates 4.13A-C). Four bulk soil samples of approximately 200 - 300 g were also removed from the contexts associated with the soil monoliths obtained from A3 for subsequent geochemical analyses. The general observations and contextual information of each of these samples is organized below by sampling location in their respective trenches, as well as in Section 4.4, by microfabric types.

Additionally in 2013, bulk sediment samples of 200 - 300 g each, were taken from other site areas for subsequent optical and non-optical pedo-geological procedures to understand site

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sedimentation, anthropogenic deposition, and pedogenesis. A total of twenty bulk sediment samples from the Argyrakis plot (covering trenches A1, A2, A3, A4S, A4N, and A5) were selected for pH testing with the aim of further understanding the taphonomic processes and soil preservation qualities across the site. All twenty soil samples were demonstrative of alkaline soil environments, ranging from pH 7.87-9.07, with an average 8.65 and median of 8.71 [Appendix 1]. This indicated a preservation potential for molluscs and bone, although phytolith preservation is anticipated to be minimal with a pH > 8. These alkaline levels reflect the parent material of the site, as well as the carbonate nodules and crusts found on pottery and other artifacts.

4.2.1 Trench A2

Between the earlier-excavated settlement to the west and the three buildings recently uncovered in the 2014 excavations, the 2013 excavations revealed a stratigraphic exposure (Trench A2) of more than 4 m in depth. Although Trench A2 was devoid of any major archaeological and architectural features (i.e., walls, floors, etc.), the exposure provided an ideal geoarchaeological opportunity to evaluate near-site depositional processes and taphonomic conditions, as noted above. General observations and contextual information of the thin sections created from the sixteen monoliths from Trench A2 are noted below, organized by related context groups assigned during excavations, as some contexts are present across multiple monoliths (Plate 4.1, Table 4.1). Basic micromorphological interpretations are also provided; these interpretations will be further discussed in relation to their site context in Chapter 5.
Figure 4.1. Locations of A2 monoliths in Trench A2. Depths are recorded at relative metres above sea level (masl) (Section drawing by Kulick).
Plate 4.2. Sample monoliths in east profile of Trench A2 in 2013, prior to removal; areas of A2MM1 and A2MM2 are not pictured (Photo by Kulick, 2013).
Table 4.1. Sample inventory Argyrakis plot, Trench 2 (2013).

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Bulk Sample No.</th>
<th>Context units (#)</th>
<th>Ceramic/typological designation</th>
<th>Vertical Location (digital GPS, masl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2MM8</td>
<td>#2012.001</td>
<td>2012</td>
<td>2012: LM IA</td>
<td>22.68-22.43 masl</td>
</tr>
<tr>
<td>A2MM9</td>
<td>#2012.001</td>
<td>2012</td>
<td>2012: LM IA</td>
<td>22.49-22.22 masl</td>
</tr>
<tr>
<td>A2MM12</td>
<td>N/A</td>
<td>2014</td>
<td>2014: MM</td>
<td>22.01-21.75 masl</td>
</tr>
<tr>
<td>A2MM15</td>
<td>#2026.003-.004</td>
<td>2026</td>
<td>2026: MM I-II</td>
<td>21.43-21.03 masl</td>
</tr>
<tr>
<td>A2MM16</td>
<td>#2026.003-.004</td>
<td>2026, 2028</td>
<td>2026: MM I-II 2028: MM IA</td>
<td>21.09-20.74 masl</td>
</tr>
</tbody>
</table>

4.2.1.1 Post-Minoan (Units #2003-2004)

Thin sections A2MM1A, A2MM1B, A2MM1C, A2MM2A, A2MM2B, and A2MM2C are related to context units #2003 and #2004, which were identified as Post-Minoan due to their containing modern materials (Plate 4.3A-F). #2003 (5 YR 6/4) was a compact and stony layer, with sparse ceramic sherds and some bone and shell fragments. Tumbled stones were also noted by excavators. #2004 (5 YR 6/4) was noted by excavators as a hard soil with sparse sherds as well, and likely modern. There was no definite distinction between these two layers, both of which seem to relate to modern materials.
**General observations**

The sediment in units #2003 and #2004 is primarily composed of sand, clay, and silt, with a poorly- to moderately-sorted close porphyric coarse/fine \((c/f_{10\mu m})\)-related distribution of approximately 70/30, with iron/manganese nodules \((20 \mu m - 500 \mu m)\) (~5%), organic material (shell fragments (~1-2%), modern roots (~1-2%), a few dark brown organic residues (~2%),) and areas of clay and diffuse iron impregnation and depletion. In the thin sections, the sand—mainly smooth, angular to rounded grains of quartzite, phyllite, and sandstone—consists dominantly of very fine sand \((v.f.s.)\)-size \((20 - 100 \mu m, ~40\%)\) to fine sand \((f.s.)\)-size \((100 - 500 \mu m, ~10\%)\), with medium sand \((m.s.)\)-size \((200 - 500 \mu m, ~2-5\%)\), coarse sand \((c.s.)\)-size \((500 - 1000 \mu m, ~5\%)\), very coarse sand \((v.c.s.)\)-size grains \((1000 - 2000 \mu m, ~1-5\%)\), and occasional fine gravel \((f.g.)\)-size grains \((>2000 \mu m, ~1-5\%)\). Carbonate \((calphartic)\) nodules and fragments of m.s.- to f.g.-size (~2%) also occur (Plate 4.4A), and the silt-size component \((2-20 \mu m)\) is ~20% of the groundmass. The iron/manganese \((Fe/Mn)\) nodules are present in all samples, generally occurring in distributions of v.f.s. to m.s.-size, ~5%, with most fragments being v.f.s.- to f.s.-size ~4%. The Fe/Mn nodules in all sections are dominantly orthic typic (~90%), with few disorthic typic impregnative nodules (~10%) in A2MM1C.

The sections all have complex, massive microstructures; A2MM2C displays an increase in ped development with moderately developed, partially-accommodating peds. All sections also display complex \((vughy/vesicular and channel)\) intrapedal microstructures with semi-smooth channels \((f.s.-m.s., ~10\%)\) and semi-smooth typic vughs/vesicles \((m.s., ~10\%)\), with a total intrapedal porosity of ~20% (Plate 4.4B).

**Interpretations**

The dominant microfabric \((MF1v,\) Plate 4.4B) in the thin sections may represent two post-depositional processes: (1) the vughy nature of the microstructure with some channels may indicate that the sediment is easily affected by water in heavy rains, and thus has the potential to
be transported easily, and tillage/plowing tools may affect the development of such sediment\textsuperscript{368}, (2) as the formation of vesicles may occur due to air being incorporated into a water-saturated sediment close to the surface,\textsuperscript{369} the vesicular nature of the microstructure may simply relate to the relatively shallow depth of these samples.

Alternatively, the formation of the vughy/vesicular microstructure may have formed through depositional, debris flow processes.\textsuperscript{370} The characteristics of the groundmass and pedofeatures—the generally poorly sorted, porphyric c/f\textsubscript{10µm}-related distribution of the groundmass, the crystallitic b-fabric, the lack of laminations/bedding, the silty and loamy composition, the massive and vughy/vesicular microstructure (vesicles indicating liquefaction), and the subangular and subrounded aggregates, fit with characteristics of debris flow sediments and microfacies.\textsuperscript{371} Furthermore, a debris flow would be a likely process affecting this area of the site, as the slopes of Petsophas are sufficiently steep to initiate a debris flow.\textsuperscript{372} Debris flow deposits and evidence of earth slumps near the excavation site are actively affecting the modern landscape (Plate 4.4E/F). When compared to the geological control samples, the nature of these sediments relate well, in terms of composition and degree of roundedness, to the Kastri alluvial deposits and river sands from nearby the site (Plate 4.4C/D).\textsuperscript{373}

As the porosity of the debris flow may be affected quickly by pedogenesis\textsuperscript{374}, it is not surprising that the microstructure of these sections demonstrate void collapse and reworking. It is possible that these materials were affected by subsequent, recent human (agricultural/cultivation) activities or other post-depositional processes. Dusty clay coatings and

\begin{itemize}
\item \textsuperscript{368} Pagliai et al. 2004.
\item \textsuperscript{369} Stoops 2003: 64-65.
\item \textsuperscript{370} “Debris flows correspond to flows of liquefied sediments. They are initiated by the removal of loose debris accumulated in gullies or by the transformation of landslides into a slurry following a rainstorm” (Betran and Texier 1999: 108). Also, local, ‘sorted’, laminated silt and clay bodies within massive debris have been observed in hyperconcentrated mud flows by Karkanas and Goldberg (2013).
\item \textsuperscript{371} Iverson 1997: 245; Boggs 2006: 47; Betran and Texier 1999: 108-109.
\item \textsuperscript{372} “Debris flows are generally initiated on steep slopes (>10°), but they can flow considerable distance on gentle slopes of 5° or less” (Boggs 2006: 46).
\item \textsuperscript{373} J. Gait, Fitch Laboratory, pers. comm. 2017.
\item \textsuperscript{374} Betran and Texier 1999: 109.
\end{itemize}
areas of calcitic and iron impregnation and depletion indicate illuviation and suggest that these thin sections now represent an E/Bt horizon.\textsuperscript{375}

\textsuperscript{375} Stoops 2010: 373.
Table 4.2. A2MM1 and A2MM2 sedimentary characteristics and micromorphological features based on thin section analysis

<table>
<thead>
<tr>
<th>Sample</th>
<th>Sorting</th>
<th>Rounding</th>
<th>Coarse fraction</th>
<th>Textural pedofeatures</th>
<th>Fine fraction</th>
<th>Void coatings</th>
<th>Fe/Mn nodules</th>
<th>Intercalations</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2MM1A</td>
<td>Poorly/moderately sorted</td>
<td>Smooth, sub-angular to sub-rounded</td>
<td>X X No Yes (~1%) Dusty clay hypocoatings</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2MM1B</td>
<td>Poorly/moderately sorted</td>
<td>Smooth, sub-angular to sub-rounded</td>
<td>X X No Yes (~1%) Typic dusty clay hypocoatings (and cappings) around voids; calcitic formation around some channels</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2MM1C</td>
<td>Poorly/moderately sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X X No Yes (~1%) Dusty clay hypocoatings</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2MM2A</td>
<td>Poorly/moderately sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X X Yes (~1%) Yes (~1%) Typic clay hypocoatings (and cappings) around voids; calcitic formation</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2MM2B</td>
<td>Poorly/moderately sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X X No No Typic clay hypocoatings around some voids (fewer than A2MM2A)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2MM2C</td>
<td>Poorly/moderately sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X X No Yes (~1%) Typic clay hypocoatings and Fe impregnation around voids</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Plate 4.3A. A2MM1A demonstrates a massive and vughy intrapedal microstructure typical of MF1v microfabric type and a close porphyric c/f10µm-related distribution of 70/30.

Plate 4.3B. A2MM2A consists of the MF1v microfabric type, with a massive and vughy intrapedal microstructure. One large clay panning/intercalation is present at bottom of section (4 - 5mm in length).
Plate 4.3C. A2MM1B consists of a massive and vughsy intrapedal microstructure; some vertical cracks are visible. Its MF1v microfabric type groundmass includes very rounded ceramic fragments and one large rounded carbonate nodule (1 - 1.5 cm) at the bottom of the section.

Plate 4.3D. A2MM2B appears to be identical to the main groundmass (MF1v microfabric type) in 2MM2A, with a massive and vughsy intrapedal microstructure. The void structure appears to exhibit a slight decrease in porosity towards the bottom of the section.
Plate 4.3E. A2MM1C exhibits a massive and vugy intrapedal microstructure with some cracks. The section (MF1v) appears to have a similar groundmass to A2MM2A and A2MM2B, which a slight increase in c.s.-v.c.s.-size grains (~10%).

Plate 4.3F. A2MM2C displays an increase in ped development with moderately developed, partially-accommodating peds, as well as a vugy intrapedal microstructure. Overall, the section appears to have more of a cracky microstructure than the overlying sections.

Plates 4.3A-F. Thin sections A2MM1A-C and A2MM2A-C.
Plate 4.4A. Rounded carbonate (calcitic) nodule, approximately 1.75 cm wide, in A2MM1B (PPL). The rounded nature of this carbonate nodule is most comparable to the roundedness of river sands or beach sands from Palaikastro (pers. comm. J. Gait 2017).

Plate 4.4B. (Photomicrograph approx. 5mm in width) Vughy/vesicular and channel microstructure (MF1v), present in all thin sections in units #2003 and #2004 (shown here in A2MM2B in PPL). This vughy/vesicular microstructure and the separation of the matrix in dark and lighter areas may relate to liquefaction and the debris flow processes that potentially deposited the sediment.

Plate 4.4C. Geological sample GSPK24 from red alluvial 'Kastri' deposits (XPL); the composition (mixture of different mineral types) appears to be identical to that of the on-site material (reference sample and photomicrograph provided by J. Gait 2017).

Plate 4.4D. Geological sample GSPK19 from river sands (XPL); these river-sands demonstrate more sub-angular rounding as well as frequent shell fragments (not pictured); this material appears similar to some of that from #2003 and #2004 (reference sample and photomicrograph provided by J. Gait 2017).
Plate 4.4E. (Above). View from slope gully with debris flow deposit, looking towards the 2015 excavation areas (Photo by Kulick, 2015). Debris flow processes may have caused the sedimentation of portions of trench A2, and the site in general.

Plate 4.4F. View looking up slope gully with debris flow (Photo by Kulick, 2015).

Plates 4.4A-F. A: Photomicrograph of A2MM1B (carbonate nodule); B: photomicrograph of A2MM2B (vughy vesicular microstructure); C: Geological sample GSPK24 from red alluvial ‘Kastri’ deposits (XPL); D: Geological sample GSPK19 from river sands (XPL); E: View from slope gully with debris flow deposit, looking towards the 2015 excavation areas; F: View looking up slope gully with debris flow, in 2015.

### 4.2.1.2 Post-palatial, LM III / LM IIIA (Units #2006 and #2007)

Sections A2MM3A, A2MM3B, A2MM3C, A2MM4A, A2MM4B, and A2MM4C are associated with context units #2006 and #2007 (Plates 4.5A-F), and have been assigned tentative dates of LM III based on the associated ceramic finds; however, #2007 may also contain some LM I material. Since deeper units below #2007 contain only Neopalatial material or earlier, this may indicate some post-depositional mixing in #2007. In the field, #2006 (5 YR 6/4) began beneath a layer of larger stones (noted to be discontinuous throughout the trench); #2007 (5 YR 4/4) includes a heavier ceramic concentration (about 20cm in thickness), which starts in the area of A2MM3B, and ends in the area of A2MM4B, as well as smaller stones; the context ends
below a level of particularly heavy ceramic concentration (~4cm in thickness). In the NW of the trench, there are traces of charred organic material.

*General observations*

The sediment in units #2006 and #2007 is primarily composed of sand, clay, and silt, with a moderately-sorted close porphyric coarse/fine (c/f\(10\mu m\))-related distribution of approximately 70/30, with iron/manganese nodules (20 \(\mu m\) - 500 \(\mu m\)) (~5%), organic material (bone fragments (~1%) (Plates 4.6C/D), shell fragments (~1-2%), modern roots (~1-2%), a few dark brown organic residues (~2%), and areas of clay and diffuse iron impregnation and depletion. In the thin sections, the sand—mainly smooth, angular to rounded grains of quartzite, phyllite, and sandstone—consists dominantly of very fine sand (v.f.s.-size (20-100 \(\mu m\), 40-50%) to fine sand (f.s.-size (100 - 500 \(\mu m\), ~10%), with medium sand (m.s.-size (200 -500 \(\mu m\), ~5-10%), coarse sand (c.s)-size (500 - 1000 \(\mu m\), ~1-5%), very coarse sand (v.c.s.-size grains (1000 - 2000 \(\mu m\), ~0-5%), and occasional fine gravel (f.g.-size grains (>2000 \(\mu m\), ~2-10%); the f.g.-size grains, which are rounded to subrounded, increase in frequency from A2MM3B and below. The silt-size component (2 - 20 \(\mu m\)) is ~20% of the groundmass. Orthic typic and disorthic typic impregnative iron/manganese nodules are present in all thin sections as well, generally occurring in distributions of v.f.s. to m.s.-size, ~5%, with most fragments being v.f.s.-to f.s.-size ~4%. All sections exhibit reddish brown, crystallitic b-fabric in XPL.

The sections (all with MF1v and MF1 microfabric types) all have massive, vughy/vesicular, and channel microstructures with semi-smooth channels (f.s.-m.s., ~ 5-10%), semi-smooth typic vughs/vesicles (m.s. - c.s., ~5-10%) and a total intrapedal porosity of ~15-20%, but A2MM3B and A2MM4A exhibit increased ped development. A2MM3B additionally has moderately developed and separated, partially-accommodating, vertically-separated peds (Plate 4.5C). A2MM4A has a weakly developed, moderately separated, partially-accommodating, vertically-separated peds (Plate 4.5B). In the field diagram (Fig. 4.1) A2MM3B and A2MM4A were noted to share the unique context of increased ceramic and pebbled concentration; thus, an observation in increased ped development in both of these sections is appropriate given the related context. A2MM3A is the only section to contain a small zone of the MF4 microfabric type, a chito-gefuiric distribution with graded bedding and coarse grains with increased degrees of roundedness and sphericity (Plates 4.5A, 4.6H).
Also notable, in A2MM3A, is an area of silty sandy laminations/bedding, which could have been formed by rapid water movement, rather than illuviation, the latter which would not produce bedding (Plates 4.6A/B).\footnote{More gradual suspension depositions of very fine clay may occur over months or years, in contrast to rapid bedding formation (Boggs 2006: 78).} In all sections, typic dusty clay hypocoatings occur (Plate 4.6E), as well as areas of iron impregnation and depletion around the voids, which increase in intensity with A2MM4A and below. Calcite formations and sparitic calcitic pendants occur around the larger mineral grains (Plate 4.6E).

\textit{Interpretations}

The overall homogeneous nature of the groundmass of the thin sections, the lack of ped development in all sections (except A2MM3B and A2MM4A), the vughy/vesicular and channel microstructure, and the presence of rounded allochthonous carbonate nodules and very rounded ceramic fragments support the notion that this sediment (MF1v) was deposited by colluvial/alluvial processes, possibly a debris or overland flow.\footnote{Stoops 2010: 941; Goldberg 1979; Nodarou et al. 2008; Betran and Texier 1999.} The vughy/vesicular and channel microstructure may also be relate to hyperconcentrated flow events.\footnote{Betran and Texier 1999: 109.}

The zone of MF4 microfabric in A3MM3A may relate to different depositional processes. The smoothness and sphericity of the sand grains, as well as decreased clay content, in MF4 suggests that these grains come from a different sediment source subjected to weathering (such as an aeolian or riverbed source) than those comprising the MF1 and MF1v microfabrics.\footnote{Comparable samples from a Palaikastro riverbed and a Palaikastro beach demonstrate similar degrees of roundedness (Plate 4.4D, 4.10B).} Nevertheless, the MF4 fabric displays reverse graded bedding; normally graded bedding (fining upwards) is typically suggestive of slow water action,\footnote{Betran and Texier 1999: 102.} while reverse graded...
bedding (coarsening upwards) may relate to sediments lain by debris flow\textsuperscript{381} or by aeolian processes.\textsuperscript{382}

The greater degree of ped development in A2MM3B and A2MM4A may indicate a different depositional episode, possibly an overland flow deposit from across the site;\textsuperscript{383} the increased concentration of rounded ceramic fragments in this layer (part of #2007) indicate that this sediment may have been transported from, or across, the site into this location. The localized evidence of silty sandy laminations or bedding in A2MM3A, which may have been produced rapidly, by a single water deposition events such as a flooding event,\textsuperscript{384} could also have been formed rapidly in sequences of massive overland flow deposits, which may typically be found “downslope of large gullies.”\textsuperscript{385} The lack of silty sandy laminations and evidence of sorting in other sections may be due to subsequent “[c]ompaction and pedogenic modification [which] tend to erase lamination and bedding within fine-grained deposits.”\textsuperscript{386}

The possible temporal correlation between these contexts, based on ceramic typological dating (LM III/IIIA), and contexts that also demonstrate rapid deposition of silty sandy lamina in Building AP1, Room 3(a) and Room 4 (LM III), the laminations or bedding and MF4 microfabric type in A2MM3A may indeed relate to the silty sandy laminae and MF4 type in AP1 (Section 4.3). Potentially, the MF1v microfabric in these contexts (#2006 and #2007) in Trench A2 may also be related to similar processes in MF1v microfabrics in Building AM1 (Section 4.3). However, potential flooding, aeolian processes, and overland flow events may have been related to different (water- and wind-influenced) conditions in different (LMIII or later) temporal phases.

\textsuperscript{381} Flügel 2004: 184.

\textsuperscript{382} Sumner 2014.

\textsuperscript{383} Betran and Texier 1999: 101-102.

\textsuperscript{384} Boggs 2006: 78.

\textsuperscript{385} “Massive deposits represent areas of hyperconcentrated flow accumulation…or areas where accretion is slow and post-depositional perturbations such as splash, bioturbation, and freezing and thawing are strong” (Betran and Texier 1999: 102).

\textsuperscript{386} Betran and Texier 1999: 102.
Table 4.3. A2MM3 and A2MM4 sedimentary characteristics and micromorphological features based on thin section analysis

<table>
<thead>
<tr>
<th>Sample</th>
<th>Sorting</th>
<th>Rounding</th>
<th>Coarse fraction</th>
<th>Textural pedofeatures</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2MM3A</td>
<td>MF1v, Poorly/ moderately sorted; MF4, well sorted</td>
<td>Smooth, sub-angular to sub-rounded and rounded</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>A2MM3B</td>
<td>Poorly/ moderately sorted</td>
<td>Smooth, sub-angular to sub-rounded</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>A2MM3C</td>
<td>Poorly/ moderately sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>A2MM4A</td>
<td>Poorly/ moderately sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>A2MM4B</td>
<td>Poorly/ moderately sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>A2MM4C</td>
<td>Poorly/ moderately sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
Plate 4.5A. The groundmass of A2MM3A consists mainly of the MF1v microfabric type, but also includes, near the top of the section, a zone of the MF4 microfabric type, a chito-gefuric groundmass with reverse graded bedding with an intrapedal porosity of ~20% and compact bridge grain and vughy/vesicular microstructure. The inverse bedding is very bioturbated and fragmented, and the intrapedal porosity is greater at the top of section and more compact towards the bottom of the section.

Plate 4.5B. Some ped development starts to become apparent in A2MM4A, as well as an increased amount of ceramic fragments. The section is mainly massive with weakly developed, moderately vertically-separated, partially-accommodating peds and a vughy intrapedal microstructure.
Plate 4.5C. A2MM3B has a groundmass of MF1v microfabric type and additionally includes vertically aligned peds as well as an increase in relative groundmass mineral component size (more gravels, slightly less silt). A bone fragment is also present, as well as relatively low intrapedal void structure (~15%), more shell fragments, and evidence of bioturbation.

Plate 4.5D. A2MM4B appears similar to A2MM4A, with a massive, weakly developed, moderately vertically-separated, partially-accommodating, peds and a vugly intrapedal microstructure. Apparent towards the bottom of the section are areas of Fe depletion, as well as Fe impregnation around voids.
Plate 4.5E. A2MM3C consists of a mixture of MF1 and MF1v microfabric types. All m.s.-size grains and larger are rounded to sub-rounded, suggesting their weathering. Overall, the section contains fewer large gravels than A2MM3B. A2MM3C also contains the most shell fragments of the A2 sections thus far (~5%).

Plate 4.5F. A2MM4C consists of the MF1v microfabric type, and, similar to A2MM4B, has areas of Fe depletion as well as Fe impregnation around voids. The section appears most similar to section A2MM5A (see Section 4.2.1.3), with areas of c/f10µm-related distributions ranging between 70/30 and 60/40.

Plates 4.5A-F. Thin sections A2MM3A-C and A2MM4A-C.
Plate 4.6A. Silty sandy laminations or bedding in A2MM3A (PPL). There is no erosional separation between laminae, so this deposit is the product of one continuous depositional episode.

Plate 4.6B. Silty sandy laminations or bedding in A2MM3A (XPL); the formation of voids following the formation of laminations/bedding are indicative of bioturbation and modern roots (one shown by white arrow).

Plate 4.6C. Bone fragment in A2MM3B (in PPL); the bone appears to have very rounded edges, suggesting movement from its original context.

Plate 4.6D. Bone fragment in A2MM3B (in XPL); in XPL, bone appears to have “ropy internal structure[s]” and birefringence due to preserved collagen, as visible in this example (Karkanas and Goldberg 2010: 838).
<table>
<thead>
<tr>
<th>Plate 4.6E</th>
<th>Plate 4.6F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Areas of calcitic hypocoatings around voids, and dusty clay coatings in voids (dark areas in voids marked by black arrows), shown here in A2MM4C (bionocular), indicative of a Bt horizon.</td>
<td>Sparitic calcitic pendant forming on a calcitic nodule in a micritic, crystallitic b-fabric (in A2MM3A in XPL). Note the angularity of the nodule, which is in contrast to the roundedness of nodules at greater depths and in different contexts.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plate 4.6G</th>
<th>Plate 4.6H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rounded nature of ceramic fragments (shown here in A2MM4A in PPL), in areas of concentration in A2MM3B and A2MM4A, is indicative of significant transport of the ceramic fragments (ceramic marked by white arrows).</td>
<td>Area of MF4 and reverse bedding in A2MM3A near top of section (PPL). The roundedness of the MF4 grains indicates weathering, such as would be characteristic of aeolian or riverbed source grains.</td>
</tr>
</tbody>
</table>

Plates 4.6A-H. A: Silty sandy laminations or bedding in A2MM3A (PPL); B: Silty sandy laminations or bedding in A2MM3A (XPL); C: Bone fragment in A2MM3B (PPL); D: Bone fragment in A2MM3B (in XPL); E: Areas of calcitic hypocoatings around voids, and dusty clay coatings in voids, in A2MM4C; F: Sparitic calcitic pendant forming on a calcitic nodule in a micritic, crystallitic b-fabric (in A2MM3A in XPL); G: Rounded ceramic fragments in A2MM4A (PPL); H: Area of MF4 and reverse bedding in A2MM3A near top of section (PPL).
4.2.1.3 Neopalatial, MM III / LM I (Units #2008, #2009, #2010, #2011, #2012)

During excavations, units #2008, #2009, #2010, #2011, and #2012 contained Neopalatial ceramics (MM III-LM I); however, the individual contexts also appeared to differ from each other in the field based on sediment compaction and the relative proportions of associated anthropogenic and natural materials. Unit #2008 (5 YR 6/4), present in sections A2MM4C, A2MM5A-C, and A2MM6A-C, differed from #2007 in that it contained LM I ceramic material and was additionally less compact. Unit #2009 (5YR 6/4, grayer in the top two-thirds), present in sections A2MM4C, A2MM5A-C, and A2MM6A-C, was comprised of a more compact sediment that included a higher proportion of clay. Unit #2010 (5 YR 6/4) (in sections from A2MM6 and A2MM7) was differentiated by a softer, sandier sediment; there were ceramic fragments present on either side of the area from which A2MM7B was located. Unit #2011 (in sections from A2MM6 and A2MM7) was more similar to #2009 in terms of its moderate compaction. Small traces of charred organic material and fewer ceramic fragments, compared to #2010, also differentiated #2011, which also contained pebbles and plaster and bone fragments. Unit #2012 (5 YR 6/4) appeared to contain only LM IA ceramic material; it consisted of a much more compact, loamy sand sediment and contained bone and shell fragments, charred organic material ceramic, and decayed tree roots.

General observations

In the thin sections, the sediment in units #2008, #2009, #2010, #2011, and #2012 is primarily composed of sand, clay, and silt, with a moderately-sorted close porphyric coarse/fine (c/f10µm)-related distribution of approximately 60/40 - 80/20 (increasing ratio with depth until A2MM7C—A2MM5A and A2MM5B: 60/40; A2MM5C through A2MM6C and A2MM8A through A2MM8C: 70/30, and A2MM6B through A2MM7C: 80/20), with orthic typic and disorthic typic impregnative iron/manganese nodules (20 µm - 500 µm) (~5%), organic material (shell fragments (~1-2%), modern roots (~1-2%), a few dark brown organic residues (~2%)), and areas of clay and diffuse iron impregnation and depletion. The sand grains—mainly smooth, angular to rounded grains of quartzite, phyllite, and sandstone—consist dominantly of very fine sand (v.f.s.-size (20 - 100 µm, 40-50%) to fine sand (f.s.-size (100 - 500 µm, ~10-30%), with medium sand (m.s.-size (200 - 500 µm, ~5-10%), coarse sand (c.s)-size (500 - 1000 µm, ~1-
5%), very coarse sand (v.c.s.)-size grains (1000 - 2000 µm, ~0-5%), and occasional fine gravel (f.g.)-size grains (>2000 µm, ~2-10%). The silt-size component (2 - 20 µm) is ~20% of the groundmass.

Like the sections from the Post-Minoan and Post-palatial contexts, the sections from this Neopalatial context all have massive, vughy/vesicular, and channel microstructures with semi-smooth channels (f.s.-m.s., ~5-10%), semi-smooth typic vughs/vesicles (m.s.-c.s., ~5-10%) and a total intrapedal porosity of ~15-20% (MF1 and MF1v microfabric types). This microstructure, along with the groundmass as well as the reddish brown, crystallitic b-fabric, qualifies these sections as the MF1v microfabric type. Sections A2MM9A through A2MM9C are differentiated by an increase in abnormal vughs (m.s.-c.s., ~15-20%) and total intrapedal porosities of ~25-30%, with more large channels occurring towards bottom half of A2MM9C. Below, A2MM8B, A2MM8C and A2MM9A through A2MM9C are further differentiated by b-fabrics with crystallitic and grano-and poro-striations; however the groundmasses are similar with those of the MF1v microfabric type.

Despite these overall similarities, the microstructure of A2MM7A appears much more developed than that of the other thin sections (Plate 4.7G), demonstrating a large, moderately to well-accommodated horizontal ped separation. A2MM7A may present a collapsed micritic (calcite) groundmass, with some grain sorting and dusty clay infillings; perhaps it was originally a completely unsorted deposit and looked more similar to the typical MF1v microstructure. In A2MM7B, one area of silty sandy sorting occurs; similar bedding formations also occur in A2MM8A and A2MM8B, and these are possible slaking crusts (Plates 4.8F-H).

A2MM7B, A2MM7C, A2MM8A, A2MM8B, and A2MM9B are the only sections from these contexts to contain specific areas of chito-gefuric/gefuric distributions; these have been labeled as MF3 and MF3r microfabrics. The MF3 microfabric is typified by poorly to moderately sorted chito-gefuric c/f_{10µm}-related distribution of sub-angular to sub-rounded grains, which appear in larger grain sizes (c.s.-size and larger) than those of the surrounding MF1 groundmass, and with minimal silt-size grains. Dusty clay bridges sometimes connect the coarser grains. In MF3r, the coarse grains are sub-rounded to rounded. Another area of different chito-gefuric distribution may be observed in between the silty sandy laminations in A2MM8B (Plates 4.8K/L), alternating with close-porphyric distributions. In A2MM9B, an area of diagonal-alignment of elongated vughs/vesicles and increased intrapedal porosity occurs (MF1d) (Plates 4.8M/N). Additionally, in A2MM9C, an area of well-sorted chito-gefuric/chito-gefuric-
monic c/f\textsubscript{10\mu m}-related distribution of about 90/10-80/20, of predominantly v.f.s.- and silt-size grains may be observed (MF4b) (Plates 4.8O/P). All grains in the MF4b microfabric type are subrounded to rounded, appearing to be very weathered, and exhibiting roundedness similar to beach sand grains.

**Interpretations**

The general uniformity of the thin sections suggests that similar depositional processes were responsible for these units (#2008-#2012), except for the evidence in A2MM7A-A2MM8B and A2MM9B-C, which potentially indicate distinct processes. Despite the more developed microstructure of A2MM7A, the collapsed micritic groundmass and generally chaotic organization of the components suggest that this layer (units #2011/#2012) of the A2 trench may have been laid in a different depositional episode, perhaps related to the movement of fine mass in a slurry (due to liquefaction) associated with a debris or overland flow.\footnote{Betran and Texier 1999: 101-102.} It is significant that overland flow deposits can range from monic (clean sand) or enaulic (sand and soil aggregates) to chitonic-gefuric distributions (formed post-depositionally), and that “such beds alternate with massive, poorly sorted layers with a chitonic to single-spaced porphyric (i.e., matrix-supported) c/f related distribution” which relate to “former structural crusts, overland flow + splash deposits with frequent scattered flakes of silt laminae, or hyperconcentrated flow deposits.”\footnote{Ibid.: 103.} Additionally, these overland flow deposits are also typified by sandy silty intercalations, caused by internal slaking, as well as dusty clay coatings.\footnote{Ibid.: 103-104.} These features of distributions and pedofeatures, noted for overland flow deposits, relate to those observed for slides A2MM7A through A2MM8B.

The observation of a different microstructure for A2MM7A is further notable as it was observed in the field to possibly overlap contexts #2010 and #2011. Both A2MM7A and A2MM7B are distinct from the other sections—A2MM7A is distinct in terms of its advance degree of ped development compared to the other sections, and A2MM9B and A2MM9C are the...
only sections from these contexts to contain a chito-gefuric/gefuric distributions with dominantly sub-rounded to rounded coarse fractions. From A2MM7C through A2MM8C, the crystallitic and grano-and poro-striated b-fabrics also indicate different states of pedogenic development. It is possible that these striations developed due to the greater depth of the sediment, or that these sediments were influenced by increased water saturation, whether via rainfall or groundwater.\(^{390}\)

In A2MM7B, the section immediately below A2MM7A, one area of silty sandy sorting occurs, and there is slaking and graded bedding, which typically form when a surface is exposed\(^{391}\); similar formations also occur in A2MM8A and A2MM8B (Plates 4.8F-H). That a slaking feature formed in this sediment is not surprising since “medium textured soils with <20% clay [like the sediment in this area] are usually very susceptible, swelling clays are more prone to crust formation”\(^{392}\) and that internal slaking features are noted for silty sandy intercalations in overland flow deposits.\(^{393}\) Slaking crusts may form “[a]s a result of aggregate disruption and rearrangement under raindrop impact (slaking), a disruptive crust (seal) with lower porosity than the underlying material is formed.”\(^{394}\) While slaking takes place on exposed surfaces,\(^{395}\) these potential crusts do not form a continuous layer, so they may have been transported from another context. Therefore, this slaking feature, in combination with variations in microstructure in A2MM7A through A2MM8B/C, may indicate that the area of this horizon in Trench A2 was exposed for a period of time, possibly subject to low-energy alluvial or aeolian processes, prior to further higher-energy deposition by an overland flow/debris deposit.\(^{396}\)

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\(^{391}\) Pagliai and Stoops 2010: 677.

\(^{392}\) Ibid.

\(^{393}\) Betran and Texier 1999: 103-104.

\(^{394}\) Pagliai and Stoops 2010: 677; Sumner 2014: 4.

\(^{395}\) Pagliai and Stoops 2010: 677.

\(^{396}\) Angelucci (2006: 10-11) has noted that thin alluvial surfaces may demonstrate “slaking, which is a typical process related to the formation of temporary stable surfaces in active fluvial environments.”
The silty, sandy laminations in these sections are also similar to those noted in A2MM3A, which may have been related to a water deposition event or overland flow deposit. It is notable that these slaking crusts or fragments of graded bedding occur in both sections A2MM8A and A2MM8B, and that the relative depth of monolith A2MM8 (22.68-22.43 masl) corresponds with unit #2012, assigned a ceramic typological phase of LM IA, a period which sees water affecting other areas of the site, including Building MP1 (discussed in Section 4.3).

Sections A2MM9B and A2MM9C are significant in their inclusion of more rounded coarse grains in their MF3r and MF4b microfabric types. The roundedness and sphericity of the grains are indicative of weathered grains with degrees of rounding similar to riverbed or beach sand grains at Palaikastro. Similar rounding and sorting is also characteristic of aeolian grains. Interestingly, the inclusion of glauconite grains in A2MM9C is suggestive of sediment input from a different source than that of the Kastri/Petsophas slopes (Plates 4.8O/P).

Glauconite, an iron-rich clay, is only found in marine environments, indicating that these rounded sediments are derived from paleo-coastline sediments. The presence of these grains in potentially Neopalatial contexts in this gully indicates that paleo-coastal sediments were either undercut from further inland or that a potential coastal flooding event moved such sediments inland, up the gully.

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Table 4.4. A2MM5 through A2MM9 sedimentary characteristics and micromorphological features based on thin section analysis

<table>
<thead>
<tr>
<th>Sample</th>
<th>Sorting</th>
<th>Rounding</th>
<th>Coarse fraction</th>
<th>Fine fraction</th>
<th>Textural pedofeatures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Quartzite/phyll-ite/sandstone</td>
<td>Calcite</td>
<td>Organic matter</td>
</tr>
<tr>
<td>A2MM5</td>
<td>Poorly/ moderated sorted</td>
<td>Smooth, sub-angular to sub-rounded</td>
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<td>X</td>
<td>No</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td>Yes (~1%)</td>
<td>Yes (~2%)</td>
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</tr>
<tr>
<td>C</td>
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<td></td>
<td></td>
<td>Yes (~1%)</td>
<td>No</td>
</tr>
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<td>A2MM6</td>
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<td>X</td>
<td>No</td>
</tr>
<tr>
<td>A</td>
<td></td>
<td></td>
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<td>Yes (~1%)</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
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<td>C</td>
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<td>Yes (~1%)</td>
<td>No</td>
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<td>A2MM7</td>
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<td>X</td>
<td>X</td>
<td>Yes (~1%)</td>
</tr>
<tr>
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<td>Yes (~1%)</td>
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<td>A2MM8 A</td>
<td>Poorly/moderately sorted</td>
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<td>X</td>
<td>X</td>
<td>No</td>
</tr>
<tr>
<td>A2MM8 B</td>
<td>Poorly/moderately sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X</td>
<td>X</td>
<td>No</td>
</tr>
<tr>
<td>A2MM8 C</td>
<td>Poorly/moderately sorted</td>
<td>Smooth, sub-angular to rounded</td>
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</tr>
<tr>
<td>A2MM9 A</td>
<td>Poorly/moderately sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X</td>
<td>X</td>
<td>No</td>
</tr>
<tr>
<td>A2MM9 B</td>
<td>Poorly/moderately sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X</td>
<td>X</td>
<td>No</td>
</tr>
<tr>
<td>A2MM9 C</td>
<td>Poorly/moderately sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X</td>
<td>X</td>
<td>No</td>
</tr>
</tbody>
</table>
Plate 4.7A. A2MM5A consists of a massive and vughy intrapedal microstructure typical of the MF1v microfabric.

Plate 4.7B. A2MM6A exhibits a massive and vughy intrapedal microstructure some areas of slightly finer groundmass and increased compaction. A hook-shaped area of lighter color (possibly related to liquefaction), separated by moderately-developed pedality in same hook-shape, is present in the upper left portion of the slide; the groundmass appears the same, but intrapedal porosity is only ~10%.
Plate 4.7C. The MF1v and MF1 microfabrics are also observable in A2MM5B, along with minor horizontal cracks. There appears to be a significant amount of modern root disturbance; charcoal may have been fragmented during slide preparation. Also preserved are very fragmented plant silicates (phytoliths), but these may be from modern roots.

Plate 4.7D. A2MM6B demonstrates a massive and vugy intrapedal microstructure with apparent modern root disturbance at the top of the section. Overall, the slide appears to show slightly more coarse grains and less silt, as well as disorthic nodules and roots indicative of disturbance. There are also silicified organic material (phytoliths) near the top of the slide (~1%) and fresh roots (possible spores, ~2%).
Plate 4.7E. A2MM5C exhibits a massive and vugly intrapedal microstructure with some weakly to moderately separated, partially-accommodating, vertically separated ped development in the upper left of section. A large charcoal fragment appears to have been disturbed/deteriorated prior to slide preparation by bioturbation or root activity.

Plate 4.7F. A2MM6C shows a massive and vugly intrapedal microstructure, as well as a large, u-shaped bioturbation channel at the bottom of the section.
Plate 4.7G. A2MM7A exhibits a massive, angular blocky, and vugly intrapedal microstructure with moderately to well accommodated peds. The groundmass appears to be a collapsed micritic groundmass with some sorting and infilling; it may originally have been an unsorted deposit, possibly a slurry. Flower-shaped calcite particles towards top of section are fossiliferous (bioclasts).

Plate 4.7H. A2MM8A is a mixture of MF1v and MF3 microfabric types. It contains one area of silty sandy sorting occurs and slaking crusts, which typically form when a surface is exposed.
Plate 4.7I. A2MM7B demonstrates a massive and vuggy intrapedal microstructure one area of silty sandy laminations by groundmass movement area (marked with yellow dashed lines). The section also has some gefuric organization in lower register (MF3). Horizontal planar voids are apparent next to the fine (large) gravel. Overall, this section appears to contain a greater amount of sand-size grains than silt.

Plate 4.7J. A2MM8B, similar to A2MM8A, contains several areas of silty sandy laminations and slaking crusts which, although they are fragmented, suggest that this context was exposed for a period of time, and possibly subject to low-energy alluvial or aeolian processes. The groundmass is a mixture of chito-gefuric MF3 type and MF1v microfabrics.
Plate 4.7K. A2MM7C has a massive and vughy intrapedal microstructure, as well as fresh roots/spores (~1%).

Plate 4.7L. A2MM8C has a massive and vughy microstructure, as well as a speckled b-fabric that is weakly grano- and poro-striated.

Plate 4.7M. A2MM9A displays a massive and vughy intrapedal microstructure with an increased intrapedal porosity (~30%). Some cracking voids (<10%) are likely part of post-depositional processes. Like sections of the A2MM7 and A2MM8 monoliths, the sediment appears chaotic, and likely to have been deposited quite rapidly. Similar to A2MM8C, it shows a crystallitic/speckled b-fabric that is weakly grano-striated and poro-striated.

Plate 4.7N. A2MM9B consists of a massive and vughy intrapedal microstructure and, like A2MM9A and intrapedal porosity of ~30%. Weak crusts are present in MF3r (outlined by yellow dashed lines). The section also has a crystallitic/speckled b-fabric that is weakly grano-striated and poro-striated, as well as diagonally-aligned vesicles/vughs, indicative of directional pressure.
Plate 4.7O. A2MM9C consists of a massive and vugly intrapedal microstructure with a total intrapedal porosity of ~25%. It notably contains a zone of MF4b microfabric type, as well as more large channels and f.g. (~10%) in the bottom half of the section. MF4b also includes glauconite, which indicates sediment input from a marine environment, rather than from the Kastri/Petsophas slopes.

Plate 4.8A. Section A2MM5C contains a large charcoal fragment which displays post-depositional vughy development in (XPL).

Plate 4.8B. A long channel microstructure is present in A2MM6A (XPL) (bounded by two white arrows) and is surrounded by a denser close porphyric matrix to the right and more vughy matrix to the left.

Plate 4.8C. Calcitic hypocoatings (lighter, more birefringent areas indicate by black arrows) are present around voids containing roots in A2MM6B (XPL).

Plate 4.8D. Fragments of silicious plant material, possibly phytoliths, in a void lined with a dusty clay coating (in A2MM5C, in PPL). Due to the presence of modern roots and bioturbation, however, this may be from more recent plant material.
Plate 4.8E. Calcite nodule and iron impregnation/coating. Note the roundedness of the calcite nodule, similar to those seen in beach/river sands (shown here in A2MM7B in XPL).

Plate 4.8F. Possible slaking crust fragment (graded bedding formed by the evaporation of water) in A2MM7B (XPL), supporting the idea that this context may have been an exposed surface for a period and saturated by water.

Plate 4.8G. Sandy silt laminations and possible slaking crusts and intercalations in A2MM8A (PPL). Also visible is a post-depositionally formed channel (marked by a white arrow), which fragmented these features and demonstrates the bioturbated nature of the sections in this context.

Plate 4.8H. Sandy silt laminations and possible slaking crusts and intercalations in A2MM8A (XPL). Note the well-sorted nature of the grains in the laminations. These features may be related to a water deposition event or overland flow deposit.
Plate 4.8I. The bone fragment in A2MM7B (PPL) indicates post-depositional movement by nature of its rounded edges (bone indicated by red arrow). Dusty clay coatings are also present in the voids (marked by black arrows).

Plate 4.8J. Bone fragment in A2MM7B (XPL); note the haversian canals (dark elliptical spots) in the bone, which displays low (first-order grey) interference colours (Karkanas and Goldberg 2010: 868).

Plate 4.8K. Chito-gefuric c/f10μm distribution and normally graded silty sandy bedding in A2MM8B (in PPL, width of micrograph is approximately 1.25 cm). Note the large, badly fragmented charcoal fragment (marked by a white arrow) and the post-deposition channel feature (marked by a yellow arrow).

Plate 4.8L. Chito-gefuric c/f10μm distribution and normally graded silty sandy bedding in A2MM8B (in XPL, width of micrograph is approximately 1.25 cm). The grains in this distribution appear to be subrounded, similar to those from noted to potentially by from river or aeolian origins (Section 4.2.1.2).
Plate 4.8M. Area of sandy silty lamination and MF1d in A2MM9B (PPL). Vughs and vesicles are present at the base of coarse-fine couplets; such features are typically observed in sedimentary crusts (Pagliai and Stoops 2010).

Plate 4.8N. Area of sandy silty lamination and MF1d in A2MM9B (XPL), with vughs and vesicles visible. Note the well-sorted nature of the weak lamination compared to the chaotic nature of the surrounding groundmass.

Plate 4.8O. Glauconite (some marked by red arrows) in unsorted MF4b zone in A2MM9C (PPL). The presence of glauconite and rounded nature of some of the grains suggests input from a marine environment.

Plate 4.8P. Glauconite (some marked by white arrows) in unsorted MF4b zone in A2MM9C (XPL). The b-fabric is additionally crystallitic/speckled b-fabric and weakly poro-striated.

Plates 4.8A-P. A: Section A2MM5C with a large charcoal fragment (XPL); B: A long channel microstructure in A2MM6A (XPL); C: Calcite hypocoatings around voids containing roots inA2MM6B (XPL); D: Fragments of silicious plant material, possibly phytoliths, in A2MM5C (PPL); E: Calcite nodule and iron impregnation/coating in A2MM7B (XPL); F: Possible slaking crust fragment in A2MM7B (XPL); G: Sandy silt laminations and possible slaking crusts and intercalations in A2MM8A (PPL); H: Sandy silt laminations and possible slaking crusts and intercalations in A2MM8A (XPL); I: Bone fragment in A2MM7B (PPL); J: Bone fragment in A2MM7B (XPL); K: Chito-gefuric c/f_{10µm} distribution and normally graded silty sandy bedding
in A2MM8B (PPL); L: Chito-gefuric c/f$_{10\mu m}$ distribution and normally graded silty sandy bedding in A2MM8B (XPL); M: Area of sandy silty lamination and MF1d in A2MM9B (PPL); N: Area of sandy silty lamination and MF1d in A2MM9B (XPL); O: Glauconite in unsorted MF4b zone in A2MM9C (PPL); P: Glauconite in unsorted MF4b zone in A2MM9C (XPL).

4.2.1.4 Protopalatial, MM (Units #2013 and #2014)

Units #2013 and #2014 were noted during excavations to contain only Protopalatial ceramics (MM). Unit #2013 (5 YR 6/4) possibly started in A2MM9C and is a sandy and gravelly layer with an increase small pebbles (compared to #2012); it additionally contains small fragments of ceramics, charred organic material, and the sediment was noted in the field to appear mottled. Unit #2014 (5 YR 6/4) was observed in the field to be a softer, sandy and pebbly layer, with a larger proportion of rounded purple phyllite pebbles. Thin sections A2MM10A, A2MM10B, A2MM10C, A2MM11A, A2MM11B, A2MM11C, A2MM12A, A2MM12B, A2MM12C, A2MM13A, A2MM13B, and A2MM13C are related to units #2013 and #2014. There was no distinct boundary identified between these two layers, but a diffuse boundary may be observed in thin section in A2MM13A/B with the unit below (#2026).

General observations

The sediment in units #2013 and #2014 is primarily composed of sand, clay, and silt, in three different types of microfabrics, mainly randomly mixed: (1) MF1v—a moderately-sorted close porphyric coarse/fine (c/f$_{10\mu m}$)-related distribution of approximately from 60/40-80/20; (2) MF3—a poorly to moderately-sorted, common chito-gefuric (c/f$_{10\mu m}$)-related distribution of approximately 90/10-80/20 of sub-angular to sub-rounded grains, which appear in larger grain sizes (c.s.-size and larger) than those of the surrounding MF1 groundmass, and with minimal silt-size grains and some dusty clay bridges; (3) MF3r—a poorly to moderately-sorted chito-gefuric c/f$_{10\mu m}$-related distribution of sub-rounded to rounded grains (more rounded than that of standard MF3), which appear in larger grain sizes (c.s.-size and larger) than those of the surrounding MF1 groundmass, and with minimal silt-size grains; and (4) MF4b—a well-sorted chito-gefuric/chito-gefuric-monic c/f$_{10\mu m}$-related distribution of about 90/10-80/20, of predominantly v.f.s.- and silt-size grains and silt with no grading/bedding visible, and in which all grains appear to be sub-rounded and rounded.
The MF3 gefuric distribution comprises ~50-75% of the groundmass of sections A2MM10A through A2MM13B; the lower half of A2MM13B is comprised of moderately to well-sorted, close-porphyric related distribution and A2MM13C is comprised of a fine-spaced gefuric related distribution (with f.s.-sized vugh-dominant microstructure). These areas of A2MM13B and A2MM13C relate to unit #2026 (MM I-II), the diffuse boundary of which may be visible in A2MM13B (Plate 4.10K). Also present in A2MM13A and A2MM13B are areas of silty-sandy bedding and possible slaking crusts (Plates 4.10I/J, 4.10L).

Like the sections from the Post-Minoan, Post-palatial, and Neopalatial contexts, the sections from this Protopalatial context all have massive, vughy/vesicular, and channel microstructures, but with a generally increased intrapedal porosity: semi-smooth channels (f.s.-m.s., ~10-15%), semi-smooth typic vughs/vesicles (m.s.-c.s., ~10-15%) and a total intrapedal porosity of ~20-35%. Additionally, the reddish brown groundmass also displays a crystallitic b-fabric, with additional grano- and poro-striations in A2MM10A-C and A2MM11C. Orthic typic and disorthic typic impregnative iron/manganese nodules (20 µm - 500 µm) (~5%), organic material (shell fragments (~0-5%) (Plate 4.10H), modern roots (~0-1%)), bone fragments (Plate 4.10E/F), ceramic fragments (~0-1%), and a few dark brown organic residues (~2%) are present.

Interpretations

As discussed for the MF1 and MF1v microfabric types in the previous sections, the homogeneous nature of the groundmass, the lack of ped development, the vughy/vesicular and channel microstructure, and the presence of rounded allochthonous carbonate nodules suggest that these sediments were deposited by colluvial/alluvial processes, possibly a debris and/or overland flow.\(^{400}\) Areas of vughy/vesicular and channel microstructure in particular may indicate hyperconcentrated flow events.\(^{401}\) The dusty clay bridges that characterize this chitogerfuric microfabric (MF3), as well as the sub-angular to sub-rounded grains, present in larger

\(^{400}\) Stoops 2010: 941; Goldberg 1979; Nodarou et al. 2008; Betran and Texier 1999.

general grain sizes than those of the surrounding MF1 and MF1v microfabrics, indicate that this layer may have been deposited by colluvial processes.\textsuperscript{402}

The sub-rounded to rounded grains present in several sections from A2MM10A (and A2MM9C) through A2MM13C (in MF4b and MF3r microfabrics) appear to be very weathered. The degree of roundedness of the subrounded and rounded coarse grains appear be similar to those from the river, beach, or aeolian sand contexts, rather than those from the red ‘Kastri’ alluvial materials (Plates 4.10A/B). However, the mixture of these microfabrics with coarse ones (MF1, MF1v, and MF3) also indicates input from other, less-weathered sources. It is possible that these sediments did mix in this gully zone (Trench A2), and did indeed originate from two different sources.

The graded bedding/silty sandy laminations and possible slaking crusts in A2MM13A and A3MM13B are similar to those in shallower units: A2MM7B, A2MM8A and A2MM8B. As noted previously, the presence of slaking crusts suggests exposure of a sediment surface for a period of time,\textsuperscript{403} while silty sandy laminations may be related to a water deposition event or overland flow deposit.\textsuperscript{404}

\textsuperscript{402} Goldberg and Arpin (1999: 334) suggest that dusty clay bridges may be pedofeatures of colluvial events.

\textsuperscript{403} Pagliai and Stoops 2010: 677.

\textsuperscript{404} Betran and Texier 1999: 102.
Table 4.5. A2MM10 through A2MM13 sedimentary characteristics and micromorphological features based on thin section analysis

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<th>Sample</th>
<th>Sorting</th>
<th>Rounding</th>
<th>Coarse fraction</th>
<th>Fine fraction</th>
<th>Void coatings</th>
<th>Fe/Mn nodules</th>
<th>Intercalations</th>
</tr>
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<tr>
<td>A2MM10A</td>
<td>Poorly/ moderately sorted</td>
<td>Smooth, sub-angular to sub-rounded</td>
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<td>X</td>
<td>No</td>
<td>No</td>
<td>X</td>
</tr>
<tr>
<td>A2MM10B</td>
<td>Poorly/ moderately sorted</td>
<td>Smooth, sub-angular to sub-rounded</td>
<td>X</td>
<td>Yes (~1%), Pinus spp.</td>
<td>Yes (~1%)</td>
<td>Areas of dusty clay concentrations (mottling appearance) and hypocoatings</td>
<td>X</td>
</tr>
<tr>
<td>A2MM10C</td>
<td>Poorly/ moderately sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X</td>
<td>Yes (~1%)</td>
<td>Yes (~1%)</td>
<td>Areas of dusty clay concentrations (mottling appearance) and hypocoatings</td>
<td>X</td>
</tr>
<tr>
<td>A2MM11A</td>
<td>Poorly/ moderately sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X</td>
<td>No</td>
<td>No</td>
<td>Some typical clay coatings; infillings common</td>
<td>X</td>
</tr>
<tr>
<td>A2MM11B</td>
<td>Poorly/ moderately sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X</td>
<td>No</td>
<td>No</td>
<td>Some typical clay coatings; infillings common</td>
<td>X</td>
</tr>
<tr>
<td>A2MM11C</td>
<td>Poorly/ moderately sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X</td>
<td>No</td>
<td>No</td>
<td>Typical clay hypocoatings and Fe impregnation around voids</td>
<td>X</td>
</tr>
<tr>
<td>A2MM12A</td>
<td>Poorly/ moderately sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X</td>
<td>No</td>
<td>No</td>
<td>Common typical clay hypocoatings around voids</td>
<td>X</td>
</tr>
<tr>
<td>A2MM12B</td>
<td>Poorly/ moderately sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X</td>
<td>No</td>
<td>No</td>
<td>Common typical clay hypocoatings around voids</td>
<td>X</td>
</tr>
<tr>
<td>A2MM12C</td>
<td>Poorly/ moderately sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X</td>
<td>No</td>
<td>No</td>
<td>Fe staining prevalent; areas of silty-clay infilling (~10%)</td>
<td>X</td>
</tr>
<tr>
<td>A2MM13A</td>
<td>Poorly/ moderately sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X</td>
<td>No</td>
<td>No</td>
<td>Fe-staining prevalent; Some dusty clay and Fe hypocoatings and infillings; Double</td>
<td>X</td>
</tr>
</tbody>
</table>
bands of clay intercalations (burnt bone and ceramic found below bands) bands appear disturbed; v.f.s.-f.s., moderately-well sorted porphyric distributions between bands

<table>
<thead>
<tr>
<th></th>
<th>Poorly/moderately sorted</th>
<th>Smooth, sub-angular to rounded</th>
<th>X</th>
<th>X</th>
<th>No</th>
<th>No</th>
<th>Fe-staining prevalent; Some dusty clay and Fe hypocoatings and infillings; band of clay intercalations with v.f.s.-f.s., moderately-well sorted porphyric distribution beneath (towards bottom of section)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2MM13B</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>A2MM13C</td>
<td>X</td>
<td>X</td>
<td>No</td>
<td></td>
<td>Yes (~1%)</td>
<td>Yes</td>
<td>Typic dusty clay and Fe hypocoatings around voids; fine material infillings (few)</td>
</tr>
</tbody>
</table>
Plate 4.9A. A2MM10A appears to have a massive and vughy intrapedal microstructure with a chaotic groundmass of MF1v, MF4b, and MF3r types, as well as some horizontal cracks near the bottom of the section. The rounded nature of the grains in MF4b and MF3r relate to those present in A2MM9C, suggesting their derivation from a marine environment. A2MM10A similarly contains a crystallitic/speckled b-fabric with grano-striation and poro-striation.

Plate 4.9B. A2MM11A, like A2MM10C displays zones of the MF1d microfabric type. The horizontal alignment of rough planar void in the bottom part of the section may suggest shrinkage or slipping (Stoops 2003: 65). Similar voids have been observed in hyperconcentrated flows (Friesem et al. 2014a, Figures 10b and c). The the c/f10µm-related fraction demonstrates higher quantity of fine materials (60/40).
Plate 4.9C. A2MM10B appears to be similar to A2MM10A with a massive and vughy microstructure and MF1v and MF3r microfabrics. However, it appears overall to contain a higher c/f_{10\mu m}-related proportion (80/20) than A2MM10A (70/30).

Plate 4.9D. A2MM11B demonstrates a massive and vughy intrapedal microstructure. The closed vughs and open vughs that are part of the MF3r chito-gefuric distribution suggest the deposition of loose sands as well as insect burrows. The loose sands were possibly deposited as fine wash (impure clay/silt) and coated areas; some look like open/worked burrows. Like A2MM11A, the c/f_{10\mu m}-related fraction demonstrates higher quantity of fine materials (65/35).
Plate 4.9E. A2MM10C contains one area of MF1d, which contains horizontally-aligned vughs/vesicles and indicates directional pressure, a feature of semi-plastic sediment. Its presence between two MF1v areas suggests multiple, smaller depositional (or truncation) events. In general, minimal evidence of anthropogenic inclusions (bone and ceramic) is present.

Plate 4.9F. A2M11C consists of a massive microstructure with dominantly chito-gefuric distributions of MF3r and MF4b. Consequently it also has a higher c/f\textsubscript{10\,\mu m}-related fraction (80/20). The section also displays a crystallitic b-fabric with weak poro-striation towards bottom of the section. The rounded nature of the grains in MF4b and MF3r relate to those present in A2MM9C and A2MM10A, suggesting their derivation from a marine environment.
Plate 4.9G. A2MM12A contains both poorly-sorted, close porphyric distributions (MF1v) and gefuric (MF3r and MF4b, 50%). Similar to sections from the A2MM11 sample, there is evidence of bioturbation through worm hole/burrows and burrows.

Plate 4.9H. A2MM13A contains more anthropogenic materials (ceramic and bone fragments) and some evidence (clay and silt bedding and sorted accumulation) suggesting slower depositional processes and an exposed surface for an extended period of time. Below the area of these laminations and clay intercalations is a much greater proportion of shell fragments (~5%) than in the rest of the section (~1%).
Plate 4.9I. A2MM12B, similar to section A2MM12A above, contains both poorly-sorted, close porphyric (MF1v) and gefuric (MF3, 50%) distributions. Areas of the MF4 microfabric are not visible. The section also has indications of worm holes/burrows, which are common (f.g., ~20%).

Plate 4.9J. A2MM13B exhibits a diffuse boundary line (marked by a yellow dashed line) between a coarser (MF3) and finer (MF1v) groundmass, suggesting different depositional episodes. This boundary may divide unit #2014 from #2026.
Plate 4.9K. A2MM12C consists of both poorly-sorted, close porphyric (MF1v and MF1d) and gefuric (MF3 and MF3r, 75%) distributions. The c/f_{10\mu m}-related fraction is approximately 75/25, except for sandy silty infilling areas (~ 10%). Fe staining is also prevalent.

Plate 4.9L. A2MM13C consists of a fine-spaced gefuric distribution of MF4b and MF1v, with f.s.-sized vughs dominant. This is different from the sections above and likely is representative of unit #2026, noted in the field for its sandy composition. The sphericity and roundedness of the MF4b grains indicate significant grain weathering.

Plate 4.10A. MF4b in A2MM10A (PPL) has a gefuric distribution; MF4b is also present in A2MM9B and A2MM9C in contexts above. The degree of roundedness of the sub-rounded and rounded coarse grains appear be similar to those from the river or beach sand contexts, rather than those from the red ‘Kastri’ alluvial materials.

Plate 4.10B. Sub-rounded coarse grains from beach sand contexts, in GSPK 2 (in XPL, photomicrograph by Gait, 2017).

Plate 4.10C. Calcitic hypocoating around a void in A2MM10A (PPL). Impregnative calcite formations in calcareous soils may form through dissolution and reprecipitation (Adderley et al. 2010: 922).

Plate 4.10D. Calcitic hypocoating around a void in A2MM10A (XPL), surrounded by a crystallitic/speckled b-fabric.
Plate 4.10E. Bone fragments are rare, but present, in A2MM12A (PPL). An increase in anthropogenic materials (bone and ceramic fragments) is seen in A2MM13A.

Plate 4.10F. Bone fragments in A2MM12A (XPL). Note the whitish nature of the fragment, suggesting that the bone may be calcined (Macphail and Goldberg 2010: 952).

Plate 4.10G. Iron infiltration of rounded fine gravels in A2MM12C (XPL).

Plate 4.10H. Degraded shell fragment (marked by white arrow) in complex microstructure in A2MM12C (XPL).
Plate 4.10I. Graded bedding/silty sandy laminations in A2MM13A (PPL) suggesting slower depositional process and the exposure of a surface for a period of time.

Plate 4.10J. Graded bedding/silty sandy laminations in A2MM13A (XPL). The chaotic nature of the section overall suggests a collapsed groundmass and post-depositional disturbance.

Plate 4.10K. Diffuse boundary (marked with white arrows) in A2MM13B (XPL) where pebbly/gravelly unit (#2014) ends and sandy unit (#2026) begins.

Plate 4.10L. Slaking crust/normally graded silty sandy bedding in A2MM13B (XPL), near bottom of section in sandy unit (#2026) also suggests post-depositional mixing of sediments in this unit.

Plates 4.10A-L. A: MF4b in A2MM10A (PPL) with a gefuric distribution; B: Sub-rounded coarse grains from beach sand contexts, in GSPK 2 (XPL); C: Calcitic hypocoating around a void in A2MM10A (PPL); D: Calcitic hypocoating around a void in A2MM10A (XPL); E: Bone fragments in A2MM12A (PPL); F: Bone fragments in A2MM12A (XPL); G: Iron infiltration of rounded fine gravels in A2MM12C (XPL); H: Degraded shell fragment in complex microstructure in A2MM12C (XPL); I: Graded bedding/silty sandy laminations in A2MM13A (PPL); J: Graded bedding/silty sandy laminations in A2MM13A (XPL); K: Diffuse boundary (in A2MM13B (XPL) where #2014 ends and #2026 begins; L: Slaking crust/normally graded silty sandy bedding in A2MM13B (XPL).
4.2.1.5 Protopalatial, MM I-II (Units #2026 and #2028)

During excavations, units #2026 and #2028 appeared to consist of generally sandier sediments than the contexts above and appeared to contain only Protopalatial ceramics (MM I-II). Unit #2026 (5 YR 6/4), associated with sections A2MM14A-C and A2MM15A-C, was observed in the field to consist of softer sediment of sand and gravels (likely due to the sediment microstructure and increased porosity), and included shell and bone fragments, as well as ceramic fragments of MM I-II types. Unit #2028 (5 YR 6/4), associated with sections A2MM16A-C, was observed in the field to consist of a harder clay layer at the top, followed by a layer of larger gravels, and finally a sandy layer at the bottom; these multiple layers observed in the field may be seen in Fig. 4.1.

General observations

Similar to the sediment in #2013 and #2014, the sediment in units #2026 and #2028 is primarily composed of sand, clay, and silt, but in five different types of microfabrics: MF1v, MF3, MF3r, MF4b, and, additionally, MF1d. Although some of these microfabrics are mixed, it is apparent that there were multiple depositional episodes within these two larger units. A2MM14 appears to transition from a coarse-grained MF1v and MF3 combination microfabric into ones with more sub-rounded and rounded grains that consists of MF3r and MF4b (Plate 4.12A-C). This diffuse transition boundary between a coarser to a finer-grained and sandier groundmass is particularly visible in A2MM14B (Plate 4.11C). In the A2MM15 sections there is another transition from more sub-rounded and rounded grains (in MF3) to increasingly sub-angular grains (in MF3r) lower in the A2MM15 monolith.

Additionally observable in the A2MM15A and AMM15B sections is the presence of some sorting. A2MM15A contains an area of discontinuous clay intercalations and sandy silty sorting beneath a large ceramic fragment (Plates 4.11B, 4.12E/F). A2MM15B contains a distinct layer of the MF4d microfabric type, typified by a diagonal-alignment of elongated vughs/vesicles and increased intrapedal porosity, as well as planar voids parallel to the direction of elongated vughs/vesicles (Plates 4.12G/H). There is also normal grading (fining upwards) of the MF4d microfabric in A2MM15B.
The A2MM16 sections contain the boundary between the #2026 and #2028 units. This may be observed by the diffuse boundary in A2MM16A between the combined MF1v/3/4b mixed microfabrics and the more rounded MF3r context (Plate 4.11G). Below this, A2MM16B and A2MM16C contain MF1v microfabric types before transitioning back to the MF4b microfabric in the bottom of A2MM16C. In the porphyric portion in these sections, the MF1v microfabric has a higher clay content (fine fraction) (Plate 4.12I). Additionally in the sections containing MF4b, occasional glauconite grains are present (Plate 4.12K/L).

Like the sections from the Post-Minoan, Post-palatial, Neopalatial, and later Protopalatial contexts, the sections from this Protopalatial context all have massive, vughy/vesicular, and channel microstructures. In contrast to the Protopalatial context of #2013 and #2014, the Protopalatial context of #2026 and #2028 has a general lower intrapedal porosity of ~20-25%, consisting of semi-smooth channels (f.s.-m.s., ~10%), semi-smooth typic vughs/vesicles (m.s.-c.s., ~10-15%), although some areas of the MF3r microfabric type exhibit an increased intrapedal porosity: ~30-35%. Overall the groundmass in both units #2026 and #2028 is reddish brown with crystallitic/speckled b-fabrics. Present throughout the sections are lower frequencies of orthic typic and disorthic typic impregnative iron/manganese nodules (20 µm - 500 µm) (~2%), organic material (shell fragments, only present in A2MM15B and lower (~1-3%), and only larger ceramic fragments in A2MM14A and A2MM15A. Neither charcoal fragments nor bone fragments are present in any of the sections, and modern roots (~1%) are only present in A2MM14B and A2MM14C, although evidence of bioturbation is apparent.

**Interpretations**

Overall, the decreased inclusion of anthropogenic materials and good quality of preservation of the larger ceramic fragments (with paint preserved) in A2MM14A and A2MM15A indicate that different depositional or post-depositional processes were impacting part of the site (Plate 4.12D). The different c/f_10µm-related distributions, sorting, and degrees of weathering of the grains in these sections indicates that these units (#2026 and #2028) were deposited by multiple, different depositional episodes, although the homogeneous nature of the groundmass suggests subsequent post-depositional mixing. The lack of ped development, vughy/vesicular and channel microstructure, and the presence of rounded allochthonous carbonate nodules suggest that the areas of MF1v microfabric type were possibly deposited
debris or overland flow,\textsuperscript{405} and possibly hyperconcentrated flow events.\textsuperscript{406} The sub-rounded to rounded grains present in MF3r and MF4b in A2MM14B, A2MM14C, A2MM15A, A2MM15C, A2MM16A and A2MM16C suggest increased exposure to weathering processes, similar to beach, river bed, or aeolian sand grains, in contrast to the ‘Kastri’ alluvial materials (Plate 4.12A-C).

The area of discontinuous clay intercalations and sandy silty sorting beneath a large ceramic fragment in A2MM15A (Plate 4.11B, Plate 4.12E/F) suggests an exposed surface for a period of time, or at least the incorporation of potential slaking crusts from other surfaces and water-influenced sorting or overland flow deposits.\textsuperscript{407} The presence of a layer of the MF4d microfabric type in A2MM15B, with diagonal-alignment of elongated vughs/vesicles and increased intrapedal porosity, as well as planar voids parallel to the direction of elongated vughs/vesicles (Plates 4.12G/H) and normal grading (fining upwards), indicates directional pressure\textsuperscript{408} as well as shrinkage or slipping.\textsuperscript{409} Possibly, these planar voids indicate shear or slip planes related to earth slides and flows.\textsuperscript{410}

\textsuperscript{405} Stoops 2010: 941; Goldberg 1979; Nodarou et al. 2008; Betran and Texier 1999.
\textsuperscript{406} Betran and Texier 1999: 109.
\textsuperscript{407} Pagliai and Stoops 2010: 677.
\textsuperscript{408} Cf. Karkanas and Van de Moortel 2014, who discuss evidence for directional pressure in Microfacies E.
\textsuperscript{409} Stoops 2003: 65.
\textsuperscript{410} Cf. Betran and Texier 1999: 115-116.
Table 4.6. A2MM14 through A2MM16 sedimentary characteristics and micromorphological features based on thin section analysis

<table>
<thead>
<tr>
<th>Sample</th>
<th>Sorting</th>
<th>Rounding</th>
<th>Quartzite/phyllite/sandstone</th>
<th>Calcite</th>
<th>Charcoal</th>
<th>Organic matter</th>
<th>Fine fraction</th>
<th>Textural pedofeatures</th>
<th>Void coatings</th>
<th>Fe/Mn nodules</th>
<th>Intercalation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2MM14A</td>
<td>Poorly/moderately sorted</td>
<td>Smooth, sub-angular to sub-rounded</td>
<td>X</td>
<td>X</td>
<td>No</td>
<td>No</td>
<td>Typic dusty clay and Fe hypocoatings around voids; fine material infillings (few)</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2MM14B</td>
<td>Poorly/moderately sorted</td>
<td>Smooth, sub-angular to sub-rounded</td>
<td>X</td>
<td>X</td>
<td>No</td>
<td>Yes (~1%)</td>
<td>Typic dusty clay and Fe hypocoatings around voids; fine material infillings (few)</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2MM14C</td>
<td>Poorly/moderately sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X</td>
<td>X</td>
<td>No</td>
<td>Yes (~1%)</td>
<td>Typic dusty clay and Fe hypocoatings around voids; fine material infillings (few)</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2MM15A</td>
<td>Poorly/moderately sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X</td>
<td>X</td>
<td>No</td>
<td>No</td>
<td>Typic dusty clay hypocoatings and intercalations</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>A2MM15B</td>
<td>Poorly/moderately sorted; MF4d: well-sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X</td>
<td>X</td>
<td>No</td>
<td>No</td>
<td>Typic dusty clay coatings; in lower portion, areas of Fe impregnation and depletion; fine material infilling (common)</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2MM15C</td>
<td>Poorly/moderately sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X</td>
<td>X</td>
<td>No</td>
<td>No</td>
<td>Typic dusty clay coatings; areas of Fe impregnation and depletion; fine material infilling (common)</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2MM16A</td>
<td>Poorly/moderately sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X</td>
<td>X</td>
<td>No</td>
<td>No</td>
<td>Typic dusty clay hypocoatings; Fe sorting around voids; fine material infilling (common)</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2MM16B</td>
<td>Poorly/moderately sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X</td>
<td>X</td>
<td>No</td>
<td>No</td>
<td>Typic dusty clay hypocoatings; Fe sorting around voids; fine material infilling (common)</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2MM16C</td>
<td>Poorly/moderately sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X</td>
<td>X</td>
<td>No</td>
<td>No</td>
<td>Typic dusty clay hypocoatings; Fe sorting around voids; fine material infilling (common)</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Plate 4.11A. A2MM14A is composed of MF1v (40%) and MF3 (60%) microfabrics. The ceramic fragment in the centre of the section appears to belong to the F4 fine fabric type, identified with MM ceramics (J. Gait, pers. comm. 2017).

Plate 4.11B. A2MM15A is composed of a mixture of MF3, MF3r, and MF4b microfabric types, poorly to moderately-sorted, with a gefuric dominant c/f10µm-related fraction of approximately 80/20. Discontinuous clay intercalations and sandy silty laminations are present beneath the large ceramic fragment. Evidence of bioturbation (worm hole/burrows, (c.s.-f.g., ~5%) are present throughout the section.

Plate 4.11C. A2MM14B exhibits a boundary layer in which MF3 (c/f10µm, 90/10) transitions into a finer-grained, more rounded, and sandier, mixed groundmass of MF3r and MF4b (c/f10µm, 80/20) (marked by a white dashed line). Bioturbation (worm holes/burrows, (c.s.-f.g., ~10%) are also present.

Plate 4.11D. A2MM15B exhibits layering of microfabric types MF3, MF4d, and a combination of MF3, MF1v, and MF1d. The top and very bottom of the section are poorly-to moderately-sorted gefuric distributions, while MF4d is moderately to well-sorted, fine-spaced gefuric. In addition to the diagonal-alignment of elongated vughs/vesicles and increased intrapedal porosity in MF4d and MF1d, as well as parallel planar voids in MF4d, there is also normal grading (fining upwards) of the MF4d microfabric. Bioturbation is apparent via worm holes/burrows (c.s.-f.g., ~5%).
Plate 4.11E. A2MM14C consists of a mixture of poorly-sorted close-porphyric (MF1v) and finer-spaced gefuric (MF3r/MF4b, ~40%) distributions. Bioturbation evidence is apparent (worm holes/burrows, c.s.-f.g., ~5%).

Plate 4.11F. A2MM15C is comprised of a combination of close-porphyric (MF1v) and moderately-sorted fine-spaced gefuric (MF3/MF4b, ~50%) distributions. Similar to sections above it, it contains evidence of worm holes/burrows, c.s.-f.g., ~10%)

Plate 4.11G. A2MM16A contains the diffuse boundary zone between units #2026 and #2028 (marked by a white dashed line). While #2026 is primarily composed of sub-angular grains, #2028 below is dominated by sub-rounded and rounded grains, suggesting different sources of sediment input. There is more clay content (finer fraction) in the porphyric distribution (c/f\text{10µm}, 60/40) compared to the gefuric distribution (c/f\text{10µm}, 80/20). There is also increased clay content, possibly due to illuviation, towards the bottom of #2026.

Plate 4.11H. In contrast to A2MM16A, this section—A2MM16B—is comprised of a poorly-sorted porphyric distribution (MF1v, c/f\text{10µm}, 50/50). This layer, with increased clay content (fine fraction), between two layers containing MF4b indicate a different episode of deposition.
Plate 4.11I. A2MM16C consists of MF1v microfabric type in the top of the section and the MF4b type in the bottom of the section (the diffuse boundary is indicated by a white dashed line). Observable in the bottom of the section is an increase in calcitic accumulations as well as an increase in shell fragments in the lower part of the section.

Plate 4.12A. MF3 in A2MM14A (shown here in PPL) is more similar to the sub-angular grains in MF3 in A9MM2A (Plate 4.12C) than to the more rounded microfabric (MF3r) in contexts above in trench A2. Note the lack of dusty bridges between the grains.

Plate 4.12B. MF4b, shown here in A2MM10A (PPL), exhibits a greater degree of roundedness and sphericity of the coarse grains than those of the surrounding groundmass. The nature of the grains are similar to those from the river or beach sand contexts, rather than those from the red ‘Kastri’ alluvial materials.

Plate 4.12C. Microfabric (MF3) (shown here in PPL), in A9MM2A is comprised of a much higher proportion of c.s.-size, m.s.-size, v.c.s.-size, and f.g.-size grains; this MF3 is only present in this section in A9. The mineral fractions include smooth, sub-angular to rounded grains of quartz/quartzite and phyllite (v.f.s., ~30%; f.s. ~30%, m.s. ~10%; c.s. ~10%; v.c.s. ~10%; f.g., sub-rounded to rounded, ~5%).

Plate 4.12D. Ceramic fragment in A2MM14A (XPL) (width of photomicrograph is approximately 0.75cm). This appears to be the same fine fabric (F4) that has been identified in other Neopalatial cups (PK 86, 88, 89, 91: hemispherical cups, MM IIIA) (J. Gait, pers. comm. 2017). Paint is preserved on both edges of the vessel (indicated by the white arrows).
Plate 4.12E. Silty sandy lamination below ceramic fragment in A2MM15A (PPL). This section contains fragments of silty sandy laminations above the ceramic fragments as well.

Plate 4.12F. Silty sandy lamination below ceramic fragment in A2MM15A (XPL). Note the normally graded nature of the lamination and the sub-angular nature of the quartzite grains in gefuric distribution (MF3).

Plate 4.12G. MF4d with the additional diagonal-alignment of the elongated vughs/vesicles and increased intrapedal porosity (shown here in A2MM15B, PPL). Also, planar voids apparent parallel to direction of elongated vughs/vesicles (marked by red arrows).

Plate 4.12H. MF4d with the additional diagonal-alignment of the elongated vughs/vesicles and increased intrapedal porosity (shown here in A2MM15B, XPL). Note the fining upwards (normally graded bedding, indicated by the white arrow).
Plate 4.12A-L. A: MF3 in A2MM14A (PPL); B: MF4b in A2MM10A (PPL); C: MF3 in A9MM2A (PPL); D: Ceramic fragment in A2MM14A (XPL) of fine fabric (F4) type; E: Silty sandy lamination below ceramic fragment in A2MM15A (PPL); F: Silty sandy lamination below ceramic fragment in A2MM15A (XPL); G: MF4d, with the additional diagonal-alignment of the elongated vughs/vesicles and increased intrapedal porosity, in A2MM15B (PPL); H: MF4d in A2MM15B (XPL); I: Dusty and limpid clay hypocoatings along a vugh in A2MM15C (PPL); J: Dusty and limpid clay hypocoatings along a vugh in A2MM15C (XPL); K: Weathered glauconite in A2MM16A (PPL); L: Weathered glauconite in A2MM16A (XPL).
4.2.2 Trench A3

East of Trench A2, north of Building AP1, and west of Building AM1, another deep trench—approximately 3 m in depth—was excavated during the 2013 season (Plate 4.1). Similar to Trench A2, Trench A3 was devoid of any major archaeological and architectural features (i.e., walls, floors, etc.), and was thus reduced from an originally 5 m x 10 m exposure to a 2 m x 3 m trench due to the compact nature of the sediment and lack of architectural evidence. Approximately 2-3 m below the modern surface a conglomerate rock formation was reached; this formation may be man-made. General observations and contextual information of the thin sections created from the five monoliths from Trench A3 are noted below, organized by related context groups assigned during excavations, as some contexts are present across multiple monoliths (Fig. 4.2, Table 4.7). Initial micromorphological interpretations are also provided; these interpretations will be further discussed in relation to their site context in Chapter 5.

Table 4.7. Sample inventory Argyrakis plot, Trench 3 (2013).

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Bulk Sample No.</th>
<th>Context units (#)</th>
<th>Ceramic/typological designation</th>
<th>Vertical Location (digital GPS, masl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A3MM1</td>
<td>A3BS1</td>
<td>3008A</td>
<td>3008A: LM III with some earlier material</td>
<td>22.615-22.419 masl</td>
</tr>
<tr>
<td>A3MM2</td>
<td>A3BS2</td>
<td>3008A/B</td>
<td>3008A/B: LM III with some earlier material</td>
<td>22.461-22.252 masl</td>
</tr>
<tr>
<td>A3MM3</td>
<td>A3BS3, 3009</td>
<td>3008B: LM III with some earlier material 3009: LM I(?)</td>
<td>22.271-22.057 masl</td>
<td></td>
</tr>
<tr>
<td>A3MM4</td>
<td>A3BS4</td>
<td>3009</td>
<td>3009: LM I(?)</td>
<td><del>22.200</del>21.860 masl</td>
</tr>
<tr>
<td>A3MM4.2</td>
<td>N/A</td>
<td>3009</td>
<td>3009: LM I(?)</td>
<td>22.149-21.917 masl</td>
</tr>
</tbody>
</table>

Figure 4.2. Locations of A3 monoliths in Trench A3, relative to one another. Heights are listed in metres above sea level (masl).
4.2.2.1 Post-palatial, LM III, and Neopalatial, LM I (Units #3008A/B)

Thin sections A3MM1A, A3MM1B, A3MM1C, A3MM2A, A3MM2B, A3MM2C, and possibly some of the A3MM3C sections are related to context units #3008A and #3008B, which were identified as LM III and potentially earlier due to their containing LM III ceramics, and some identified as possibly earlier ceramics (Plates 4.14A-F, 4.14I). Unit #3008A was noted during excavations to contain a possible mixture of LM III and potentially earlier, LM I materials.
(perhaps caused by post-depositional disturbance), in #3008B (deeper units, #3009 and below, were observed to contain LM I and MM materials).

Unit #3008A/B (5YR 5/6 and 5YR 4/4) was observed in the field to be distinct in its softer compaction compared to overlying units and the additional inclusion of calcium carbonate nodules. While most ceramics from #3008A were identified as LM III types, some ceramics from A3MM1B were identified as LM I; most ceramics from #3008B were identified as MM II.412

General observations

Sections A3MM1 through A3MM3 are mainly composed of MF1 and MF1v microfabric types with poorly to moderately sorted, close-porphyric c/f10µm related distributions of 70/30, with iron/manganese nodules (20 µm - 500 µm) (~2-5%), organic material (bone fragments (~0-2%), shell fragments (~2-3%), modern roots (~1%), a few dark brown organic residues (~2%)), and areas of clay and diffuse iron impregnation and depletion. The coarse groundmass of the thin sections (MF1 and MF1v) consists of smooth, sub-angular to rounded grains of quartzite, phyllite, and sandstone—consists dominantly of silt-size grains (~40-60%), very fine sand (v.f.s.-size (20 - 100 µm, ~10%) to fine sand (f.s.-size (100 - 500 µm, ~5-10%), with medium sand (m.s.-size (200 - 500 µm, ~2-5%), coarse sand (c.s)-size (500 - 1000 µm, ~5%), very coarse sand (v.c.s.-size grains (1000 - 2000 µm, ~10%), and rounded to sub-rounded fine gravel (f.g.-size grains (>2000 µm, ~0-10%). All sections exhibit reddish brown, weakly crystallitic b-fabric and complex microstructures (primarily sub-angular blocky, cracky, channel, and vughy). Generally, the sections have semi-smooth channels (f.s.-m.s., ~5-10%), semi-smooth typic vughs/vesicles (m.s.-c.s., ~5-10%) and a total intrapedal porosity of ~15-20%.

Some differences may be observed in the sections, however. Section A3MM1A and A3MM1C contain zones of the MF4 microfabric type, with a poorly to moderately sorted; chito-gefuric distribution of v.f.s.- and silt-size grains (Plates 4.14A, 4.15A/B). While the grains in A3MM1A exhibit fining upwards, typical of MF4, they are unsorted in A3MM1C.

Additionally, sections A3MM3A and A3MM3B demonstrate increased ped development (Plates 4.14G/H, 4.15G/H). Section A3MM3B contains an area of the MF1d microfabric type, which demonstrates horizontal alignment of the elongated vughs/vesicles and increased intrapedal porosity (Plates 4.15C/D). No further indications of sorting are apparent in the thin sections. Typic dusty clay hypocoatings (occurring in about one-third of the voids, <50μm) and calcitic hypocoatings and cappings (on less than one-third of the coarse grains) are observable in the sections. Areas of clay/iron impregnation and depletion also are observable around the voids; depletion features are particularly noticeable in A3MM2B and A3MM2C (Plates 4.14E/F). A large calcitic formation is observable A3MM3A (Plate 4.14G).

Interpretations

The dominant microfabrics (MF1v and MF1) in the thin sections may be representative of different depositional processes, as noted above: (1) a vughy microstructure may indicate that the sediment was transported by hydrogeological processes;⁴¹³ (2) a vesicular microstructure may be due to air being incorporated into a water-saturated sediment close to the surface⁴¹⁴; (3) a vughy/vesicular microstructure may have formed through debris flow processes.⁴¹⁵ As observed in some of the thin sections in the upper units of Trench A2, the characteristics of the groundmass and pedofeatures of sections A3MM1 through A3MM3 from Trench A3—the generally poorly sorted, porphyric c/f₁₀μm-related distribution of the groundmass, the weakly cystalitic b-fabric, the lack of laminations/bedding (except for the occurrences of MF4 in A3MM1A), the silty and loamy composition, the massive and vughy/vesicular microstructure (vesicles indicating liquefaction), and the subangular and subrounded aggregates—are typical of debris flow sediments and microfacies.⁴¹⁶

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⁴¹⁵ As observed in previous studies, “Debris flows correspond to flows of liquefied sediments. They are initiated by the removal of loose debris accumulated in gullies or by the transformation of landslides into a slurry following a rainstorm...” (Betran and Texier 1999: 108).
The structures of A3MM2A through A3MM2C demonstrate increasing ped development and decreasing porosity, compared to the A3MM1 sections. Additionally, section A3MM3B contains microfabric MF1d, which is typified by horizontal alignment of the elongated vughs/vesicles, indicating directional pressure, a feature of semi-plastic sediment.\textsuperscript{417} If sediment in these contexts (A3MM1 through A3MM3) was deposited by debris flows (whether in a single event or multiple events), it is likely that the deeper contexts experienced increased void collapse and reworking.

It is notable that these features and the ceramic typological contexts in #3008A correlate well with those in units #2006 and #2007 in Trench A2. If these units are indeed related, it may be concluded that similar slope processes (debris flows) impacted both this Trench 3 and Trench 2 area, and likely the area of the Post-palatial buildings (API and possible AM1).

In terms of sediment origin, the sub-angular to sub-rounded nature and composition of the coarse grains of these sediments are similar to the nature and composition of the Kastri alluvial deposits from near the site (Plates 4.4C/D).\textsuperscript{418} Dusty clay coatings and areas of calcitic and iron impregnation and depletion, indicate illuviation (after the stabilization of the mass-transported debris\textsuperscript{419}) and suggest that these thin sections now represent an E/Bt horizon.\textsuperscript{420} The zones of the MF4 microfabric in A3MM1A exhibit normally graded bedding (fining upwards), typical of MF4 in other sections; this normally graded bedding in the MF4 type is suggestive of slow water action.\textsuperscript{421} The smoothness and sphericity of the sand grains in these areas of graded bedding (MF4) are also indicative of these grains coming from a different sediment source (such as a riverbed) than those constituting the MF1 and MF1v microfabrics.\textsuperscript{422} In contrast, the zone of MF4 is unsorted in A3MM1C—likely affected by reworking processes.

\textsuperscript{417} Cf. Karkanas and Van de Moortel 2014: discussion of Microfacies E.
\textsuperscript{418} J. Gait, Fitch Laboratory, pers. comm. 2017.
\textsuperscript{419} Federoff et al. 2010: 1013-1014.
\textsuperscript{420} Stoops 2010: 373.
\textsuperscript{421} Boggs 2006: 31-34.
\textsuperscript{422} Comparable samples from a Palaikastro riverbed and a Palaikastro beach demonstrate similar degrees of roundedness (Plates 4.4D, 4.10B).
The presence of the MF4 microfabric may be an indication of a relatively stable, exposed surface on which a water saturation event occurred. The location of MF4 in the uppermost sections of unit #3008A, which is associated with Post-palatial (LM III) ceramic types, is notable because this MF4 type is only found in association with LM III contexts in other thin sections from Building AP1 and Building AM1 (only one section in AM1: A6MM1C) (see Section 4.3). Furthermore, the MF1v microfabric in the LM III units in Trench A2 (#2006 and #2007) and MF1v in Building AM1 (Section 4.3) may relate to similar overland flow processes, regardless of whether these events were contemporaneous.
Table 4.8. A3MM1 through A3MM3 sedimentary characteristics and micromorphological features based on thin section analysis

<table>
<thead>
<tr>
<th>Sample</th>
<th>Sorting</th>
<th>Rounding</th>
<th>Coarse fraction</th>
<th>Textural pedofeatures</th>
<th>Fine fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>A3MM1A</td>
<td>MF1v</td>
<td>Smooth, sub-angular to sub-rounded</td>
<td>X</td>
<td>Dusty clay coatings (&lt;33%, &lt;50μm); areas of iron depletion and concentration (panning); calcitic hypocoatings and cappings (&lt;33%)</td>
<td>X</td>
</tr>
<tr>
<td>A3MM1B</td>
<td>Poorly/ moderately sorted</td>
<td>Smooth, sub-angular to sub-rounded</td>
<td>X</td>
<td>Dusty clay coatings (&lt;33%, &lt;50μm); areas of iron depletion and concentration (patches of iron staining); calcitic hypocoatings and cappings (&lt;33%)</td>
<td>X</td>
</tr>
<tr>
<td>A3MM1C</td>
<td>Poorly/ moderately sorted; MF4, well sorted</td>
<td>Smooth, sub-angular to sub-rounded</td>
<td>X</td>
<td>Dusty clay coatings (&lt;33%, &lt;50μm); areas of iron depletion and concentration (patches of iron staining); calcitic hypocoatings and cappings (&lt;33%)</td>
<td>X</td>
</tr>
<tr>
<td>A3MM2A</td>
<td>Poorly/ moderately sorted</td>
<td>Smooth, sub-angular to sub-rounded</td>
<td>X</td>
<td>Dusty clay coatings (&lt;33%, &lt;50μm); areas of iron depletion and concentration (patches of iron staining); calcitic hypocoatings and cappings (&lt;33%)</td>
<td>X</td>
</tr>
<tr>
<td>A3MM2B</td>
<td>Poorly/ moderately sorted</td>
<td>Smooth, sub-angular to sub-rounded</td>
<td>X</td>
<td>Dusty clay coatings (&lt;33%, &lt;50μm); areas of iron depletion and concentration (patches of iron staining); calcitic hypocoatings and cappings (&lt;33%)</td>
<td>X</td>
</tr>
<tr>
<td>A3MM2C</td>
<td>Poorly/ moderately sorted</td>
<td>Smooth</td>
<td>X</td>
<td>Dusty clay coatings (&lt;33%, &lt;50μm); areas of iron depletion and concentration (patches of iron staining); calcitic hypocoatings and cappings (&lt;33%)</td>
<td>X</td>
</tr>
<tr>
<td>Sample</td>
<td>Texture</td>
<td>Grain Size</td>
<td>Iron Depletion</td>
<td>Calcitic Hypocoatings</td>
<td>Dusty Clay Coatings</td>
</tr>
<tr>
<td>--------</td>
<td>------------------</td>
<td>----------------</td>
<td>----------------</td>
<td>-----------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>A3MM3A</td>
<td>Poorly/moderately sorted</td>
<td>Smooth, sub-angular to sub-rounded</td>
<td>X</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>A3MM3B</td>
<td>Poorly/moderately sorted</td>
<td>Smooth, sub-angular to sub-rounded</td>
<td>X</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>A3MM3C</td>
<td>Poorly/moderately sorted</td>
<td>Smooth, sub-angular to sub-rounded</td>
<td>X</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>
Plate 4.14A. A3MM1A consists of the MF1v microfabric with a zone of the MF4 microfabric, which displays normally graded bedding (fining upwards), typical of MF4 in other sections; this normally graded bedding in the MF4 type is suggestive of slow water action. The weathering of the sand grains in these areas of graded bedding (MF4) indicates that these grains come from a different sediment source than those constituting the MF1 and MF1v microfabric.

Plate 4.14B. A3MM1B is composed of the MF1v microfabric type and a complex microstructure (predominantly massive, also sub-angular blocky and vugly), with weakly developed pedality, partially- to moderately-accommodating peds. One large, very rounded fragment of ceramic is present in the section.
Plate 4.14C. A3MM1C consists of the MF1v microfabric with one zone of MF4. The section has a complex microstructure (sub-angular blocky and vughy), poorly developed pedality, and partially- to moderately-accommodating peds. One horizontal fissure is present at the top of section. The section has much less developed peds than A3MM1B.

Plate 4.14D. A3MM2A is composed of a complex microstructure (mainly sub-angular blocky), with weakly to moderately developed pedality, partially- to well-accommodating peds, some vertical cracks, and a vughy microstructure near bottom of section (due to bioturbation). A large, rounded ceramic fragment is present, as well as burnt bone fragments. The groundmass (MF1) is much less vughy than that in the sections above, with a total intrapedal porosity of 15%.
Plate 4.14. A3MM2C exhibits a complex microstructure (massive, sub-angular blocky, channel, and cracky), with weakly to moderately developed pedality, partially-to well-accommodating peds, and some vertical cracks. Larger rounded f.g.-size grains (~5%) and rare ceramic fragments (very rounded).

Plate 4.14F. A3MM2B also consists of a complex (sub-angular blocky and channel) microstructure, with weakly to moderately developed pedality, and partially-to well-accommodating peds. There is also an increase in larger, rounded f.g.-size grains in the groundmass (~10%).
G. A3MM3A demonstrates a complex (sub-angular, cracky, and vughy) microstructure, with moderately to well-developed pedality, and partially- to well-accommodating peds. The section is much more developed than sections above, including A3MM2C. Additionally observable are varying patterns in void structure, with an area of increased vughy microstructure (MF1v) and an area of horizontally-aligned vughs (MF1d). A large area of calcitic formation is present in the bottom of the section.

H. A3MM3B consists of a complex (sub-angular, cracky, and vughy) microstructure, with moderately to well-developed pedality, partially- to well-accommodating peds. The section (partly MF1) exhibits the same degree of development as A3MM3A but includes the additional inclusion of larger, sub-angular f.g.-size grains, similar to those seen in MF3.

I. A3MM3C exhibits a complex (cracky and vughy) microstructure, with poorly to moderately-developed pedality, and partially- to well-accommodating peds. Similar to A3MM3B, it incorporates larger, sub-angular f.g.-size grains, similar to those seen in MF3.

Plate 4.15A. MF4 near the top of A3MM1A (PPL), appears to be the same microfabric as the MF4 type visible in some of the A5E sections. It consists of a chito-gefuric-monic distribution with a minimal proportion of fine fine material (c/f$_{10\mu m}$ 95/5-80/20), and exists in the form of graded bedding.

Plate 4.15B. MF4 near the top of A3MM1A (XPL), appears to be the same microfabric as the MF4 type visible in some of the A5E sections. Note grain size decreasing in size from bottom of arrow to arrow point; some disturbance is due to bioturbation.

Plate 4.15C. MF1d in A3MM3A (PPL), an area of diagonal-alignment (somewhat crescentic as well) of elongated vughs/vesicles and increased intrapedal porosity may suggest directional pressure.

Plate 4.15D. The area of diagonal-alignment (somewhat crescentic as well) of elongated vughs/vesicles and increased intrapedal porosity of MF1d in A3MM3A (XPL) also exhibits dusty clay coatings of voids.
Plate 4.15E. Burnt bone fragment in A3MM3A (PPL). Possible worked bone was identified in unit #3009, but not in unit #3008B, which is associated with this thin section.

Plate 4.15F. Burnt bone fragment in A3MM3A (XPL). Note the dull gray appearance (lowered interference colours) in XPL (Macphail and Goldberg 2010: 952).

Plate 4.15G. Well-accommodating peds in A3MM3B (PPL); similar ped development occurs in A3MM3A and A3MM3C.

Plate 4.15H. Well-accommodating peds in A3MM3B (XPL), within a weakly crystallitic b-fabric.

Plates 4.15A-H. A: MF4 near the top of A3MM1A (PPL); B: MF4 near the top of A3MM1A (XPL); C: MF1d in A3MM3A (PPL); D: MF1d in A3MM3A (XPL); E: Burnt bone fragment in A3MM3A (PPL); F: Burnt bone fragment in A3MM3A (XPL); G: Well-accommodating peds in A3MM3B (PPL); H: Well-accommodating peds in A3MM3B (XPL).
4.2.2.2 Neopalatial, LM I, and Protopalatial, MM (Units #3009, 3010, and 3013)

Part of thin section A3MM3C and thin sections A3MM4A, A3MM4B, A3MM4C, A3MM4.2A, A3MM4.2B, A3MM4.2C, A3MM5A, A3MM5B, and A3MM5C are related to units #3009, 3010, and 3013 based on their ceramic typological features (Plates 4.14I, 4.16A-I). Unit #3009 (5 YR 4/4) was observed to be very compact and contained many rounded gravels, calcium carbonate nodules, ceramic fragments, and bone fragments. Although noted in the field to contain fewer ceramic sherds and fewer fragments of charred organic material, obsidian and mud brick fragments were additionally found in unit #3009. Ceramic types from #3009 were identified as LM I types. Unit #3010 was also very compact, contained small and medium gravels, and possibly additional clay content, and was differentiated by its containing MM (including possibly MM IB) material. Unit #3013 similarly consisted of very compact sediment, with possible worked bone fragments, shell fragments, and ceramics, identified as MM types (although the quantity of ceramics significantly decreased in #3013).\(^\text{423}\)

*General observations*

Sections A3MM4, A3MM4.2, and A3MM5 are all dominantly composed of a combination of MF1, MF1v, and MF3 microfabric types with poorly- to moderately-sorted, close-porphyric c/f\(_{10\mu m}\) related distributions of 70/30 - 60/40, with iron/manganese nodules (20 µm - 500 µm) (~5%), organic material (bone fragments (~1%), shell fragments (~1%), modern roots (~1%), a few dark brown organic residues (~2%), and areas of clay and diffuse iron impregnation and depletion. The coarse groundmass of the thin sections (MF1/MF1v/3r types) consists of smooth, sub-angular to sub-rounded grains of quartzite, phyllite, and sandstone—silt-size grains (~30%), very fine sand (v.f.s.-)size (20 - 100 µm, ~20%) to fine sand (f.s.-)size (100 - 500 µm, ~10%), with medium sand (m.s.-)size (200 - 500 µm, all sub-rounded, ~5%), coarse sand (c.s.-)size (500 - 1000 µm, ~5%), very coarse sand (v.c.s.-)size grains (1000 - 2000 µm, ~10%), and rounded to sub-rounded fine gravel (f.g.-)size grains (>2000 µm, ~10-15%). All sections exhibit reddish brown and crystallitic b-fabric and complex microstructures

\(^{423}\) N. Momigliano, field notes and pers comm. 2013.
(primarily massive, channel, and vughy). Like the sections of unit #3008A/B, these sections have semi-smooth channels (f.s.-m.s., ~5-10%), semi-smooth typic vughs/vesicles (m.s.-c.s., ~5-10%) and a total intrapedal porosity of ~15-20%.

There is a notable increase in the unsorted nature of these sections (from units #3009, #3010, and #3013) compared to sections from overlying units (#3008A/B), particularly with an increase in f.g.-size coarse components (~10-15%). Additionally, the fine fabric consists of a more developed dusty clay matrix with some areas of limpid clay, and exhibits a cross-striated and speckled b-fabric (Plates 4.17C-H). Sections A3MM5B and A3MM5C, which correspond to units #3010 and #3013 also contain areas of silty sandy laminations (mainly in A3MM5C) (Plates 4.17K/L), also contains within its matrix zones of the MF2 microfabric, which is characterized by a denser, close porphyric c/f_{10µm}-related distribution of 80/20, a groundmass including silt, ~50%; v.f.s.-size, ~40%; f.s.-size ~2%; and m.s.-size ~2%, as well as orthic and disorthic typic impregnative iron hydroxide nodules (v.f.s.-size ~5%) (Plate 4.17I).

**Interpretations**

As noted for the overlying thin sections in units #3008A/B, the dominant microfabrics (MF1v and MF1) and vughy/vesicular microstructures in the thin sections may be representative of different depositional processes, including hydrogeological and debris flow processes. Similar to the groundmass and pedofeatures of sections A3MM1 through A3MM3, the poorly sorted, porphyric c/f_{10µm}-related distribution of the groundmass, the crystallitic b-fabric, the lack of laminations/bedding (except for the occurrences of MF2 in A3MM5B and A3MM5C), the silty and loamy composition, the massive and vughy/vesicular microstructure, and the sub-angular and sub-rounded aggregates, are typical of debris flow sediments and microfacies.

Additionally, these microfabrics appear mixed with features of the MF3 microfabric type, a poorly-sorted, common gefuric (c/f_{10µm})-related distribution of approximately 90/10 -80/20 with sub-angular to sub-rounded grains, which appear in larger grain sizes (c.s.-size and larger) than those of the surrounding MF1 groundmass. These features are also suggestive of debris flow sediments. The additional presence of the MF2 microfabric in sections A2MM5B and A2MM5C may also relate to the incorporation of crescent-like structure of MF2 in A3MM5B.
It is possible that the crescentic structure may be related to structures noted in deformation processes during a debris flow.\textsuperscript{425}

Also notable is the fine material in these sections, associated with units #3009, #3010, and #3013, which consists of a more developed dusty clay matrix with some areas of limpid clay, as well as a cross-striated and speckled b-fabric (Plates 4.17C-H). The presence of dusty and limpid clay is likely the result of illuviation (transport of fine particles post-deposition)\textsuperscript{426} and may be related to quite evolved Bt horizons. The crystallitic and cross-striated b-fabric may be a result of shrink and swell processes, typically related to vertic materials, which may occur in calcareous soils in arid/semi-arid environments.\textsuperscript{427}

Overall, these thin section features are possibly indicative of multiple episodes of overland flow across this site area. It may be notable that the MF3 microfabric is also noted in Trench A2 only in units related to Protopalatial (MM) ceramic types, as observed here in Trench A3. However, this microfabric also occurs in sections outside these trenches (in an exterior space north of Building AP1 and from contexts in Building AMI); similar overland flow processes may have influenced these areas, although not necessarily contemporaneously.


\textsuperscript{426} Stoops 2003: 108.

\textsuperscript{427} Kovda and Mermut 2010: 208-209.
Table 4.9. A3MM4, A3MM4.2, and A3MM5 sedimentary characteristics and micromorphological features based on thin section analysis

<table>
<thead>
<tr>
<th>Sample</th>
<th>Sorting</th>
<th>Rounding</th>
<th>Coarse fraction</th>
<th>Textural pedofeatures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Quartzite/phylite/sandstone</td>
<td>Calcite</td>
</tr>
<tr>
<td>A2MM4A</td>
<td>Poorly/moderately sorted</td>
<td>Smooth, sub-angular to sub-rounded</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>A2MM4B</td>
<td>Poorly/moderately sorted</td>
<td>Smooth, sub-angular to sub-rounded</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>A2MM4C</td>
<td>Poorly/moderately sorted</td>
<td>Smooth, sub-angular to sub-rounded</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>A2MM4.2A</td>
<td>Poorly/moderately sorted</td>
<td>Smooth, sub-angular to sub-rounded</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>A2MM4.2B</td>
<td>Poorly/moderately sorted</td>
<td>Smooth, sub-angular to sub-rounded</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>A2MM4.2C</td>
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<td>Smooth, sub-angular to sub-rounded</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>A3MM5A</td>
<td>Poorly/moderately sorted</td>
<td>Smooth, sub-angular to sub-rounded</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>A3MM5B</td>
<td>Poorly/moderately sorted</td>
<td>Smooth, sub-angular to sub-rounded</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>A3MM5C</td>
<td>Poorly/moderately sorted</td>
<td>Smooth, sub-angular to sub-rounded</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
Plate 4.16A. A3MM4A demonstrates a very different microfabric mix than that of the sections above in Trench A3. The large, subrounded and rounded calcitic nodules are similar to those near the bottom of Trench A2, in section A2MM16C. Although not at the same relative depth, perhaps these reflect similar pedogenic conditions.

Plate 4.16B. A3MM4.2A displays a massive and vughy intrapedal microstructure (MF1v microfabric type). A large charcoal fragment of Pinus spp. is present, and is also cracking.
Plate 4.16C. A3MM4B displays a complex (massive and vughy) microstructure. It appears more compact than A3MM4A, and it additionally includes an increased proportion of c.s.-size grains (10-15%) of groundmass. Dark, dusty clay coatings are also present around the voids. The ceramic fragment appears to be the F4 fine fabric type, typical for MM cups (J. Gait pers. comm. 2017).

Plate 4.16D. A3MM4.2B has a complex (massive, vughy, and channel) microstructure with a significant degree of bioturbation visible. The section appears most similar to that of A3MM4.2C.
Plate 4.16. A3MM4C displays a complex (massive, vughy, and channel) microstructure and appears similar to A3MM4B, although it contains fewer coarse grains and a lower porosity (15%), instead of (20%).

Plate 4.16F. A3MM4.2C demonstrates a dominantly channel microstructure with some vughs (one large vugh is present in the centre of the section, surrounded by dusty clay coatings and hypocoatings. Overall, the MF1 microfabric type dominates.
Plate 4.16G. A3MM5A displays a massive and vughy microstructure with a mixed groundmass of MF1v, MF3, and MF3r, similar to some of the mixed structures in the A2MM12 sections, which are at similar relative depths and perhaps indicative of similar processes.

Plate 4.16H. A3MM5C consists of a massive and vughy microstructure with one large, horizontal fissure, moderately accommodated. It contains both porphyric microfabrics MF1v and a denser close porphric MF2 microfabric, as well as areas of lamination in the bottom portion of the section, which bottom portion of section correlates with units #3010 and #3013.
Plate 4.16. A3MM5B exhibits a massive and vugly microstructure with mixed MF1v and MF3 microfabrics, as well as one zone of the MF2 microfabric. While appearing massive, there are areas of sorting, which appear to have been affected by bioturbation or possibly flow currents (MF2, Plate 4.17I).

Plates 4.16A-I. Thin sections A3MM4A-C, A3MM4.2A-C, and A3MM5A-C.
Plate 4.17A. Large, sub-rounded quartzite and calcitic nodules in A3MM4A (XPL) in a porphyric groundmass.


Plate 4.17C. Dusty and limpid clay coatings in A3MM4A (PPL).

Plate 4.17D. Dusty and limpid clay coatings in A3MM4A (XPL).
Plate 4.17E. Dusty-clay dominated matrix with cracks in areas of A3MM4A (PPL). These clay features may be indicative of illuviation and are unique to the A3MM4 sections.

Plate 4.17F. Dusty-clay matrix with some areas of limpid clay in A3MM4A (XPL) demonstrates cross-striated and speckled b-fabric. Crystallitic and cross-striated b-fabric may be a result of shrink and swell processes, typically related to vertic materials, which may occur in calcareous soils in arid/semi-arid environments (Kovda and Mermut 2010: 208-209).

Plate 4.17G. Similar to A3MM4A, A3MM4B (shown here in PPL), contains dusty and limpid clay coatings.

Plate 4.17H. Dusty and limpid clay coatings in A3MM4B (XPL). Some extinction lines are visible, indicating the continuous orientation of some of the clay particles (Stoops 2003: 111).
Plate 4.17I. Sorting of silty and sandy grains in A3MM5B (in PPL) may be related to structures noted in deformation processes during a debris flow (Phillips 2006: 729-732) (direction of flow indicated by white arrows).

Plate 4.17J. Cracky/planar voids and charcoal fragment and dusty/limpid clay formations in A3MM4B (PPL).

Plate 4.17K. MF2 (close porphyric) microfabric in one area of A3MM5C (PPL), and platy microstructure with planar voids, possibly indicative of shear/slip planes (Betran and Texier 1999: 115-116).

Plate 4.17L. MF2 (close porphyric) microfabric in one area of A3MM5C (XPL), and platy microstructure with planar voids. Also visible is the crystallitic b-fabric with dusty clay coatings in the planar voids.

Plates 4.17A-L. A: Large, sub-rounded quartzite and calcitic nodules in A3MM4A (XPL); B: Iron-rich clay pendant surrounded by a calcitic pendant and crystallitic b-fabric in A3MM4A (XPL); C: Dusty and limpid clay coatings in A3MM4A (PPL); D: Dusty and limpid clay coatings in A3MM4A (XPL); E: Dusty-clay dominated matrix with cracks in areas of A3MM4A (PPL); F: Dusty-clay matrix with some areas of limpid clay in A3MM4A (XPL); G: Dusty and limpid clay coatings in A3MM4B (PPL), similar to A3MM4A; H: Dusty and limpid clay coatings in A3MM4B (XPL); I: Sorting of silty and sandy grains in A3MM5B (in PPL); J: Cracky/planar voids and charcoal fragment and dusty/limpid clay formations in A3MM4B (PPL); K: MF2 (close porphyric) microfabric in one area of A3MM5C (PPL), and platy microstructure with planar voids; L: MF2 (close porphyric) microfabric in one area of A3MM5C (XPL), and platy microstructure with planar voids.
4.3 2014 Excavations: Buildings AP1, AM1, and MP1

During the 2014 excavations, thirteen sediment monoliths were obtained in order to build upon the understanding of the depositional context of the site stratigraphy and landscape transformation in the new areas of excavation (Fig. 4.3). The general observations and contextual information of each of these samples is organized below by sampling location in their respective buildings and exterior spaces. A total of 113 bulk soil samples of 200-300 g each (including those taken in context with the sediment monoliths) from the 2014 excavations were obtained for subsequent analyses and were submitted to pH testing with the aim of further understanding the taphonomic processes and soil preservation qualities across the site, and at varying depths. The pH range of all 113 samples was 8.21-9.32, with an average of 8.85 and median of 8.89 (Appendix 1). These results demonstrate alkaline soil environments, and thus preservation potentials similar to those of the samples from 2013.

Figure 4.3. Location of 2014 micromorphological sampling locations (Plan by Spencer 2016).
4.3.1 Building AP1

Building AP1, excavated in the 2013-2015 seasons, was occupied in MM III-LM IA. Archaeological (ceramic and architectural) materials indicate that there was a hiatus in occupation until LM III. In the latter occupation phase, the structure measures approximately 11 metres E-W by 10 metres N-S.\(^{428}\) The external walls of the structure, which include local sandstone ashlar blocks, some with plaster, are preserved.\(^{429}\) The larger structure has been divided by walls into rooms/spaces (Plate 4.25), with varying evidence for occupation records, primarily for the LM III occupation phases (Palaikastro Periods XIV-XV).\(^{430}\) It appears that earlier Neopalatial (MM III-LM IA) walls were restructured and used in the later LM III occupation, and the presence of significant quantities of Neopalatial ceramics and materials suggests that Building AP1 was a substantial building in the Neopalatial period. Any potential occupation during the earlier, Protopalatial period (particularly in Rooms 3a and 4) needs further investigation in this structure.\(^{431}\)

4.3.1.1 Room 3(a)

Two sediment monoliths (A5EMM1 and A5EMM2) were taken from the excavated area of trench A5E (Fig. 4.4) and may contain an LM III context and part of an LM III floor (tentatively identified during excavations) (#3050), as well as earlier materials indicative of abandonment or collapse (#3056/#3058) that possibly relate to a collapse layer with larger structural stones, since the tops of two walls (Wall 25 to the West and Wall 30 to the East) occur at lower relative depths. The sediment monoliths were taken from immediately south of a threshold stone, located 80-200 cm from the A5E-A5W trench division (Plates 4.18, 4.19). Ceramic and charcoal fragments were visible in the profile of the contexts sampled and a crumbly, pebbly surface was visible 19 cm from the top of the monoliths, which may relate to the field observation of the tentative LM III floor. Monolith A5EMM1 was divided into four

\(^{428}\) PALAP BSA Report 2015: 1.
\(^{429}\) Ibid.
\(^{430}\) Ibid.
\(^{431}\) Ibid.
thin sections, and monolith A5EMM2 was divided into three thin sections; the thin sections were cut so as to create overlapping sections along the approximately 37 cm of each monolith, from the highest point sampled in #3050 to the deepest, as follows: A5EMM1A, A5EMM2A, A5EMM1B, A5EMM2B, A5EMM1C, A5EMM2C, A5EMM1D (Plates 4.19, 4.20A-G). Four bulk samples were taken for geochemical analysis from the associated contexts.

*General Observations (refer to Table 4.10)*

The thin sections are primarily composed of sand, clay, and silt, with varying proportions of poorly-sorted close porphyric coarse/fine (c/f\(_{10\mu m}\)) related distribution of approximately from 80/20-60/40 (microfabric (MF) 1) and well-sorted chito-gefuric/chito-gefuric-monic c/f\(_{10\mu m}\) related distribution of about 95/5-90/10 (microfabric (MF) 4). In the close porphyric distributions, the mineral components of the groundmass consist of smooth, sub-angular to rounded grains of quartz and quartzite (very fine sand (v.f.s.)-size, dominant, ~40-50%; fine sand (f.s.)-size, ~10-20%; medium sand (m.s.)-size, ~2-5%; course-sand (c.s.)-size, ~2%; very course sand (v.c.s.)-size, ~1%; fine gravel (f.g.)-size, sub-rounded to rounded, ~3-5%); and approximately ~20-30% silt. Few phyllitic-quartzite (phylite) and/or sandstone sand grains are also present throughout the sections (v.f.s.-v.c.s., approximately ~10% of coarse component), as well as orthic and disorthic typic impregnative iron hydroxide nodules (v.f.s.-c.s. ~2-5%) and few dark brown (organic) residues (~2-5%). In contrast to the porphyric distributions, the chito-gefuric/chito-gefuric-monic distributions consist of coarse grains of v.f.s.-size, ~45%; f.s.-size ~3%, m.s.-size, ~1%, and c.s.-size, ~1%, and ~50% silt (Plate 4.21C/D); the chito-gefuric/chito-gefuric-monic distributions also exhibit graded bedding (fining upwards) (Plate 4.21E/F).

Other microfabric types present, but not dominating the A5E thin sections, include MF1c, which exhibits the same features as MF 1 but includes additional c.s.-size grains; MF1o - similar to MF1 but with a higher content of charred organic material; and MF2 - a finer-grained version of the MF1 porphyric c/f\(_{10\mu m}\)-related distribution. Additionally, porphyric silty-sandy laminae/laminations also occur in the sections, consisting of approximately ~80% silt and ~20% clay.

The voids in the thin sections with porphyric c/f\(_{10\mu m}\)-related distributions are comprised of rough channels (10\(\mu\)m - 500\(\mu\)m, ~10%) and semi-smooth, irregular-shaped vughs (10 - 200\(\mu\)m, ~5%), and have a total intrapedal porosity of ~15-20%. The areas of chito-
gerfuric/chito-gefuric-monic c/f\textsubscript{10\textmu m}-related distribution have a total intrapedal porosity of ~20-30%. Areas of dense silty clay laminae contain only regular and irregular shaped vesicles/vughs (20 - 200\textmu m) and exhibit a total intrapedal porosity of ~5%.

Iron/manganese (Fe/Mn) nodules (20 \textmu m - 1000 \textmu m) (~2-5%), organic material (roots/wood/plant material) (<1-2%), charcoal (<1-5%) (Plate 4.21A), bone (<1-1%), shell fragments (~1%), ceramic fragments (<1-2%) (Plate 4.21B), and plaster fragments (~0-2%) occur in the sections. Areas of calcite impregnations and hypocoatings are present throughout the sections, and appear to have occurred prior to silty clay coatings, suggesting typical soil pedogenesis (Plate 4.21G/H). In addition to the presence of calcite, areas of iron impregnation and depletion suggest that the sections contain sediment from E/Btk horizon. Evidence of root activity and bioturbation are present throughout the sections, but are less prevalent in the thin sections taken from greater depths.

**Interpretations**

While the A5E thin sections contain different microfabrics, none of these microfabrics or other features is indicative of an anthropogenically-created surface/floor. It is likely that the surface/floor tentatively identified during excavations in #3050 corresponds to the start of multiple layers and silty clay laminations associated with MF4 (the chito-gefuric/chito-gefuric-monic groundmass) in thin section A5EMM2B (Plate 4.20D); this was noted in the field as a ‘crumbly, pebbly surface visible at 19 cm from the top of the monoliths’. The different distributions of the coarse and fine materials (close porphyric and chito-gefuric/chito-gefuric-monic) and the silty clay coatings and laminae/laminations suggest several possible processes affecting this area of the site, all of which indicate the influence of water: (1) the transportation of coarse particles (quartz sand grains) is typical via the rapid wetting of soils;\textsuperscript{432} (2) the clay and silt coatings present in the sections may be flood coatings, as finer materials may travel farther in suspension;\textsuperscript{433} (3) the absence of layering within the clay and silt coatings is suggestive of

\textsuperscript{432} Stoops 2010: 381.

\textsuperscript{433} Ibid.
turbulent flow\footnote{Miedema 2002.} or secondary illuviation\footnote{Stoops 2010: 382.}. While clay and silt coatings and laminations may simply form through illuviation\footnote{Illuviation is the process by which fine particles are translocated vertically through a profile by suspension in water.}, the alternating layers of larger sand grains in A5EMM2B, A5EMM1C, A5EMM2C, and A5EMM1D demonstrate that was not only the fine particles that were sorted (Plate 4.20D-G). The coarse, sand-size particles are sorted as well, as graded bedding (Plates 4.21C-F). The formation of graded bedding is a process that cannot occur by colluvial deposition;\footnote{Betrand and Texier 1999; Stoops 2010.} coarse fractions of colluvial depositions are generally poorly-sorted, and not graded.

Graded bedding, which may be defined as “sedimentation units characterized by distinct vertical gradations in grain size,”\footnote{Boggs 2006: 80.} may be formed when a surface is saturated but then experiences sudden drying.\footnote{Courty et al. 1989; Miller and Goldberg 2009: 79.} While laminated features in colluvial deposits may indicate areas of “rapid vertical or lateral particle accumulation, which can be extensive (e.g. downslope of large gullies),” the chito-gefuric distributions of colluvial material are generally related to slow phases of water infiltration, leading to the illuviation of fine material.\footnote{Stoops 2010: 101-102.} Therefore, the multiple layers of graded bedding in the sections, from A5EMM2B and below, may indicate multiple wetting and rapid drying events, over the approximately 19 cm of profile covered by A5EMM2B to A5EMM1D.

While the normally graded bedding (fining upwards) suggests slow water action, the transportation of such large quantities of fine sediment could indicate a higher energy event impacting nearby areas.\footnote{Boggs 2006: 31-34.} The small sizes of the sand grains involved in the bedding and laminations are indicative of ‘relative’ high-energy sorting. This is due to the fact that eroded material outside medium sand (m.s.)-size (200 - 500 µm) requires a higher velocity to be eroded
and suspended/transported in flowing water; any larger or smaller particles require a higher velocity to be displaced and transported due to the greater shear stress that the water flow needs to match to displace smaller and larger particles.\textsuperscript{442} Once transported in suspension (small particles) or as a bed load (larger particles), the larger (coarser) particles will fall out of suspension the suspension/bed load first, and the smaller (finer) particles will fall out of suspension last, resulting in graded bedding.\textsuperscript{443} Furthermore, the smoothness and sphericity of the sand grains in these areas of graded bedding (MF4) suggests that the grains come from a different source than the rest of the sediment, which is generally more sub-angular and slightly rougher. The sand grains in MF4 could come from the riverbed/gully excavated in 2013 (see Section 4.2) or could possibly be beach sediment based on their rounded and smooth nature.\textsuperscript{444}

The dark colour of the dusty/silty/impure clay coatings (Plates 4.21C/D, 4.21G/H) in all of the thin sections suggests their inclusion of fine organic matter; these pedostructures do indicate illuviation and suggest that these thin sections are representative of an E/Bt horizon and/or colluvial material, and also may be associated with deforestation or other anthropogenic changes, such as cultivation.\textsuperscript{445} The dominant sediment (MF1) in the thin sections above A5EMM2B, are representative of non-laminated colluvial material based on the silty and loamy composition, massive, weakly-developed angular block microstructure, fine fractions, anorthic Fe/Mn nodules, and fragments of clay coatings.\textsuperscript{446} An increase in the amount of charred organic material—seen particularly well in MF1o in A5EMM1D—might support an association with fire or anthropogenic activities involving burning (Plate 4.21B). As this section is related to potential phases of water saturation, it is possible that a water-related event (e.g., heavy rains) could simultaneously cause alluvial deposition.

As there does not appear to be any anthropogenically-created surface/floor in the thin sections, but rather that there were possibly episodes of water saturation occurring

\textsuperscript{442} This process is further explained by the Hjulström-Sundborg principle for sediment transport (Boggs 2006: 29).

\textsuperscript{443} Boggs 2006: 31-34.

\textsuperscript{444} Jankowski et al. 2014, Fig. 4. Comparable samples from a Palaikastro riverbed and a Palaikastro beach demonstrate similar degrees of roundedness (Plates 4.4D, 4.10B).

\textsuperscript{445} Stoops 2010: 373.

\textsuperscript{446} Mücher 1974; Stoops 2010: 103.
simultaneously with, or preceding, colluvial depositions, it is possible that this context (#3050) is representative of a phase of abandonment of Room 3(a) in Building AP1. It is not presently possible to determine the time frame of this abandonment based on the bed forms alone, as the rate at which beds form may vary from seconds or hours, to months or years. This interpretation will be discussed further in relation to other site areas in Chapter 5.

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447 Boggs 2006: 79.
Table 4.10. A5E and A5W sedimentary characteristics and micromorphological features based on thin section analysis

<table>
<thead>
<tr>
<th>Sample</th>
<th>Sorting</th>
<th>Rounding</th>
<th>Coarse fraction</th>
<th>Textural pedofeatures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Void coatings</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fe/Mn nodules</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Intercalat-ions</td>
</tr>
<tr>
<td>A5EMM1A</td>
<td>Poorly-sorted (90%)</td>
<td>Smooth, sub-angular to rounded</td>
<td>X  X</td>
<td>Dusty clay hypocoatings and infillings</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(10 - 50μm) (in 25% of voids)</td>
</tr>
<tr>
<td>A5EMM2A</td>
<td>Poorly-sorted; few well-sorted zones</td>
<td>Smooth, sub-angular to rounded</td>
<td>X  X</td>
<td>Dusty clay hypocoatings and infillings</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(10 - 50μm); dusty clay bridges; silty clay laminations</td>
</tr>
<tr>
<td>A5EMM1B</td>
<td>Poorly-sorted; few well-sorted zones</td>
<td>Smooth, sub-angular to rounded</td>
<td>X  X</td>
<td>Silt and sand compound layering (bedding); clay laminations; dusty clay hypocoatings and infillings</td>
</tr>
<tr>
<td>A5EMM2B</td>
<td>Poorly-to well-sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X  X</td>
<td>Silty clay laminations (20 - 100 μm) present throughout, primarily in [1/2] matrix and not in bedding areas at bottom</td>
</tr>
<tr>
<td>A5EMM1C</td>
<td>Poorly-to well-sorted (50%/50%)</td>
<td>Smooth, sub-angular to rounded</td>
<td>X  X</td>
<td>Thin, impure clay coatings of chito-gefuric grains; silty clay laminations very rare (&lt;3%)</td>
</tr>
<tr>
<td>A5EMM2C</td>
<td>Poorly-to well-sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X  X</td>
<td>Impure clay laminations alternating in areas of sandy-silty measure (10 - 500 μm, 25% of laminated groundmass)</td>
</tr>
<tr>
<td>A5EMM1D</td>
<td>Poorly-to well-sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X  X</td>
<td>Silty clay laminations (20 - 100 μm) present throughout; dusty clay hypocoatings</td>
</tr>
<tr>
<td>A5WMM1</td>
<td>Poorly-sorted; well-sorted laminations</td>
<td>Smooth, sub-angular to rounded</td>
<td>X  X</td>
<td>Silty sandy lamination (plane); dusty clay quasicoatings and laminations (10 - 50 μm)</td>
</tr>
</tbody>
</table>
Figure 4.4. Location of A5EMM1 and A5EMM2 in Building AP1, Room 3(a) (Plan by Spencer 2016).
Plate 4.18. (A) Location of A5E monoliths behind threshold, prior to removal. (B) Sediment prior to taking monoliths. Sediment appears homogeneous to the naked eye; the only feature noted during excavations was a pebbly surface approximately 19 cm from the top of the monoliths (C) Location of monoliths with larger area of threshold and Wall 16 visible.
Plate 4.19. (Left) A5E thin sections in relative relation to one another (not to scale; each section is approximately 5 cm by 7.5 cm); (Right) Thin sections in monoliths before being processed.
Plate 4.20A. A5EMM1A demonstrates a complex (massive, angular blocky and crumby microstructure) with angular blocky peds, moderately separated and partially-accommodated. It contains one area (~10% of the thin section) of laminations/bedding of rounded sand grains with chito-gefuristic distribution (encircled by the dashed line). The rest of the thin section displays a close poyphyric distribution. No anthropogenic surfaces/floors are visible in this section.

Plate 4.20B. A5EMM2A consists of a complex (granular and subangular blocky microstructure) with angular blocky peds that are moderately separated, partially-accommodated. The c/ʃ_{10μm} distribution of the groundmass is divide between close porphyric (60%) (microfabric 1 (MF1)) and chito-gefuristic (40%) (MF4). MF1 is a dense porphyric groundmass with fragmented silty clay laminations and an intrapedal porosity of 15% (crumby and vughy/vesicular); MF4 is a chito-gefuristic groundmass with graded bedding with an intrapedal porosity of ~20%; chito-gefuristic (compact bridge grain and vughy/vesicular). MF1/2 is the zone of mixing of MF1 and MF4 with indistinguishable boundaries. As in section A5EMM1A, no surfaces/floors are visible.
Plate 4.20C. A5EMM1B. Similar to sections A5EMM1A and A5EMM2A, this section has a complex microstructure (massive and crack microstructure with angular block peds) with angular blocky peds, moderately to highly separated, and partially-accommodated. Also similar to A5EMM2A, this section contains a few zones of well-sorted groundmass that appear to be silty clay laminations (indicated by yellow dashed lines). The c/f$_{10\mu m}$ distribution of MF1 is similar to that in A5EMM1A (70/30), although the zones indicated by MF1c indicate a change in the microfabric type with c.s.-size grains being more dominant (c/f$_{10\mu m}$ is 60/40). The boundaries between MF1 and MF1c are distinct, but no surfaces/floors are visible.

Plate 4.20D. A5EMM2B. The top and bottom of A5EMM2B appear to be different to naked eye; the very top of the section appears to contain a higher proportion of charred organic material; the bottom of the section appears to contain multiple layers and silty clay laminations. Above the visible layers/laminations, a chito-gefuric-monic distribution (MF4) displays very few fine material (c/f$_{10\mu m}$ 95/5-90/10), and a zone of graded bedding (outlined by yellow lines) is present; below the bottom yellow line, the bedding is normally graded. MF4 comprises approximately 60% of the section, while the mainly close porphyric distribution (MF1/2) (c/f$_{10\mu m}$ 70/30) comprises about 40%. The overall section demonstrates a complex microstructure (compact and bridged grain, vughy/vesicular, crumby) with weakly separated, partially-accommodated peds.
Plate 4.20E. A5EMM1C demonstrates a complex (massive, grain, and vughy) microstructure with peds weakly separated, and partially-accommodated where separated. It also exhibits an equally-mixed groundmass to that of MF1/4 in A5EMM2B, based on its c/f$_{10µm}$ distributions of close porphyric (60/40; ~50%) chito-gefuric-monic (80/20; ~50%). The porphyric distribution is dominantly comprised of subangular grains, while the chito-gefuric-monic distribution consists of predominantly rounded grains, suggesting different grain sources. The rounded ceramic fragment at the base of the section appears to be related to the C1 coarse fabric type, typical of cooking and storage wares in the Proto- and Neopalatial periods (J. Gait, pers. comm. Jan. 2017). The ceramic fragment is surrounded by zones of normally graded bedding (indicated by the white lines) and silty clay laminations (indicated by areas in dashed lines). Charcoal fragments include conifer wood charcoal (L. Picornell-Gelabert, pers. comm. 2016).

Plate 4.20F. A5EMM2C is comprised of a complex (compact, bridged-grain structure, massive, and vesicular) microstructure with weakly separated, partially-accommodated peds. It may be divided into three zones: MF1- a mainly close porphyric related distribution (c/f$_{10µm}$ 80/20), MF4- a chito-gefuric-monic (compact bridge grain and vughy/vesicular) distribution (c/f$_{10µm}$ 95/5-90/10 (silt ~20%, v.f.s. ~30%, f.s. ~20%, m.s. ~10%, c.s. ~10%)), and a zone of mixed porphyric and silty sandy bedding (silty sandy bedding: silt ~80%; v.f.s. ~20%, and close porphyric silty sandy bedding (silt ~60%, v.f.s. ~20%, clay ~20%) (outlined by red lines). No surfaces/floors are apparent.
Plate 4.20G. A5EMM1D shows the least post-depositional disturbance (mainly due to bioturbation) of the A5E thin sections. It is comprised of a complex (massive, vesicular, angular blocky) microstructure with angular blocky ped development through the upper half of the section, and moderately separated, partially-accommodated peds. The section contains four different microfabric types: MF1 - dense, close porphyric (75%) (similar to MF1 in A5EMM2A and A5EMM1B); MF4 - chito-gefuric (25%) with c/f10µm of 90/10 with graded bedding (similar to that of MF 4 in A5EMM2C); MF2 - fine grain porphyric (70/30) (similar to the MF1 dominant in A5EMM1A, A5EMM1C, and A5EMM2C), and MF1o - a dense porphyric distribution like MF1, but higher in organic material. Clay laminations are present throughout the section, but no surfaces/floors are apparent. Charcoal fragments include conifer wood charcoal fragments (L. Picornell-Gelabert, pers. comm. 2016).

Plates 4.20A-G. Thin sections A5EMM1A-D and A5EMM2A-C.
Plate 4.21A. Fabric of ceramic fragment in A5EMM1C (XPL). This fabric may relate to the coarse fabric identified as C1, which is associated with cooking and storage wares in the Proto- and Neopalatial periods (J. Gait, pers. comm. Jan. 2017). Note the large, horizontally-aligned phyllite inclusions, typical of the C1 fabric.

Plate 4.21B. Charred organic material in A5EMM2B. The increased in occurrence of charred organic material with the simultaneous occurrences of water-lain sediments might support an association of burning events and alluvial events.

Plate 4.21C. Charred organic material in a silty clay lamination, underlying chito-gerfuric-monic graded bedding in A5EMM2B (PPL). Dusty clay hypocoating in void (shown by white arrow).

Plate 4.21D. Charred organic material in a silty clay lamination, underlying chito-gerfuric-monic graded bedding in A5EMM2B (XPL). Dusty clay hypocoating in void (shown by white arrow).
Plate 4.21E. Graded bedding in A5EMM1D (PPL). Note grain size decreasing in size from bottom of arrows to arrow points.

Plate 4.21F. Graded bedding in A5EMM1D (XPL). Note grain size decreasing in size from bottom of arrows to arrow points.

Plate 4.21G. Dusty clay hypocoatings (indicated by arrow) in a calcitic, iron-depleted matrix, suggestive of an E/Bt horizon (A5EMM2A, shown in PPL). Calcium carbonate hypocoatings are typical in arid and semi-arid regions and in areas with variable water tables.448

Plate 4.21H. Dusty clay hypocoatings (indicated by arrow) in a calcitic, iron-depleted matrix, suggestive of an E/Bt horizon (A5EMM2A, shown in XPL). The calcite hypocoatings demonstrate micritic structures and appear to have formed prior to the dusty clay hypocoatings.

Plates 4.21A-H. A: Fabric of ceramic fragment in A5EMM1C (XPL); B: Charred organic material in A5EMM2B; C: Charred organic material in a silty clay lamination, underlying chito-gerfuric-monoc graded bedding in A5EMM2B (PPL); D: Charred organic material in a silty clay lamination, underlying chito-gerfuric-monoc graded bedding in A5EMM2B (XPL); E: Graded bedding in A5EMM1D (PPL); F: Graded bedding in A5EMM1D (XPL); G: Dusty clay hypocoatings in a calcitic, iron-depleted matrix, suggestive of an E/Bt horizon in A5EMM2A (PPL); H: Dusty clay hypocoatings in a calcitic, iron-depleted matrix, suggestive of an E/Bt horizon in A5EMM2A (XPL).

448 Seghal and Stoops 1972; Courty 1990; Stoops 2010: 277.
4.3.1.2 Room 4

One sediment monolith was removed from trench A5W, from a context that was approximately 40 cm west of the A5E-A5W division, and just south of a TS point on Wall 16 (Fig. 4.5, Plate 4.22). The monolith contained an LM III context related to the upper part of context #3050 in Room 3(a), which was associated with the two monoliths taken from Room 3(a). No floor surfaces were noted for the sampled context (#3051) in Room 4, and a floor level had not been reached in excavations; a test trench in the north of Room 4 (#3163) did not reach a floor, and #3163 was suggested to be collapse debris. Ceramic fragments are visible in the profile of the monolith, as well as a layer of pebbles in the middle of the approximately 13 cm of the exposed profile from which the monolith was taken. Only one section was made from the monolith, labeled A5WMM1, and overlapped the pebbly boundary noted in the field (Plate 4.23). One bulk sample was taken, from the sediment associated with the monolith, for geochemical analysis.

General Observations (refer to Table 4.10)

Thin section A5WMM1 (Plate 4.23) is composed of sand, silt, and clay, with a poorly sorted close porphyric coarse/fine (c/f10µm) related distribution of approximately 60/40; this porphyric distribution makes up about 90% of the groundmass, with the other 10% comprised of silty sandy laminations (Table 4.10). In the close porphyric distributions, the mineral components of the groundmass consist of smooth, sub-angular to rounded grains of quartzite, phyllite, and sandstone (very fine sand (v.f.s.-size), dominant, ~40%; fine sand (f.s.-size), ~10%; medium sand (m.s.-size), ~5%; course sand (c.s.-size), ~2%; very course sand (v.c.s.-size), ~1%; fine gravel (f.g.-size), sub-rounded to rounded, ~3%); and ~30% silt. Phyllite and sandstone grains make up ~10% of coarse component (v.f.s.-v.c.s.). The groundmass also includes orthic and disorthic typic impregnative Fe/Mn nodules (v.f.s.-c.s.-size) (~5%) and a few dark brown (organic) residues (~5%). The silty sandy laminations (also porphyric) are comprised of silt (~80%) and clay (~20%) (Plate 4.24D/E). The voids in the section consist of rough channels (10µm-500µm, ~5-10%), semi-smooth, vesicles and irregular-shaped vughs (10-200µm, ~10%), contributing to a total intrapedal porosity of ~15-20%. The silty sandy laminations have much
lower porosity, but do contain some regular and irregular shaped vesicles/vughs (20-200µm) and exhibit a total intrapedal porosity of approximately 5-10%.

Organic material (roots/wood/plant material) (1%), charcoal (<1%), bone (<1-1%), shell fragments (~1%), ceramic fragments (1%), and rounded plaster fragments (2-3%) also occur in the section. Also present are dusty clay quasicoatings around some voids (25%, 10 - 50 µm), as well as calcitic pendants\textsuperscript{449} around fine gravel (up to 500 µm in pendant thickness) and dusty clay laminations (10%, 10 - 50 µm). In addition to the calcitic pendants, areas of iron impregnation and depletion indicate this section’s location in an E/Btk horizon, as observed for the A5E sections. Also observable in the A5E thin sections, there is evidence of root activity and bioturbation affecting much of the A5WMM1 section. Despite this evidence for disturbance, multicell phytoliths have been preserved in this section; it needs to be determined whether substitution of the calcium silicate by calcium carbonate is occurring or has occurred. Several of these phytoliths have been tentatively identified as tracheids (from wood of dicotyledonous plants, such as trees) (Plates 4.24A-C).\textsuperscript{450}

Interpretation

As no anthropogenic surfaces or floors are visible in A5WMM1, it is likely that this section corresponds to an LM III depositional environment during the abandonment of Building AP1 in LM IIIA2-B, relating to that abandonment of Room 3(a). However, this section (representing #3050) does not demonstrate processes identical to those occurring in Room 3(a) (in #3050-3058/3056). In contrast to the lower sections in A5E during this LM IIIA2-B phase, there is no evidence in A5WMM1 of graded bedding or chito-gefuric/chito-gefuric-monic c/f\textsubscript{10µm}-related distributions in the groundmass. However, A5WMM1 does contain a fragment of a fine sandy silty lamination towards its centre, possibly relating to the “layer of pebbles” observed in the field.

\textsuperscript{449} Stoops 2010: 272.
\textsuperscript{450} Albert et al. 2011.
Individual lamina/beds, such as the silty sandy laminar fragment, may be formed through “essentially constant physical, chemical, or biological conditions.”\textsuperscript{451} This thick lamina (or fine bed), varying between about 500 µm to 5 mm thick, and approximately 2 cm in length, may have resulted from “a minor fluctuation in flow conditions rather than representing constant physical condition.”\textsuperscript{452} It has been demonstrated that beds are commonly produced rapidly, by single events such as floods (possibly only lasting for seconds or minutes, but also with the possibility of occurring over hours or days, or even longer).\textsuperscript{453} Such a rapid deposition of this silty sandy lamina may indeed relate to the depositional processes occurring in Room 3(a). Both processes may relate to the same water deposition or drying events, although they represent different phases of these events (the lamina are suggestive of rapid deposition, while the graded bedding indicates drying, possibly after “deposition in the last phases of a heavy flood…or by turbidity currents”).\textsuperscript{454}

It is feasible that different processes occurred in these two rooms during and following an LM IIIA2-B flooding event. Perhaps Wall 25 (seen in Plate 4.18), which divided the rooms, prevented water from collecting in Room 4; alternatively, this sample section simply was taken from an area that did not contain such depositional evidence (due to lack of occurrence or subsequent bioturbation). Studies have also demonstrated that “[m]any beds are not preserved to become part of the geologic record but are destroyed by succeeding erosional episodes. The preservation potential appears to be greater for those beds deposited by an event of great magnitude, such as a very large flood, than for those formed by very small scale events.”\textsuperscript{455}

Perhaps, factoring in the evidence of significant bioturbation in A5WMM1, this lamina indicates that a significant (flooding) event did occur since the lamina was preserved since the Post-palatial period.

\textsuperscript{451} Boggs 2006: 78.
\textsuperscript{452} Goldberg and Macphail 2006: 20-21; Boggs 2006: 76-78.
\textsuperscript{453} This rapid development or deposition is in contrast to the slower, more gradual suspension depositions of very fine clay, which may occur over months or years (Boggs 2006: 78).
\textsuperscript{454} Boggs 2006: 80.
\textsuperscript{455} Ibid.: 78.
The presence of phytoliths in this section may indicate one of two possibilities: (1) the movement of more recent material from the surface transported through vertical cracks or via bioturbation, and/or (2) the preservation of more archaic plant remains. Therefore, the value of the phytoliths, tentatively identified by the author as tracheids (from wood of dicotyledonous plants, such as trees) (Plates 4.24A-C), in relation to archaeological interpretations has yet to be determined. The preservation of organic remains on site is relatively poor due to the site’s taphonomic conditions and alkaline environment (Appendix 1). Whether the phytoliths are indeed derived from ancient contexts or more recent ones, this finding suggests that conducting phytolith analysis via the bulk sediments samples could be a useful avenue for further research on environmental conditions at the site.

456 Stoops 2010: 207.
457 Albert et al. 2011.
458 Goldberg and Macphail 2006: 47.
Figure 4.5. Location of A5WMM1 in Building AP1, Room 4 (Plan by Spencer 2016).
Plate 4.22A. Sediment of monolith A5WMM1, immediately behind Wall 16 in Building AP1, Room 4. No surfaces were visible to the naked eye during excavations.

Plate 4.22B. Monolith A5WMM1 prior to removal from context. The monolith (and section) span approximately 13 cm, crossing the level relative to the tops of the stones of Wall 16.

Plate 4.22C. Location of A5WMM1 relative to Wall 16 (running E-W) and Wall 25 (running N-S), which are associated with LM III contexts.

Plate 4.22D. Monolith A5WMM1 after removal from the site context.

Plates 4.22A-C. Context of monolith A5WMM1 in Building AP1, Room 4.
Plate 4.23: A5WMM1 demonstrates a complex (channel and crumby) microstructure with moderately separated, poorly to moderately accommodated peds. It contains one silty sandy lamination (approximately 5-10% of the section’s groundmass, encircled with the dashed yellow line). The groundmass shows a close porphyric distribution similar to that seen in MF1 of the A5E sections. Calcitic pendants are visible around fine gravel (up to 500 µm in pendant thickness). No anthropogenic surfaces/floors are visible in this section.

Plate 4.24A. Silicified plant material (phytolith) in A5EMM1: tracheid (PPL). Whether this material relates to ancient contexts or more recent ones will need to be determined.

Plate 4.24B. Silicified plant material (phytolith) in A5WMM1: tracheid (PPL).

Plate 4.24C. Silicified plant material (phytolith) in A5WMM1: tracheid, same as above (XPL).
Plate 4.24D. Silty sandy laminations are comprised of silt (~80%) and clay (~20%) in A5WMM1 (PPL). These laminae may be suggestive of rapid deposition events by water.

Plate 4.24E. Silty sandy laminations are comprised of silt (~80%) and clay (~20%) in A5WMM1 (XPL).

Plate 4.23. Thin section A5WMM1.

Plate 4.24A-C. Silicified plant material (phytolith) in A5WMM1.

Plate 4.25. Aerial photograph and architectural designations of Building AP1 (Quentin Letesson 2016).
4.3.1.3 Exterior Space (north of Building AP1)

Two sediment monoliths (A9MM1 and A9MM2) were taken from an unexcavated baulk left in the centre of the excavated area of trench A9, to the north of Building AP1 (Fig. 4.6, Plates 4.26A-D). The contexts preserved in these monoliths relate to units #6039-#6043 were interpreted during excavations as containing rubble from an upper level wall collapse or leveling episode, or, alternatively, as containing fill from a midden context. Within these units was a complete surface of tiny pebbles, loosely packed, with possible shell fragments. Such a surface was not immediately observable in the monoliths removed from the field. Monolith A9MM1 was divided into three thin sections, and monolith A9MM2 was divided into four thin sections; the thin sections were cut so as to create overlapping sections, along the approximately 37 cm of each monolith, from the highest point sampled in #6039 to the lowest point sample in #6043, as follows: A9MM2A, A9MM1A, A9MM2B, A9MM1B, A9MM2C, A9MM1C, A9MM2D (Plate 4.27). Four bulk samples were taken for geochemical analysis from this context.

General Observations (refer to Table 4.11)

The thin sections (Plates 4.28A-G) are composed of sand, clay, and silt, with varying proportions of poorly-sorted close porphyric coarse/fine (c/f10µm)-related distribution of approximately 80/20-70/30 and, in A9MM2A, a moderately-sorted chito-gefuric c/f10µm related distribution of 90/10 (Plate 4.28A). In the close porphyric distributions (MF1), the mineral components of the groundmass consist of smooth, sub-angular to rounded grains of quartz/quartzite, phyllite, sandstone, and dolomitic limestone (very fine sand (v.f.s.-size, dominant, ~20-50%; fine sand (f.s.-size, ~5-20%; medium sand (m.s.)-size, ~2-5%; course-sand (c.s.)-size, ~2%; very coarse sand (v.c.s.)-size, ~1%; fine gravel (f.g.)-size, sub-rounded to rounded, ~0-3%); and ~15-35% silt. In all thin sections, some orthic and disorthic typic impregnative iron/clay concentrations/nodules (v.f.s.-c.s. ~10%) and few dark brown (organic) residues (~2-5%) are also present. In contrast to the porphyric distributions, the chito-gefuric distribution (MF3) in A9MM2A consists of coarse grains of v.f.s.-size, ~30%; f.s.-size ~30%;

m.s.-size, ~10%; and c.s.-size ~10%; v.c.s-size ~10%; f.g., sub-rounded to rounded, ~5%; and ~5% silt. In A9MM2A, there are additional chito-gefuric silty-sandy bedding/laminations consisting of silt, ~50%; v.f.s. ~50%, and, in A9MM2A, A9MM1B, A9MM2B, A9MM2C, and A9MM2D, there are some fragmented, porphyric silty-sandy laminations composed of silt, ~80% and dusty clay, ~20%; these laminations comprise <5% of the groundmass in all sections, except A9MM2A (~5-10%).

The voids in the thin sections with porphyric c/f$_{10\mu m}$-related distributions are comprised of rough channels (10µm - 500µm, ~5-10%) and semi-smooth, irregular-shaped vughs (10 - 200µm, ~5-10%), and have a total intrapedal porosity of approximately 15-20%. The areas of chito-gerfuric c/f$_{10\mu m}$-related distribution in A9MM2A have complex packing voids/intergrain voids (10-100 µm) and a total intrapedal porosity of approximately 20%.

Iron/clay concentrations/nodules (20 µm - 1000 µm) (~2-5%), organic material (roots/wood/plant material) (~1-5%), charcoal (~1-3%), bone (<1-1%), shell fragments (~2-3%) in all sections, except the bottom half of section A9MM2A (<1%), ceramic fragments (<1-2%), and plaster fragments (<1-2%) (Plate 4.29A) occur in the sections. Areas of calcitic nodules, impregnations, quasicoatings, and hypocoatings are present throughout the sections and appear to have occurred prior to silty clay coatings, suggesting typical soil pedogenesis (Plates 4.29B, 4.29K/L). Like the A5E sections, in addition to the presence of calcite, areas of iron impregnation and depletion suggest that the sections contain sediment from E/Btk horizon. Evidence of root activity and bioturbation are present throughout the sections, and there is no significant change in degree of bioturbation with depth.

Interpretations

During excavations, ‘nerochoma’ (water-lain sediment) was observed above the context of this sample in unit #6038. The only thin section of the A9 thin sections (#6039-6043) which appears to be differentiated from the typical porphyric groundmass is the chito-gefuric distribution, present only in the uppermost section, A9MM2A. It is possible that this may be related to the pebbly layer noted to be ‘nerochoma’ during excavations. However, the dusty clay bridges that characterize this chito-gerfuric microfabric (MF3), and the sub-angular to rounded
grains, which demonstrate larger sizes than those of the surrounding matrix, suggest that this layer may have been deposited in a colluvial, rather than alluvial, event (Plates 4.29G/H).\textsuperscript{461}

Throughout the sections, some water-action is evident (silty-sandy/clay graded laminations and intercalations of dusty clay), below the chito-gerfuric area (MF3) in A9MM2A (Plates 4.29C-F). However, these pedofeatures may have formed post-depositionally, however, as the upper A9 sections display large fissures, and the pedofeatures may simply be fragmented by bioturbation. Notably, in all of the sections, carbonate (calcitic) nodules and coatings are present. Their micritic and microsparitic features differentiate them from the fragments of plaster in the thin sections (Plates 4.29A/B). Although there are some Fe oxide/clay coatings around portions of these calcitic nodules and coatings, most of the calcitic nodules appear to be orthic, and thus have not likely undergone transportation.

Although there are no distinct, \textit{in situ} surfaces/floors, the inclusions of plaster, iron oxide staining, charred material, and shell and bone fragments may be related to earlier earthen floors\textsuperscript{462}; the sediment, however, is too disturbed to identify earlier earthen floors with any certainty. Overall, the poor-sorting of the sediment, which contains larger and fine materials, and the general lack of orientation of the materials, makes it unlikely that this material was related to an earthen surface. Notably, the section from the lowest relative depth, A9MM2D, does contain a higher proportion of charred organic material (MF1o) in its groundmass (3%) than in other sections (<1-1%). This observation could correspond to the finding of a hearth located nearby this context. Possibly if the charcoal surrounding this hearth is related to the hearth, then one may conclude that this sediment was not completely washed away following the occupation. Additionally, it is interesting that no phytoliths were observed in the A9 thin sections, close to the location of the possible hearth, yet there were phytoliths preserved in A5WMM1.

\textsuperscript{461} Goldberg et al. (1999: 334) suggest that dusty clay bridges may be pedofeatures of colluvial events.

\textsuperscript{462} Karkanas and Goldberg 2010; Karkanas and Efstratiou 2009.
Table 4.11. A9 sedimentary characteristics and micromorphological features based on thin section analysis

<table>
<thead>
<tr>
<th>Sample</th>
<th>Sorting</th>
<th>Rounding</th>
<th>Coarse fraction</th>
<th>Textural pedofeatures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Quartzite/</td>
<td>Fine fraction</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>phyllite/</td>
<td>void</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>sandstone</td>
<td>coatings</td>
</tr>
<tr>
<td>A9MM2A</td>
<td>Poorly- to</td>
<td>smooth, sub-angular to rounded</td>
<td>X</td>
<td>Dusty clay</td>
</tr>
<tr>
<td></td>
<td>moderately-</td>
<td></td>
<td>X</td>
<td>hypocoatings</td>
</tr>
<tr>
<td></td>
<td>sorted</td>
<td></td>
<td></td>
<td>(10-50 μm); dusty clay</td>
</tr>
<tr>
<td>A9MM1A</td>
<td>Poorly-sorted</td>
<td>smooth, sub-angular to rounded</td>
<td>X</td>
<td>hypocoatings</td>
</tr>
<tr>
<td>A9MM2B</td>
<td>Poorly-sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X</td>
<td>Dusty clay</td>
</tr>
<tr>
<td>A9MM1B</td>
<td>Poorly-sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X</td>
<td>hypocoatings</td>
</tr>
<tr>
<td>A9MM2C</td>
<td>Poorly-sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X</td>
<td>Dusty clay</td>
</tr>
<tr>
<td>A9MM1C</td>
<td>Poorly-sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X</td>
<td>hypocoatings</td>
</tr>
<tr>
<td>A9MM2D</td>
<td>Poorly-sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X</td>
<td>Dusty clay</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>hypocoatings</td>
</tr>
</tbody>
</table>
Figure 4.6. Location of A9MM1 and A9MM2 in Building AP1, Room 3(a) (Plan by Spencer 2016).
Plate 4.26A. Trench A9, north of Building AP1, with pedestal left intact for micromorphology sampling. Top of pedestal is #6039; bottom of pedestal is #6043. Note the stony tumble surrounding the pedestal.

Plate 4.26B. Close up view of micromorphology pedestal A9. No surfaces/floors are visible to the naked eye.

Plate 4.26C. Monolith A9MM1 and A9MM2 before removal from Trench A9.

Plate 4.26D. Close up view of stony tumble, the base of unit #6043, which was interpreted in the field as rubble from an upper level wall collapse or leveling episode, or, alternatively, containing fill from a midden context.

Plates 4.26A-D. Contexts of A9MM1 in area north of Building AP1.
Plate 4.27. (Left) A9 thin sections in relative relation to one another (not to scale; each section is approximately 5 cm by 7.5 cm); (Right) Thin sections in monoliths before being processed.
Plate 4.28A. A9MM2A is the only thin section in A9 to exhibit two the two microfabrics described above—a close porphyric microfabric (MF1) and a chito-gefuric microfabric (MF3), similar to that in some of the A5E sections. MF1 demonstrates a complex (vugly/vesicular and channel) microstructure, while MF3 displays a bridged grain microstructure. Overall, the peds are weakly developed and partially-accommodated. Two areas of normally graded bedding occur (encircled by yellow dashed lines) (with possible laminar crusts), but the rest of the section appears to be disturbed by bioturbation. Calcitic pendants appear to only occur in the area of diffuse mixing of the microfabrics (labeled MF 1/3). The two different microfabrics suggest different depositional episodes towards top of slide chito-gefuric appears to be identical to that in A5E.

Plate 4.28B. A9MM1A displays a complex (massive and channel) microstructure with weakly separated, weakly developed, partially-accommodating peds. The close porphyric c/f10µm-related distribution is 75/25, and the coarse fraction is composed of v.f.s., ~30%; f.s. ~10%, m.s. ~5%; c.s. ~2%; v.c.s. ~1%; f.g., sub-rounded to rounded, ~2%, along with silt (~30%). The void structure is composed of rough channels (10 - 500µm, 10%), semi-smooth, irregular-shaped vughs (10 - 200µm, 5%), with a total intrapedal porosity of 15%. As in the other A9 thin sections, calcitic pendants are present on larger grains. Only one area of normally graded bedding occurs nears the top of the section along a void, so it was possibly formed post-depositionally. Bioturbation is apparent in the presence of modern roots (3-5% of the groundmass).
Plate 4.28C. Observable in A9MM2B is a complex (massive, vesicular, and cracky) microstructure) with moderately separated, partially- to moderately-accommodated peds. Note the large diagonal fissure in the middle of the section. The close porphyric c/f10µm-related distribution is 70/30, and the coarse fraction is composed of v.f.s., ~20%; f.s. ~20%, m.s. ~2%; c.s. ~2%; v.c.s. ~1%; f.g., sub-rounded to rounded, ~2%, along with silt (~35%). The void structure is composed of rough channels (10 - 500µm, 10%), semi-smooth, irregular-shaped vughs (10 - 200µm, 10%), with a total intrapedal porosity of 20%. There is one area of two silty sandy laminations with normally graded separating them (encircled by the yellow dashed line). As observed in the other A9 sections, calcitic pendants are present on larger grains, and bioturbation is apparent in the presence of modern roots (3-5% of the groundmass).

Plate 4.28D. A9MM1B exhibits a complex (massive, slightly vesicular, with one large prismatic separation) microstructure, with poorly separated, partially- to well-accommodated peds. A close porphyric c/f10µm-related distribution is 75/25, and is comprised of v.f.s., ~30%; f.s. ~10%, m.s. ~5%; c.s. ~2%; v.c.s. ~1%; f.g., sub-rounded to rounded, ~2%, along with silt (~30%). The void structure is composed of rough channels (10 - 500µm, 10%), semi-smooth, irregular-shaped vughs (10 - 200µm, 10%), with a total intrapedal porosity of 15%. Plaster fragments are present, as well as calcitic nodules with clay coatings. Two areas of normally-graded bedding are visible towards bottom of section (encircled by yellow dashed lines).
Plate 4.28E. A9MM2C displays a complex (cracky and vesicular) microstructure with angular blocky peds, moderately separated and partially- to well-accommodated. A large marble fragment, with calcitic pendants, aligns with the large fissures in the section. The close porphyric c/f_{10µm}-related distribution is 80/20, and the coarse fraction is composed of v.f.s., ~40%; f.s. ~15%, m.s. ~2%; c.s. ~2%; v.c.s. ~1%; f.g., sub-rounded to rounded, ~1%, along with silt (~20%). The void structure is composed of rough channels (10 - 500µm, 5-10%), semi-smooth, irregular-shaped vughs (10 - 200µm, 10%), with a total intrapedal porosity of 15-20%. Vague bedding (alternating coarse and fine particles) occurs throughout; perhaps bioturbation has affected the original sorting, or the orientation of the fine material is a result of post-depositional processes. Shells make up 3% of the groundmass at the bottom of the section.

Plate 4.28F. A9MM1C contains the most void space of all of the sections, but the least intrapedal porosity (10%), divided between rough channels (10 - 500µm, 5%) and semi-smooth, irregular-shaped vughs (10 - 200µm, 5%). Overall, it has a complex (massive, angular blocky, and granular) microstructure with well-separated, partially- to well-accommodated peds. The close porphyric c/f_{10µm}-related distribution is identical to that of A9MM1B: 75/25, and is comprised of v.f.s., ~30%; f.s. ~10%, m.s. ~5%; c.s. ~2%; v.c.s. ~1%; f.g., sub-rounded to rounded, ~2%, along with silt (~30%). One slightly bedded area (a possible structural crust) occurs along a void (encircled by a yellow dashed line); possibly this is a result of water action via the void. Microfossils (similar to foraminifera/diatoms) in the section appear to be from degraded limestone, rather than from water sources.
Plate 4.28G. A9MM2D is distinct, from the rest of the A9 sections due to its complex (granular, single grain, spongy, and subangular blocky) microstructure with moderately separated, partially-to well-accommodated peds. It displays compound and complex interpedal packing voids; rough channels (10 - 500µm, 10%) and semi-smooth, irregular-shaped vughs (10 - 200µm, 10%) contribute to a total intrapedal porosity of 20%. The close porphyric c/f<sub>10µm</sub>-related distribution is similar is 70/30, with a coarse fraction composed of v.f.s., ~20%; f.s. ~20%, m.s. ~2%; c.s. ~2%; v.c.s. ~1%, as well as silt (~35%). One area of normally graded bedding occurs (encircled by a yellow dashed line). It is unclear whether the increased proportion of charred organic material, particularly in the area delineated by the white line (MF10), is related to occupation or post-depositional material; it may relate to the hearth located in a nearby context. The large, worn ceramic fragment may belong to the C1 coarse fabric type, associated with cooking and storage wares (J. Gait, pers. comm. Jan. 2017).

Plates 4.28A-G. Thin sections A9MM1A-C and A9MM2A-D.
Plate 4.29A. Fragment of (anthropogenically-made) plaster in A9MM1B (shown in XPL). Note the lower refractivity than the calcitic nodule in Plate 4.29B. Plaster fragments are present in most of the A9 thin sections (<1-2% of the groundmass).

Plate 4.29B. Carbonate (calcitic) nodule, with micritic and microsparitic characteristics, is distinct from anthropogenically-created plaster in Plate 4.29A. Calcitic nodules are present throughout the A9 thin sections, as well as in most thin sections from the site.

Plate 4.29C. Bedding/lamina shown in A9MM2A is indicative of sorting through water saturation (shown in PPL).

Plate 4.29D. Bedding/lamina shown in A9MM2A is indicative of sorting through water saturation (shown in XPL).
Plate 4.29E. Normally graded bedding in A9MM2A, with dusty clay hypocoatings (some shown by white arrows) (PPL).

Plate 4.29F. Normally graded bedding in A9MM2A, with dusty clay hypocoatings (some shown by white arrows) (XPL).

Plate 4.29G. Microfabric (MF) 3 (shown here in PPL), in A9MM2A is comprised of a much higher proportion of c.s.-size, m.s.-size, v.c.s.-size, and f.g.-size grains; this MF3 is only present in this section in A9. The mineral fractions include smooth, sub-angular to rounded grains of quartz/quartzite and phyllite (v.f.s., ~30%; f.s. ~30%, m.s. ~10%; c.s. ~10%; v.c.s. ~10%; f.g., sub-rounded to rounded, ~5%).

Plate 4.29H. Microfabric (MF) 3 (shown here in XPL), in A9MM2A, is comprised of a much higher proportion of c.s.-size, m.s.-size, v.c.s.-size, and f.g.-size grains. Note the dusty clay coatings and bridges (some shown by white arrows). Section A9MM2A is the only section in A9 to contain this particular MF3, with larger proportions of larger coarse grains. The clay bridge may relate to colluvial deposition features.
Plate 4.29I. Clay intercalation (shown by yellow arrow) and very fine silty sandy lamination (shown by red arrow) in A9MM1B, suggestion of post-depositional translocation of fine material by water (PPL).

Plate 4.29J. Clay intercalation (shown by yellow arrow) and very fine silty sandy lamination (shown by red arrow) in A9MM1B, suggestion of post-depositional translocation of fine material by water (XPL).

Plate 4.29K. Silt clay lamination (shown by white arrow) developed around voids, following calcitic quasicoating (shown by yellow arrow) of voids, in A9MM2D (PPL). The formation of clay coatings/laminations following calcitic coatings is suggestive of typical soil pedogenesis.

Plate 4.29L. Silt clay lamination (shown by white arrow) developed around voids, following calcitic quasicoating (shown by yellow arrow) of voids, in A9MM2D (XPL). The movement of this fine material would likely occur post-depositionally by suspension and translocation via voids.

Plates 4.29A-L. A: Fragment of (anthropogenically-made) plaster in A9MM1B (XPL); B: Carbonate (calcitic) nodule, with micritic and microsparitic characteristics, throughout A9 thin sections; C: Bedding/lamina shown in A9MM2A (PPL); D: Bedding/lamina shown in A9MM2A (XPL); E: Normally graded bedding in A9MM2A (PPL); F: Normally graded bedding in A9MM2A (XPL); G: MF3 in A9MM2A (PPL); H: MF3 in A9MM2A (XPL); I: Clay intercalation and very fine silty sandy lamination in A9MM1B (PPL); J: Clay intercalation and very fine silty sandy lamination in A9MM1B (XPL); K: Silt clay lamination developed around voids, following calcitic quasicoating of voids, in A9MM2D (PPL); L: Silt clay lamination developed around voids, following calcitic quasicoating of voids, in A9MM2D (XPL).
4.3.2 Building AM1

Excavated in 2013-2015, Building AM1 (including original trenches A6/A7 and A4S/A4N) was built in the LM IB period (Palaikastro periods XI-XII), but then the structure appears to have been abandoned (Plate 4.30).\textsuperscript{463} There is some LM III material above the LM IB structure, but the LM III surfaces are elusive.

As discussed earlier (Section 3.2.3.2), based on site topography, the entire area of Building AM1 (and site as a whole) have been affected by colluvium coming from the slopes beneath Petsophas.\textsuperscript{464} In terms of more recent constructions affecting the area, the previous landowner (the grandfather of Maria Papadakis) recalled building one of the walls (Wall 1) across the area, and that it utilized earlier (ancient) walls in some areas. Recent material (modern pottery and other finds) is mixed with earlier Minoan material (LM III and MM), likely the result of intensive ploughing and cultivation in recent times. This activity may have disturbed the upper courses of ancient walls.\textsuperscript{465} The only walls that appear to be LM III in this area have been identified as “casual field or boundary walls.”\textsuperscript{466} The LM III occupation, attested in trenches A6 and A7, consists of a “LM III clay surface, locally paved with slabs and areas with a very dense concentration of small- to medium-sized stones/cobbles” (Plate 4.31)\textsuperscript{467} It is unclear what occurred between the earlier LM IB occupation of this area and this subsequent LM III occupation. Based on the changes to the earlier LM IB walls, it is possible that LM III rebuilding activities involved the reuse of some of these stones; also possible is that the LM III layers are destruction debris from nearby buildings.\textsuperscript{468}

\textsuperscript{463} PALAP BSA report 2014; PALAP BSA report 2015.

\textsuperscript{464} PALAP BSA report 2014: 18.

\textsuperscript{465} Ibid.

\textsuperscript{466} Ibid.

\textsuperscript{467} Ibid.: 19.

\textsuperscript{468} Ibid.
Plate 4.30. Aerial photograph and architectural designations of Building AM1 (Quentin Letesson 2016; after BSA report 2014: 24, Fig. 35).
Plate 4.31. View of LM III occupation debris from the East, of trench A6, showing (a) the LM III paved surface and (b) a “dense layers of stones/cobbles” (Photo from BSA report 2014: 19, Fig. 28).
4.3.2.1 Room 4

Two sediment monoliths were taken from a baulk section among excavated contexts in the centre of Room 4 Building AP1 (originally trench A6) (Plate 4.30, Fig. 4.7). The monoliths incorporate a probable mixed LM III and LM IB context (spanning units #1069 to #1082). Units #1069 + #1081 have been identified as a potential street level or “a leveling operation to fill in the gap left by an earlier Neopalatial street when the area was reoccupied in the Postpalatial period” based on the observation of a “very compact and hard layer of packed stones and pebbles” in these units.\(^\text{469}\) Excavations did not reveal an LM I surface at the time that the monoliths were removed in 2014. At the time of removal, it was hypothesized that the top of the monoliths sat above the possible LM III surface or leveling operation (#1069), although the top of one of the surrounding walls (Wall 12), at a lower relative depth, is probably from the LM III period as well. The monoliths were noted by excavators to additionally incorporate a probable LM I context, although excavations have not yet revealed an LM I surface. Plaster and ceramic fragments were visible in the baulk from which the monoliths were taken. Monolith A6MM1 and A6MM2 were divided into 3 thin sections each; the thin sections were cut so as to create overlapping sections, along the approximately 28 vertical cm of each monolith, from the highest point sampled in #1069 to the deepest, as follows: A6MM1A, A6MM2A, A6MM1B, A6MM2B, A6MM1C, A6MM2C, A6MM1D (Plates 4.32, 4.33). Four bulk samples for geochemical analysis were also taken from this baulk.

*General Observations (refer to Table 4.12)*

The A6 thin sections are primarily composed of sand, clay, and silt, with varying proportions of poorly- to well-sorted close porphyric coarse/fine (c/f\(_{10\mu m}\))-related distribution (MF1) of approximately from 80/20-70/30 and, only in A6MM1C, an area of well-sorted chito-gefuric-monc c/f\(_{10\mu m}\)-related distribution (MF4) of about 90/10. In the close porphyric distributions, two different densities of distributions occur (one with c/f\(_{10\mu m}\)-related distribution of 70/30 (MF1) and one with more fine components (MF2): c/f\(_{10\mu m}\)-related distribution of 80/20 (Plates 4.35A-D). The mineral components of the MF1 groundmass consist of smooth, sub-

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\(^{469}\) PALAP BSA report 2014: 21.
angular to rounded grains of quartzite, phyllite, and sandstone (very fine sand (v.f.s.)-size, dominant, ~30-35%; fine sand (f.s.)-size, ~5-10%; medium sand (m.s.)-size, ~2-5%; course-sand (c.s.)-size, ~1-2%; very coarse sand (v.c.s.)-size, ~1%; fine gravel (f.g.)-size, sub-rounded to rounded, ~3-5%); and approximately ~30-40% silt. Orthic and disorthic typic impregnative Fe/Mn nodules (v.f.s.-c.s. ~5%) and few dark brown (organic) residues (~2-5%). The mineral components of the MF2 groundmass include silt, ~70%; v.f.s.-size, ~20%; f.s.-size ~3%; and m.s.-size ~2%, as well as orthic and disorthic typic impregnative iron hydroxide nodules (v.f.s.-size ~5%). The porphyric MFs are also distinguished by varying void structures. MF1 has a void structure comprised of rough channels (10 - 500µm, 5-10%) and semi-smooth, irregular-shaped vughs/vesicles (10 - 500µm, 5-10%), with a total intrapedal porosity of 15%, while MF2 has a total intrapedal porosity of 5-10%.

An additional porphyric distribution occurs in only the A6MM1C and A6MM1A thin sections (only one small fragment towards the bottom of A6MM1A): a c/f10µm-related porphyric distribution with ash aggregates, consisting of ash mixed with sub-angular coarse grains of v.f.s.-size, ~45%; f.s.-size ~3%, m.s.-size, ~1%, and c.s.-size, ~1%, and approximately 40% silt; this ash-mixed microfabric has been labeled as MF1a (Plates 4.34F, 4.35E/F).

Organic material (roots/wood/plant material) (<1-2%), charcoal (<1-5%) (Fig. 8), burnt bone (<1-1%) (present only in A6MM1C and A6MM2B), shell fragments (~1%), ceramic fragments (~1%), and plaster fragments (~1%) occur in the sections. A6MM1A and A6MM1C are particularly distinct from the other thin sections in that A6MM1A appears to contain an amalgamation of rounded pebbles (f.g.-size) and plaster near the top of the section (Plates 4.35I/J), surrounded by a cracky microstructure (Plates 4.35G/H), and A6MM1A and A6MM1C are the only sections that appear to contain rounded aggregates of ash-mixed matrix (MF1a) comprising <2% of the groundmass in A6MM1A and 5-10% of the groundmass in A6MM1C, along with more rounded plaster fragments, m.s.-size or larger (~5%). In A6MM1B, one area of silty sandy laminations/bedding (50% silt/50% v.f.s.-size grains) is located beneath a large sandstone fragment (Plates 4.35K/L), but evidence of root activity and bioturbation are present throughout the other areas of the thin sections and do not vary with depth. Areas of calcitic impregnations, pendants, and hypocoatings are present throughout all of the A6 thin sections, and appear to have occurred prior to the development of dusty and limpid clay coatings,
suggesting typical soil pedogenesis. In addition to the presence of calcite, areas of iron impregnation and depletion suggest that the sections contain sediment from Bt or C horizon.\(^{470}\) Notable in A6MM1C are limpid clay formations surrounded by calcitic formations (Plates 4.35M/N), as well as indications of directional pressure on the sediment (Plates 4.35O-R).

**Interpretations**

In A6MM1A, the roundedness and sphericity of the f.g.-size gravels suggests their origin from beach sediments, or riverbeds near the beach, rather than from alluvially-rounded sediments. The presence of these gravels, cemented with plaster fragments, suggests this area to be part of the LM III floor noted during excavations (#1069); however, this surface does not appear to be complete, nor *in situ*. There is not much anthropogenic material beneath this surface until the depth of A6MM1C is reached. There are possibly some very weak indications of former bedding, but, in general, the sections are affected too much by bioturbation (including modern roots) to be able to identify surfaces below A6MM1A.

One exception to this observation of general bioturbation and homogeneous nature of the groundmass (between MF1 and MF2) is section A6MM1C, which may have preserved beaten floor material. Present in A6MM1C is MF1d (mixed-ash aggregates) and indications of directional pressure through diagonally-oriented v.f.s.-size grains, diagonally-stratified vughs/vesicles, and layering of the iron-rich MF1 groundmass (Plates 4.35E/F, 4.35O-R). These indications of directional pressure may also be described as a deformation features of semi-plastic sediment and could result from liquefaction and movement due to gravity (natural mass flows) or human action (by hand, implement, or foot). If associated with human action, such features (while in this case may be related to the large rounded gravel above this feature) of “dense bedded occupational debris with evidence of sorting” have been interpreted in other sites “as beaten floor material made by trampling and not constructed floors per se.”\(^{471}\) Alternatively, this may be interpreted as intentional ‘constructional packing’ over the LM IB surface, beneath

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\(^{470}\) Kühn et al. 2010: 375.

the LM III plastered floor surface. While the transportation of the sediment aggregates (and association with natural mass flows) is suggested due to the roundedness of the aggregates (ash aggregates, plasters, inclusion of limpid clay fragments (in A6MM1B)), the archaeological context could indicate that these features relate to the preservation of a potential earthen surface/beaten floor or ceiling between the LM III plastered floor and the LM IB floor (reached in the 2015 excavations). A similar directional pressure feature may be observed in M1/A4SMM3A, and where there is no indication of a large gravel possibly having affected its formation (Plate 4.40C/D).

Overall, the sediment in the A6 thin sections is representative of non-laminated colluvial material based on the silty composition, massive, weakly-developed angular blocky microstructure, fine fractions, and fragments of clay coatings. In contrast to the completely mixed sediment of the A9 sections north of Building AP1, it appears that, in section A6MM1C, some beaten or trampled surfaces/floors may have been preserved between the LM IB and LM III occupations. Perhaps, this directional pressure feature in A6MM1C is indicative of leveling practices prior to the LM III use of this area; alternatively, this feature may signal an occupation phase between the LM IB and LM III phase. Regardless of whether this directional pressure feature is indicative of a surface/floor, it is clear that different, colluvial processes affected this area after the LM IB occupation. Possibly, the plaster floor material in A6MM1C was churned up from another area of the site and transported here, or the LM III material was just incredibly disturbed post-occupation. The fragmentary nature of the bedding fragments in the A6 sections may demonstrate that post-depositional, colluvial processes destroyed “abandonment” layers between the LM IB and LM III occupations, while the location of the A5E thin sections in Building AP1 may have preserved what “abandonment” looks like in the LM III period, at least in this area of the site.

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Table 4.12. A6 sedimentary characteristics and micromorphological features based on thin section analysis

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<td>X</td>
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<tr>
<td>A6MM2C</td>
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<td>Smooth, sub-angular to rounded</td>
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Figure 4.7. Location of A6MM1 and A6MM2 in Building AM1, Room 4 (Plan by Spencer 2016).
Plate 4.32A Baulk sediment block of A6 monoliths in Building AM1, Room 4, prior to removal (R. Kulick, 2014).

Plate 4.32B Sediment prior to taking monoliths. Sediment appears homogeneous to the naked eye; the only feature noted during excavations was a pebbly surface approximately 19 cm from the top of the monoliths (R. Kulick, 2014).

Plate 4.32C: View towards the east, showing location of Room 4 in relation to surrounding rooms/spaces in Building AM1 (image shown is from BSA report 2015: 38, Fig. 52).

Plate 4.33. (Left) A6 thin sections in relative relation to one another (not to scale; each section is approximately 5 cm by 7.5 cm); (Right) Thin sections in monoliths before being processed (R. Kulick, 2014).
Plate 4.34A. A6MM2A consists of complex (sub-angular blocky, granular, crumby) microstructures with moderately separated, partially-accommodated peds. MF1 is more granular and crumby dominant; MF1 is more sub-angular blocky dominant. For MF1, the close porphyric c/f10µm-related distribution is 70/30, and the coarse fraction is composed of v.f.s., ~30 %; f.s. ~5%, m.s. ~5%; c.s. ~2%; v.c.s. ~3%; f.g., sub-rounded to rounded, ~5%, along with silt (~40%). The void structure is composed of rough channels (10 - 500µm, ~5-10%), semi-smooth, irregular-shaped vughs (10 - 200µm, ~5-10%), with a total intrapedal porosity of 15%. MF2 has a close porphyric c/f10µm-related distribution is 80/20, and the coarse fraction is composed of v.f.s., ~20 %; f.s. ~3%, m.s. ~2; along with silt (~70%). The total intrapedal porosity of MF2 is ~5-10%. No surfaces or bedding are visible.

Plate 4.34B. A6MM1A demonstrates two different microstructures; the second (MF2) displays a dominantly cracky microstructure (rather than vughy (MF1)). The features of the MF1 and MF2 microfabrics are consistent with those identified in A6MM2A. Microstructure 2 is possibly related to a displaced plaster floor surface (circled in yellow). Notice in the top of this section what appears to be plaster with rounded pebbles. The matrix surrounding this area has a dominantly cracky microstructure, in contrast to the vughy microstructure in the bottom of the section. However, this potential plaster surface is incomplete. There are some very, very weak indications of former bedding, with some normally graded bedding beneath the floor fragments, in contrast to the strong evidence of bedding in the A5E sections. There also appears to be a very small fragment of ash aggregate at the bottom of the section, as well as two conifer wood charcoal fragments (identified by L. Picornell-Gelabert, pers. comm. 2016).
Plate 4.34C. A6MM2B appears to connect well with section A6MM2A; it contains identical microfabric types (MF1 and MF2). The top of the section (MF2) connects with the bottom of A6MM2A, so this may be a distinct (in situ) layer of the fine porphyric material.

Plate 4.34D. A6MM1B displays a complex (angular blocky, channel, and slightly vesicular (10%)) microstructure, with angular blocky pedds, moderately separated and partially- to well-accommodated. Thus, while this section appears to be massive, some parts of the pedds are accommodated very well; possibly, this is due to the pressure of a surface above the area of the section. The c/f_{10\mu m}-related distribution (70/30) is composed of silt: ~30%; v.f.s., ~35 %; f.s. ~10%, m.s. ~5%; c.s. ~1%; v.c.s. ~2%; f.g., sub-rounded to rounded, ~2%. The void structure consists of rough channels (10 - 500\mu m, ~10-15%), semi-smooth, irregular-shaped vughs/vesicles (10 - 500\mu m, 5%), and a total intrapedal porosity of ~15-20%. Only one area of bedding (50% silt/50% v.f.s) exists beneath the sandstone fragment; the rest of the section is bioturbated and with a larger sandy fraction, and some clay laminations (~10%, 20-50 \mu m). The bedding area is shaped by regular and irregular vesicles/vughs (20-200\mu m, ~5%), with a total intrapedal porosity of ~5%.
Plate 4.34E. A6MM2C shares same two b-fabrics as A6MM2A and A6MM2B; the groundmass varies throughout, but distinct boundaries are not particularly apparent between MF1 and MF2. Interestingly, in A6MM2A and A6MM2C, clay pedofeatures are rare.

Plate 4.34F. A6MM1C is composed of a complex (weakly angular blocky and vesicular) microstructure with sub-angular blocky peds that are weakly to moderately separated, and partially-accommodated. The porphyric c/f_{10\mu m}-related distribution varies between coarser and finer grained, thus it is labeled (MF1/2); MF2 is more prominent towards the bottom of the section, and a few areas have normally graded bedding. In the bottom of the section MF1 has a vughy/vesicular structure (~20% intrapedal porosity) (MF1v). An area of directionally-aligned vughs within MF1v is MF1d. A6MM1C is the only section with indications of burnt bone (neither A6MM1A nor A6MM1B have burnt bone); A6MM1C also contains more rounded plaster fragments, m.s.-size or larger (~5%) and some areas of ash (~5-10%) mixed with matrix (MF1a) (circled in blue). A large charcoal fragment (identified as conifer wood charcoal by L. Picornell-Gelabert, pers. comm. 2016) is also present in the section. Due to the directional-alignment and vesicular nature of the bottom of the section; this area (MF1d) could possibly have been related to a surface.

Plate 4.34A-F. Thin sections A6MM1A-C and A6MM2A-C.
Plate 4.35A. A9MM2A. MF1 (PPL). Note the charred organic material as well (show by the yellow arrow).

Plate 4.35B. MF1 in A6MM2A (XPL). The yellow arrow indicates charred organic material.

Plate 4.35C. MF2 in A9MM2A (PPL). Note the much higher proportion of silt-size grains (~70%) compared to the higher proportions of v.f.s.-f.s.-size grains in MF1 (Plates 4.35A/B).

Plate 4.35D. MF2 in A9MM2A (XPL). Note the much higher proportion of silt-size grains (~70%) compared to the higher proportions of v.f.s.-f.s.-size grains in MF1 (Plates 4.35A/B). Note the greater crystallic birefrigence of the matrix compared to that of MF1.
Plate 4.35E. MF4 in A6MM1C, with possible light gray aggregates of recrystallized ash (PPL).

Plate 4.35F. MF4 in A6MM1C, with possible light gray aggregates of recrystallized ash (XPL). Note cemented nature and apparent dull birefringence.

Plate 4.35G. MF2 (PPL) in A6MM1A displays a dominantly cracky microstructure (rather than vughy), and is possibly related to a displaced plaster floor surface.

Plate 4.35H. MF2 (XPL) in A6MM1A displays a dominantly cracky microstructure (rather than vughy), and is possibly related to a displaced plaster floor surface.
Plate 4.35I. Plaster floor fragments in A6MM1A (PPL), with mm-sized, rounded pebbles. The roundedness and sphericity of these pebbles (shown by yellow arrows) suggests their origin from beach sediments, or riverbeds near the beach, rather than from alluvially-rounded sediments.

Plate 4.35J. Plaster fragments, from a plaster floor, in A6MM1A (XPL), with highly-striated clay in voids between plaster fragments (shown by red arrow).

Plate 4.35K. A6MM1B contains only one area of silty sandy laminations/bedding (50% silt/50% v.f.s.-size grains), located beneath the large sandstone fragment (PPL).

Plate 4.35L. A6MM1B (same as Plate 4.35K but in XPL). Additionally visible is a dusty/limpid clay hypocoating (shown by white arrow).
Plate 4.35A-P. A: MF1 in A9MM2A (PPL); B: MF1 in A6MM2A (XPL); C: MF2 in A9MM2A (PPL); D: MF2 in A9MM2A (XPL); E: MF4 in A6MM1C, with possible light gray aggregates of (recrystallized) ash (PPL); F: MF4 in A6MM1C, with possible light gray aggregates of (recrystallized) ash (XPL); G: MF2 (PPL) in A6MM1A, possibly related to a displaced plaster floor surface; H: MF2 (XPL) in A6MM1A, possibly related to a displaced plaster floor surface; I: A6MM1A. Plaster floor fragments (PPL); J: A6MM1A. Plaster fragments (XPL) from the plaster floor; K: Area of silty sandy laminations/bedding in A6MM1B (PPL); L: A6MM1B (same as Plate 4.35K but in XPL); M: Calcitic nodule with limpid clay core and dusty clay coatings in A6MM1C (PPL); N: Calcitic nodule with limpid clay core and dusty clay coatings in A6MM1C (XPL); O: Indications of directional and possible rotational pressure in MF1 in A6MM1C along a diagonal plane (PPL); P: Indications of directional pressure in MF1 in A6MM1C along a diagonal plane (XPL).
4.3.2.2 Room 12

Additionally, three sediment monoliths were taken from Room 12 in Building AM1 (trench M1/A4S) to determine whether any surfaces existed in the room above the LM IB floor packing, and whether there was evidence of industrial activity in this area (Fig. 4.8). In Room 12, a bronze axe head and a large grinding stone, stone grinder, and an amphora were found (Plate 4.36). Room 12 may also have had access to the exterior of Building AM1 through a gap in Wall 20 on its eastern side; therefore, it was possibly impacted by colluvial/alluvial processes more than were the rooms to the west. The monoliths were taken from under a large stone in the NE corner of the room, bordered by Wall 37 and Wall 20 (Plate 4.37). According to the excavators, an LM IB surface is indicated by plaster, 40 cm below the location of the top of the monolith M1/A4A1, corresponding to the depth at which the bronze axe head was located. The top of the monolith M1/A4S1 is located beneath the start of unit #2099, and the base monolith M1/A4S3 corresponds to unit #2015. Monolith M1/A4SMM1 was divided into 3 thin sections (M1/A4AMM1A, M1/A4SMM1B, and M1/A4SMM1C), M1/A4SMM2 was made into a single section, and M1/A4SMM3 was divided into two sections (M1/A4SMM3A and M1/A4SMM3B) (Plates 4.38, 4.39)—the sections together span approximately 40 vertical cm.

General Observations (refer to Table 4.13)

Similar to the A6 thin sections, the M1/A4S thin sections are primarily composed of sand, clay, and silt, with varying proportions of poorly- to well-sorted close porphyric coarse/fine (c/f<sub>10µm</sub>)-related distribution (MF1) of approximately from 80/20-60/40. The mineral components of the MF1 groundmass consist of smooth, sub-angular to rounded grains of quartzite, phyllite, and sandstone (very fine sand (v.f.s.)-size, dominant, ~20-35%; fine sand (f.s.)-size, ~5-10%; medium sand (m.s.)-size, ~3-5%; course-sand (c.s.)-size, ~2-5%; very course sand (v.c.s.)-size, ~2-3%; fine gravel (f.g.)-size, sub-rounded to rounded, ~2-5%); and

approximately ~25-50% silt. Orthic and disorthic typic impregnative Fe/Mn nodules (v.f.s.-c.s. ~5-10%) and few dark brown (organic) residues (~2-5%) are also present in the groundmass. In the M1/A4S sections, MF1 has a void structure comprised of rough channels (10 - 500µm, ~10-15%) and semi-smooth, irregular-shaped vughs/vesicles (10 - 500µm, ~5-10%), with a total intrapedal porosity of ~15-20%.

Notably, several variations of this MF1 microfabric type occur in the M1/A4S sections, which may be divided into the following four subtypes of MF1: MF1a (possibly): MF1 with ash-mixed aggregates (as described in section 4.3.2.1), which occurs in M1/A4SMM1C; MF3: the chito-gefuric distribution (as described for A9MM2A in 4.3.1.3), which occurs in M1/A4SMM1B and M1/A4SMM2 (Plates 4.40/A/B); MF1c/3: a combination of MF1c (as described in A5EMM1A in 4.3.1.1), but with the bridges between the c.s.-size grains formed by a MF1 groundmass (c/f10µm is 60/40), which occurs in (M1/A4SMM3B (Plate 4.40G); MF1v: MF1 with different, vesicular structure (comprised of rough and smooth channels (10 - 200 µm, 10% (most 20-100 µm (~8%)) and semi-smooth, irregular-shaped vughs/vesicles (10 - 200 µm, 10%), with a total intrapedal porosity of 20%), which occurs in M1/A4SMM1A, M1/A4SMM1B, M1/A4SMM 2, and M1/A4SMM3A (Plate 4.40E/F); and MF1d: MF1v with the additional diagonal-alignment of the elongated vughs/vesicles (vesicles dominate (20 - 500 µm, 20%) and there are additionally some vughs/channels (10 - 500 µm, 5%), with a total intrapedal porosity of 25%) (Plates 4.40C/D), which occurs in sections M1/A4SMM1A and M1/A4SMM3A (Plates 4.40A/D). The vesicular microstructure (MF1v/1d) that dominates most of the M1/A4S thin sections is particularly notable as none of the other thin sections from on-site present similar vesicular microstructures.

In sections M1/A4SMM1C and M1/A4AMM3A, fragments of the fine-grained porphyric MF2 microfabric (described in section 4.3.2.1) may also be observed. The mineral components of the MF2 microfabric are similar to MF2 in the A6 sections, and include silt, ~70%; v.f.s.-size, ~20%; f.s.-size ~3%; and m.s.-size ~2%, as well as orthic and disorthic typic impregnative iron hydroxide nodules (v.f.s.-size ~5%). MF2 has a total intrapedal porosity of 5-10%.

Organic material (roots/wood/plant material) (0-2%), charcoal (<1%), burnt bone (1%) (only in M1/A4SMM1B and M1/A4SMM3A), shell fragments (<1-2%), ceramic fragments (<1-1%), and plaster fragments (1-2%) occur in the sections. Overall, the organic context in the M1/A4S sections is lower than that in the other sections. Additionally present in the M1/A4SMM3A sections is an area of silty clay laminations/intercalations, which occurs only in
the area of the diagonally-aligned vesicular microstructure (MF1d). Although a gravelly layer was noted in the area of M1/A4SMM1B during excavation, this layer is not observed in thin section; in general, the thin sections display evidence of substantial root activity and bioturbation. Areas of calcitic impregnations, pendants (some fragmented from grains), and hypocoatings are present throughout the M1/A4S thin sections, and appear to have occurred prior to the development of dusty and limpid clay coatings, suggesting typical soil pedogenesis, as noted for the A6 sections. Areas of iron impregnation and depletion suggest that the sections contain sediment from Bt or C horizon.474

Interpretations

As in the sediment in the A6 thin sections, the sediment in the M1/A4S thin sections is overall representative of non-laminated colluvial material based on the silty composition, massive, weakly-developed, angular blocky microstructure, fine fractions, and fragments of clay coatings and clay bridges. Notable in the thin sections are the diagonally-stratified and elongated vughs/vesicles in sections M1/A4SMM1A and M1/A4SMM3A (MF1d), which fit the features of ‘vesicular crusts’, which typically form in material similar to that noted for the site-sediment with high silt and sand content and lower clay content, as well as a calcitic, crystallitic b-fabric.475 The formation of vesicles may occur due to “the incorporation of air bubbles in near-surface horizons,”476 suggesting the exposure of the MF1d surfaces for a period of time. This may indicate that the sedimentation of Building AMI may have occurred in multiple episodes after the LM IB occupation and prior to the LM III occupation. Additionally visible in the M1/A4SMM3A section are fine, iron-rich clay laminations/intercalations within the MF1d zone, and, notably, this MF1d zone is the only area in the section to contain bone fragments. These observations suggest that the MF1d microfabric may represent beaten earth/floor material due to trampling/pressure, as it contains fine, horizontally-aligned vughs/vesicles, clay slaking

474 Kühn et al. 2010: 375.
475 Pagliai and Stoops 2010: 683.
features, and inclusion of bone fragments.\textsuperscript{477} The evidence from M1/A4SMM3A is much stronger for such a feature than the partially disturbed MF1d microfabric in A6MM1C.

Moreover, it is notable that all three sections with this MF1d microfabric type come from Building AM1; this microfabric type is not present in any other sections from the site buildings. It is feasible that these ‘vesicular crusts’ may have formed simultaneously during a post-LM IB abandonment phase of the building (since water-saturation of the building surfaces would be needed to trap the air-bubbles beneath the exposed surfaces within the structure). It is also possible that these vesicular crusts and evidence of directional pressure formed as a result of intentional ‘constructional packing’ over the LM IB surface (as noted earlier), beneath the LM III plastered floor surface, as noted earlier for Room 4 (Section 4.3.2.1).\textsuperscript{478} Alternatively, these vesicular crusts/constructional packing could relate to a phase of informal occupation of the structure between the LM IB and LM III phases.

\textsuperscript{477} Karkanas and Van de Moortel 2014: 205 (Table 2); 208, citing Macphail et al. 2004; Macphail and Goldberg 2010.

\textsuperscript{478} Matthews and Postgate 1994; Matthews 1995; Mathews et al. 1996; Adderley et al. 2010; Macphail and Goldberg 2010: 941-942.
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<td>(MF1v/MF1d) Poorly-sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X X No Yes (~2%)</td>
<td>Dusty clay coatings and hypocoatings (10-50 μm, 50%) X</td>
</tr>
<tr>
<td>M1/A4SM M1B</td>
<td>(MF1v) poorly-sorted; (MF3) moderately-sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X X No Yes (~1%)</td>
<td>Dusty and limpid clay coatings and dusty clay hypocoatings and quasicoatings (10-50 μm, 50%) X</td>
</tr>
<tr>
<td>M1/A4SM M1C</td>
<td>(MF1) poorly-sorted; (MF2) well-sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X X Yes (&lt;1%) Yes (~2%)</td>
<td>clay hypocoatings and quasicoatings (10-50 μm, 50%) X</td>
</tr>
<tr>
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<td>Smooth, sub-angular to rounded</td>
<td>X X Yes (~1%) No</td>
<td>Dusty and limpid clay coatings and dusty clay hypocoatings (10-50 μm, 50%) X</td>
</tr>
<tr>
<td>M1/A4SM M3A</td>
<td>(MF1v/MF1d) poorly-sorted; (MF2) well-sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X X Yes (&lt;1%) No</td>
<td>Dusty clay laminations; dusty clay hypocoatings and quasicoatings (10-50 μm, 50%) X</td>
</tr>
<tr>
<td>M1/A4SM M3B</td>
<td>(MF1) poorly-sorted; (MF1c/3) moderately-sorted</td>
<td>Smooth, sub-angular to rounded</td>
<td>X X No Yes (~2%)</td>
<td>Dusty clay hypocoatings and quasicoatings (10-50 μm, 50%); (MF1c/3) dusty clay coatings (10-100 μm, 100%) X</td>
</tr>
</tbody>
</table>
Figure 4.8. Location of M1/A4S1, M1/A4SMM2, and M1/A4SMM3 in Building AM1, Room 12 (Plan by Spencer 2016).
Plate 4.36. View towards the West of Room 12, showing possibly access to the exterior of the building through the Wall 20.
Plate 4.37. A: Location of monoliths (only M1/A4SMM1 already prepared) in the NW corner of Room 12, in Building AM1; B: Sediment prior to taking monoliths. Sediment appears homogeneous, but larger boulders are apparent at the bottom of the profile. These boulders prevented removal of a monolith from this lower portion of the profile. Note the ceramic bowl fragment present in the profile (marked by the white arrow); C: View towards the East of monolith profile within Room 12; Wall 20 (open to the exterior) is visible. (R. Kulick, 2014).
Plate 4.38 (Left) M1/A4S thin sections in relative relation to one another (not to scale; each section is approximately 5 cm by 7.5 cm); (above) thin sections in monoliths before being processed (R. Kulick, 2014).
Plate 4.39A. M1/A4SMM1A has an MF1v microfabric, with some elongated vesicles diagonally aligned (MF1d, note those particularly visible in between the areas of the white dashed lines). It displays a complex (angular blocky, channel, cracky, crumby) microstructure with sub-angular blocky, moderately-well separated, partially-accommodated peds. The close porphyric c/f 10 µm-related distribution is 75/25, and the coarse fraction is composed of v.f.s., ~30%; f.s. ~10%; m.s. ~5%; c.s. ~5%; v.c.s. ~3%; f.g., sub-rounded to rounded, ~2%, along with silt (~25%). The void structure is composed of rough channels (10 - 500 µm, 15%), semi-smooth, irregular-shaped vughs (10 - 200 µm, 5%), with a total intrapedal porosity of 20%. Large calcitic pendants (some fragmented from grains, 100 - 500 µm) are present.

Plate 4.39B. M1/A4SMM1B is composed dominantly of the MF1v microfabric, but also includes some fragments of MF3 (circled by white lines). MF1v (c/f 10 µm 70/30) has a complex (cracky, channel, angular blocky, vesicular) microstructure, with moderately- to well-separated, partially-accommodated peds; MF3 (c/f 10 µm 90/10) has a complex (compact bridged-grain) microstructure. In contrast to the MF1v void structure (noted in Fig. 45A), MF3 is comprised of compound packing voids (20 - 200 µm with a total intrapedal porosity of 25%). The coarse fraction of MF1v consists of v.f.s., ~30%; f.s. ~10%, m.s. ~5%; c.s. ~5%; v.c.s. ~3%, f.g. ~2%) with silt, ~25%. MF3 consists of silt, ~10%, v.f.s., ~40%; f.s. ~25%, m.s. ~5%. Calcitic pendants are consist with those of M1/A4SMM1A. There are some very very weak indications of clay laminations, but the sections is, overall, very bioturbated.
Plate 4.39C. MF1v of M1/A4SMM2 has a complex (angular blocky, channel, vesicular) microstructure with angular blocky peds that are moderately- to well-separated and partially-to well-accommodated. MF3 (outline in white) has a microstructure (compact bridged-grain structure) and features identical to that of MF3 in M1/A4SMM1B. Notable throughout is that the voids are predominantly horizontal, and many are vesicles: MF1v has rough and smooth channels (10 - 200 µm, 10%; most 20 - 100 µm (~8%)), semi-smooth, irregular-shaped vughs/vesicles (10 - 200µm, 10%) and a total intrapedal porosity of 20%. MF1v (c/f10µm 85/15-70/30) consists of silt, ~50%; f.v.s., ~20%; f.s. ~5%, m.s. ~3%; c.s.~3%; v.c.s. ~2%; f.g., sub-rounded to rounded, ~2). MF3 consists of silt: ~10%, v.f.s., ~40%; f.s. ~25% and m.s. ~5%. There appear to be a greater proportion of vughs/vesicles in the bottom half of the section, and vertical ped separation dominates. A conifer wood charcoal fragment is also present (L. Picornell-Gelabert, pers. comm. 2016).

Plate 4.39D. M1/A4SMM1C consists of MF1, a complex (angular blocky, channel, cracky, crumby; bottom more vesicular) microstructure, with sub-angular blocky peds, moderately separated, and partially-accommodated. Its void structure is comprised of rough channels (10 - 500µm, 5-10%) and semi-smooth, irregular-shaped vughs/vesicles (10-500µm, 5-10%), with a total intrapedal porosity of 15%. MF2 in this sections is identical to that in Room 4, with a total intrapedal porosity of 5-10%. MF1 (c/f10µm 70/30) consists of silt: ~40%; v.f.s., ~30%; f.s. ~5%, m.s. ~5%; c.s. ~2%; v.c.s. ~3%; f.g., sub-rounded to rounded, ~5%). MF 2 consists of silt, ~70%; v.f.s., ~20%, f.s. ~3%, and m.s. ~2%. There are a few very small fragments of degraded plaster in this section.
Plate 4.39E. M1/A4SMM3A consists of a complex (massive, angular blocky, channel, vesicular) microstructure with angular blocky pedds, moderately separated, and partially-accommodated. The areas denoted by 1v and 1d have predominantly (horizontally-) vesicular microstructures. MF1/1v has rough and smooth channels (5 - 200 µm, 10%; most 20 - 100 µm (8%)), semi-smooth, irregular-shaped vughs/vesicles (10 - 200µm, 15%) and a total intrapedal porosity of 20%; MF2 has an intrapedal porosity of only 5-10%; vesicles dominate the void structure of MF1d (20-500µm, 20%); vughs/channels (10-500, 5%), for a total intrapedal porosity of 25%. MF1/1v (c/f 10µm 80/20-70/30) consists of silt: ~40%; v.f.s., ~30 %; f.s. ~5%, m.s. ~5%; c.s. ~2%; v.c.s. ~3%; f.g., sub-rounded to rounded, ~5%). MF2 consists of silt, ~70%; v.f.s., ~20%, f.s., ~3%, and m.s. ~2%. MF1d is identical to MF1v but is additionally characterized by an increase in horizontally-aligned vesicles. Areas of iron/clay laminations/intercalations occur only in area of increased vesicular nature (MF1d).

Plate 4.39F. M1/A4SMM3B is characterized by a complex (massive, angular blocky, channel, vesicular) microstructure, as well as a compact bridged-grain structure (in MF1c/3). The orientation of the voids are predominantly horizontal, and there are many vesicles. MF1/1v has rough and smooth channels (5 - 200 µm, 10%; most 20 - 100 µm (8%)), semi-smooth, irregularly-shaped vughs/vesicles (10 - 200µm, 15%) and a total intrapedal porosity of 20%; MF 1c/3 has compound packing voids (20 - 500µm) and a total intrapedal porosity of 25%. As in M1/A4SMM3A, MF1/1v (c/f10µm 70/30) consists of silt: ~40%; v.f.s., ~30 %; f.s. ~5%, m.s. ~5%; c.s. ~2%; v.c.s. ~3%; f.g., sub-rounded to rounded, ~5%). MF1c/3 appears to be like MF3, but with the gravels bridged by an MF1c microfabric. MF1c/3 consists of silt: ~20%, v.f.s., ~20%; f.s., ~10%, m.s., ~10%; and v.c.s., ~20%. Additionally, the sand-size grains in MF1c/3 appear to be much more sub-angular than the fine-grained MF3 distribution seen in other sections.

Plates 4.39A-F. Thin sections M1/A4SMM1A-C, M1/A4SMM2, and M1/A4SMM3A-B.
Plate 4.40A. MF3, shown here in M1/A4SMM1B (PPL) appears to be similar to that in A6MM2A, and is suggestive of colluvial sedimentation due to the bridged-grain structure. Note the dusty clay bridges between grains (indicated by the red arrow).

Plate 4.40B. MF3, shown here in M1/A4SMM1B (XPL) appears to be similar to that in A6MM2A. Note the lower proportion of silt (10%) compared to that in the typical MF1 groundmass (silt, 25-50% in the M1/A4S sections).

Plate 4.40C. Notable in the thin section M1/A4SMM3A (shown here in PPL) are the diagonally-stratified and elongated vughs/vesicles (MF1d). These features resemble that of ‘vesicular crusts’, which typically form in material similar to that noted for the site – sediment with high silt and sand content and lower clay content, as well as a calcitic, crystallitic b-fabric.

Plate 4.40D. Observable above in M1/A4SMM3A (shown in XPL) is the calcitic, crystallitic b-fabric of MF1d. This feature, and that of high silt and sand content but lower clay content, is typical for sediments in which vesicular crusts may form. Such a vesicular features may also align under directional pressure and may indicate that this MF1d type was a beaten earthen surface or ceiling, given the additional inclusion of clay/iron laminations and bone fragments in its groundmass.
Plate 4.40. E. M1/A4SMM2 (shown here in PPL) is characterized by a generally vesicular and vughy microstructure (MF1v). Note the irregular shape of the vughs, as well as the horizontal rough planar void (interconnected the vughs), typical of vesicular microstructures.

Plate 4.40. F. Dusty and weakly limpid clay coatings and hypocoatings are visible in MF1v (shown here in XPL) in M1/A4SMM2. Note the calcitic, crystallitic b-fabric, typical for vesicular crust formation.

Plate 4.40. G. MF1c/3 (shown here in M1/A4SMM3B in XPL) is characterized by the chito-gefuric related distribution of MF3; here, however, the bridges between larger grains (typical of the c.s.- and f.g.-size grains dominant in the MF1c type) is formed by MF1 microfabric type.

Plates 4.40A-G. A: MF3 in M1/A4SMM1B (PPL) is suggestive of colluvial sedimentation; B: MF3 in M1/A4SMM1B (XPL) is suggestive of colluvial sedimentation; C: Diagonally-stratified and elongated vughs/vesicles (MF1d) in M1/A4SMM3A (PPL); D: Calcitic, crystallitic b-fabric of MF1d in M1/A4SMM3A (XPL); E: Vesicular and vughy microstructure (MF1v) in M1/A4SMM2 (PPL); F: Dusty and weakly limpid clay coatings and hypocoatings in MF1v in M1/A4SMM2 (XPL); G: MF1c/3 in M1/A4SMM3B (XPL) is characterized by the chito-gefuric related distribution of MF3.
4.3.3 Building MP1

Building MP1 (covering trench M4 in 2014 and trench P5 in 2015) appears to have been occupied only in LM IA (Palaikastro period X), but then not occupied thereafter (Plates 4.41, 4.42). This is in contrast to the other Buildings (AP1 and MP1), where there is occupation in the LM IB and LM III periods in AM1, and occupation in the Neopalatial (MM III-LM IA) and LM III periods in AP1. Also notable is the relatively shallow nature of burial of the walls of Building MP1 (in the Mavrokoukoulakis plot) beneath the modern surface (less than 30 cm below the modern surface). Although some LM III ceramics were found in topsoil contexts, including as #7010, these artifacts have been disturbed; the same context contained modern artifacts, such as barbed wire and a WWII bullet casing, and post-depositional disturbance from modern trees, roots, and colluvial/alluvial events. These unique features, in addition to the lack of information on the function of the building and its various rooms and spaces, make an investigation into the use of space and post-occupational phase of the building a subject of interest for further investigations. Three sediment monoliths were taken from two different areas outside of Building MP1 in 2014, as no floor surface were reached in the structure until the 2015 season.

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479 PALAP BSA report 2015.
480 Ibid.: 50.
Plate 4.41. Aerial photograph of Building MP1 (Quentin Letesson 2016; after 2015 excavation season).

Plate 4.42. Aerial photograph and architectural (wall) designations of Building MP1 (and AM1) (Quentin Letesson 2016; after 2015 excavation season).
4.3.3.1 Exterior Space 9 (Context 9.2)

Two samples (M4MM1 and M4MM1) were taken from the area outside the corner of Wall 22 and Wall 24, above and into what was identified during excavations as a potential Neopalatial street surface because of its compaction and ceramic materials (Fig. 4.9, Plate 4.43). Both sediment monoliths were very crumbly, with one break occurring approximately halfway into section M4MM2 (Plates 4.44, 4.45). The lack of cohesiveness of the sediment above the possible street surface was observed during excavations. It was hypothesized during excavations that this area was likely the exterior of the structure (formed by the corner of Wall 22 and Wall 24), in the area of a potential Neopalatial street surface. The contexts of samples M4MM1 and M4MM2 span units #7014 and #7019. One bulk sample was taken from each of these units for geochemical analysis.

General observations (refer to Table 4.14)

Three microfabrics are present in these two thin sections; two of which are unique to this particular site context. The first microfabric (MF1), present in both sections, is the typical close porphyric c/f10µm-related distribution (70/30) of silt, sand, and clay, seen in other thin sections from the site. It consists of a complex (granular and crumby) microstructure with the coarse component being comprised of grains of v.f.s.-size, ~20-35%; f.s.-size ~10-20%, m.s.-size ~5%; c.s.-size ~2%; v.c.s.-size ~1-2%; f.g.-size (sub-rounded to rounded), ~1-5%, and silt, ~20-35%; orthic and disorthic typic impregnative iron hydroxide nodules (v.f.s.-c.s.-size ~2-5%) are also present. MF1 contains compound and complex packing voids (40%); the intrapedal void structure is composed of rough channels (10 - 500 µm, 10-15%) and semi-smooth, irregular-shaped vughs/vesicles (10 -500 µm, 5%), with a total intrapedal porosity of 15-20%. The groundmass also includes orthic and disorthic typic impregnative iron nodules (v.f.s.-c.s.-size) (~5%) and a few dark brown (organic) residues (~5%). Calcitic pendants occur on 75% of the f.g.-size grains (100 - 750 µm) (Plate 4.46H).

The second microfabric (MF5), present only in M4MM1, exhibits a porphyric c/f10µm-related distribution (80/20-90/10) of silt, sand, and clay. It consists of a cracky/crumby microstructure. The coarse component of MF5 is comprised of grains of v.f.s.-size, ~85%; f.s.-
size, ~5%, m.s.-size, ~5%; c.s.-size, ~2%; orthic and disorthic typic impregnative iron/clay nodules (v.f.s.-c.s.-size, ~3%) are included in the groundmass as well. This microfabric also contains clay hypocoatings (50%, 10 - 50 µm) and areas of micritic calcitic inclusions ranging from 20 - 2000 µm (30% of groundmass) (Plates 4.46A/B). The void structure is also reduced and composed of primarily long, planar voids, with a porosity accounting for approximately 10% of the microfabric.

Beneath parts of this MF5, in M4MM1, are areas of porphyric silty-sandy laminae/laminations, consisting of approximately ~80% silt and ~20% clay, alternating with some mixed layers with larger sand-size grains (Plates 4.46C/D). In places, these layers and laminations appear to be graded, and in several places they demonstrate reverse graded bedding (fine fraction at the bottom overlain by coarse grains).

The third microfabric (MF6) is only present in M4MM2 in the bottom part of the thin section (Plates 4.46E/F). It consists of a crack and planar microstructure with moderately- to well-separated, moderately- to well-accommodated peds. The close porphyric c/f10µm-related distribution consists of smooth, sub-angular to rounded grains (v.f.s.-size, ~40%; f.s.-size, ~5-10%, m.s.-size, ~5%; c.s.-size, ~2%; f.g.-size, ~5%) and silt, ~50%; the groundmass also includes orthic and disorthic typic impregnative iron/clay nodules (v.f.s.-c.s.-size ~3%). Rough and planar channels (10 - 500 µm, 10-15%) and semi-smooth, irregular-shaped vughs/vesicles (10 - 500µm, 5%) contribute to an intrapedal porosity of 10% in MF6. Clay hypocoatings and quasicoatings (50%, 10 - 50 µm) are also present. Significantly, there is no organic material present in MF3, except for some plaster fragments (~2% of the groundmass). Notably, the b-fabric is reddish brown, cross-striated, and speckled.

**Interpretations**

The fact that MF5 is very dense and consists of long planar voids, possibly due to shrinkage, might indicate that this material is an earthen construction material.481 Supporting the idea that this material is anthropogenically-made is the observation of a higher proportion of

481 Friesem et al. 2011; 2014a,b; Goldberg and Macphail, 2006; Nodarou et al., 2008.
micritic calcite mixed with clay (more so than present in the other thin sections); the calcite may derive from local sediment, ash, or lime plaster.\textsuperscript{482}

The fact that there are not many voids indicative for plant temper (typical in some mud brick) can be the result of two possibilities: (1) these samples are not mud brick but the remains of other earthen construction technique such as rammed earth, in which plant temper is not utilized; (2) this is an advanced stage of degradation of mud brick in which the material has been washed away and the original structure has been lost and therefore there is no indication of the temper.\textsuperscript{483} Since there are some mud brick remains in poor condition that were found during the excavation of Building MP1, MF5 could indeed be degraded mud brick. Additionally, the laminations (Plates 4.46C/D) beneath the MF5 areas are graded bedding and indicate the washing away of clay and coarser grains, perhaps from mud brick walls. The fact that there is some reverse graded bedding (fine fraction at the bottom overlain by coarse grains), which is not typical for puddles and running water, indicates sediment gravity processes that might be related to mud brick degradation.\textsuperscript{484} Such features can be also observed inside mudbricks as the result of kneading and pugging during the manufacture of the mud brick,\textsuperscript{485} and this further supports the idea of MF5 being mud brick, or a related earthen construction material.

Additionally, there are bright orange, prismatic inclusions (possibly hematite) in a few areas (<5\%) of the MF5 microfabric, but occurring in 20-30\% of groundmass where they appear. It has been suggested that heating of construction materials such as mud brick, daub, and adobe can cause “reddening…by the formation of hematite (oxidizing conditions),”\textsuperscript{486} thus raising a further question of whether this structure and/or the potential mud brick was burned.

The lower area (MF6) of section M4MM2 is much denser than the surrounding groundmass, and the presence of long planar voids, which may be indicative of trampling, suggests that this microfabric is actually the Neopalatial street surface. The context from which the sample was taken also makes it very likely that this part of the sample is of the street surface

\textsuperscript{482} Stoops 2010.
\textsuperscript{483} Friesem, pers. comm. 2016.
\textsuperscript{484} Friesem et al. 2011.
\textsuperscript{485} Friesem et al. 2014a: 560.
\textsuperscript{486} Macphail and Goldberg 2010: 948; Goldberg and Macphail 2006.
on which post-abandonment mud brick walls may have started to degrade and accumulate. Additionally supportive of MF6 as a street surface is the c/f$_{10\mu m}$-related distribution (40/60), which demonstrates a much higher fine component than the other microfabrics. The fine components may be dust being trampled into the street surface. The disintegration of the potential mud brick material on the street may have contributed to the preservation of the street itself. These observations, in particular the planar structures, also follow the observations made of informal floors noted by Karkanas and Efstratiou.

This interpretation, of Building MP1 potentially having mud brick walls is significant because it was subsequently never rebuilt (in contrast to Buildings AP1 and AM1), following possible mud brick degradation. If this is accurate, this is a very different finding from what is hypothesized to have occurred in Building AP1, where reoccupation is believed to reoccur after “abandonment.” In contrast to AP1, there is no preserved, alluvially-lain graded bedding in MP1, other than that possibly attributed to mud brick. The process by which this potential mud brick material and Neopalatial street surface were preserved requires further investigation, particularly if there was no LM IB nor LM III construction overlying as it, since it was uncovered only 20 - 30 cm beneath the modern surface.

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488 After Friesem et al. 2014b: 88. Friesem (2014b: 88) observed in experimental studies that the roofs collapse directly on the floor.
Table 4.14. M4 sedimentary characteristics and micromorphological features based on thin section analysis

<table>
<thead>
<tr>
<th>Sample</th>
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<td></td>
<td></td>
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<td></td>
</tr>
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<td></td>
<td></td>
<td>phyllite/</td>
<td></td>
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Figure 4.9. Location of M4MM1 and M4MM2 in Building MP1, Exterior Space 9 (Plan by Spencer 2016).
Plates 4.43A-B. A: Sediment prior to taking monoliths from the outside corner of walls 22 and 24 of Building MP1. Sediment appears homogeneous to the naked eye and is incredibly crumbly; B: Sediment monolith M4MM1 prepared, prior to removal (R. Kulick, 2014).
Plate 4.44. (Left) M4 thin sections in relative relation to one another (not to scale; each section is approximately 5 cm by 7.5 cm); (Right) Thin sections in monoliths before being processed (R. Kulick, 2014).
Plate 4.45A. The fractions (circled in white) appear to be construction material (MF5). Note the complex (granular, crumby) microstructure; the possible mud brick has a cracky microstructure. MF5 (the mud brick) has a c/f_{10\mu m}-related distribution of 20/80-10/90, and is composed of v.f.s., ~85%; f.s. ~5%, m.s. ~5%; c.s. ~2%, and Fe/Mn nodules (v.f.s.-c.s. ~3%). Hematite inclusions also occur in a few areas (<5%) of fabric, but occurring with 20-30% of groundmass where they appear. MF5 also includes calcite/plaster mottling/inclusions in mud brick from 20-2000 um (30% of groundmass).

Plate 4.45B. Note the distinct difference between the complex (crumby and angular blocky) microstructure of (1) in contrast to the compact, cracky microstructure with long planar voids (6: possible street surface). MF6 (the area beneath the yellow line) demonstrates a c/f_{10\mu m}-related distribution of 40/60, and consists of silt, 40%, v.f.s., ~20%; f.s. ~10%, m.s. ~5%; c.s. ~2%; and f.g. ~5%. This c/f_{10\mu m} ratio is significant because it demonstrates a higher fine component and may suggest that dust is being trampled into the street surface. MF6 also has a crystallitic and cross-striated b-fabric, suggestive of soil formation processes. The ceramic fragment from a straight-sided cup appears to belong to the F4 fine fabric type, typical for Neopalatial (MM IIIA/B) cups (J. Gait pers. comm. 2017).

Plates 4.45A-B. Thin sections M4MM1 and M4MM2.
Plate 4.46A. Possible collapsed mud brick matrix in M4MM1 (PPL). Note the dense nature of the groundmass and the micritic calcite mixed with clay.

Plate 4.46B. Possible collapsed mud brick matrix in M4MM1 (XPL). Note birefringence of the micritic calcite b-fabric.

Plate 4.46C. Laminations of fine material (dark bands indicated by white arrows) and graded bedding in M4MM1 (PPL). There are some areas of reverse graded bedding, which indicates sediment gravity processes that might be related to mud brick degradation.

Plate 4.46D. Laminations of fine material (dark bands indicated by white arrows) and graded bedding in M4MM1 (XPL). Alternating layers of birefringent sand-size grains with dark silt/clay particles are particularly apparent in XPL.
Plate 4.46E. MF6 (shown in PPL, in M4MM2) displays a groundmass with long planar voids (indicated by red arrows) and a much greater proportion of silt, which may indicate dust trampled into the street surface.

Plate 4.46F. MF6 (shown in XPL, in M4MM2) exhibits a cross-striated b-fabric; while porostriated or local parallel-striated fabrics may be caused by extensive wet trampling, cross-striation may be attributed to soil formation process (e.g. vertic soils).

Plate 4.46G. Fabric of ceramic cup fragment in M4MM2 (XPL). This appears to be the same fine fabric (F4) that has been identified in other Neopalatial cups (PK 86, 88, 89, 91: hemispherical cups, MM IIIA) (J. Gait pers. comm. 2017). Note the paint preserved on the edge of the vessel (indicated by the white arrow).

Plate 4.46H. Calcitic pendant, showing multiple laminations of alternative darkness. Darker layers of calcitic may indicate the inclusions of increased amounts of organic materials during formation.
4.3.3.2 Exterior Space 10 (Context 10.2)

Monolith M4MM3 was taken from Exterior Space 10, an extension of trench M4 in 2014, to the north of Building MP1 (Fig 4.10, Plate 4.47). This exterior space was typified by packed sediment running alongside (east) and outside (north) of possible Neopalatial street and drain (Exterior Space 9). The monolith spans units #7043, 7049/7050, 7051, 7052, and 7053; anthropogenic materials were limited, but were noted in all units. A harder, more compact surface was noted during excavations in the sediment corresponding to the top 1.5 centimetres of the monolith, which was hypothesized to have been an LM I surface, overlying Middle Minoan contexts. The aim of the thin section sampling is to determine if there is indeed a division
between LM I and MM units in this area. One monolith, approximately 15 cm in height, was divided into two thin sections: M4MM3A and M4MM3B (Plates 4.48, 4.49A/B). One bulk sample was taken for geochemical analysis from the associated context.

**General observations (refer to Table 4.14)**

One general microfabric was observed in the two thin sections: the typical microfabric for the site sections thus far (MF1), although there is an increased proportion of large, centimetre-sized gravels in both sections compared to that in other site areas. In these sections, MF1 exhibits a typical close porphyric cl/f\textsubscript{10\mu m}-related distribution (80/20-70/30) of silt, sand, and clay, seen in other thin sections from the site. Section M4MM3A does exhibit a slightly different microstructure (complex (massive, angular blocky, and vugly) microstructure) compared to that of M4MM3B (complex (crumby, vesicular, and granular) microstructure). The coarse component of MF1 in these sections is comprised of grains of v.f.s.-size, 30-60%; f.s.-size, ~10-20%, m.s.-size, ~5%; c.s.-size, ~1-5%; v.c.s.-size, ~1-5%; f.g.-size (sub-rounded to rounded), ~10%, and silt, 10-20% (Plates 4.50E/F). Orthic and disorthic typic impregnative iron hydroxide nodules (v.f.s.-c.s.-size ~3-5%) are also present.

The void structure in M4MM3A is comprised of rough channels (10 - 500\mu m, 10%), semi-smooth, irregular-shaped vughs/vesicles (10 - 500\mu m, 5%), and has a total intrapedal porosity of 15%. While similar void structures are present in M4MM3B, M4MM3B is has a total intrapedal porosity of 20-30%, with the upper area containing a much more vesicular microstructure, with greater proportion of vesicles. Additionally, M4MM3B includes some rounded and very degraded plaster fragments, as well as a generally smaller grain-size and fewer gravels in the upper portion of the section, with a greater number of larger gravels towards the bottom of the section. It is also notable that M4MM3B contains a greater proportion of shell fragments (5%) compared to 1% in section M4MM3A, as well as several visible grains of glauconite.
Interpretations

Although a harder-packed sediment was observed in the field, 1.5 cm below the top of the monolith, this harder compaction was difficult to observe in the thin sections. It is apparent, however, that the microstructure of M4MM3A (more angular blocky and vughy) differs from that of M4MM3B (more vesicular) (Plates 4.50A-D). Additionally, compared to M4MM3B, M4MM3A has a generally smaller grain-size, with fewer gravels in the upper part of the section, as well as fewer voids (total intrapedal porosity of 15%), compared to the total intrapedal porosity of M4MM3B: 20-30%. Indeed, these features could contribute to the denser nature of the material that was observed in the field. Nevertheless, no readily-made surface or packing is visible.

It is also significant that M4MM3B is more poorly-sorted and has more vesicles than M4MM3A, particularly in the upper part of the section. Also in M3MM3B, there is not a lot of silt present (only 20% silt), though this is more silt than in M4MM3A (only 10% silt). Additionally, very small fragments of shell are present throughout, and there are also several grains of glauconite; these features suggest that some of these M4MM3B sediments derived from a marine environment.\footnote{Mees and Stoops 2010: 871; Miedema et al. 1974; MacKenzie and Adams 2009.} It is possible, therefore, to suggest that the vesicular features in the top part of M4MM3B as forming in a water-saturated environment,\footnote{Stoops 2003: 64-65.} if the early sediments in M4MM3B were indeed deposited by marine/alluvial processes. Since this area of the site was completely exposed to processes of aggradation, it would not be surprising for this area to easily flood/become water-saturated.
Figure 4.10. Location of M4MM3 in Building MP1, Exterior Space 10 (Plan by Spencer 2016).

Plate 4.47 A) Location of monolith M4MM3 in Exterior Space 10, Context 10.2, located south of MP1 and east of AM1; (B) Sediment prior to taking monoliths. Sediment appears homogeneous and very friable due to small gravels.
Plate 4.48. (Left) M4 thin sections in relative relation to one another (not to scale; each section is approximately 5 cm by 7.5 cm); (Right) Thin sections in monoliths before being processed (R. Kulick, 2014).
Plate 4.49A. M4MM3A has a complex (massive, angular blocky, and vughy) microstructure with moderately- to well-separated, partially- to well-accommodated peds. Rounded and very degraded plaster are included in the matrix, as well as calcitic features. Compared to M4MM3B, M4MM3A has a generally smaller grain-size, with fewer gravels in the upper part of the section. No real bedding is apparent, nor is any plastered surface.

Plate 4.49B. It is notable in M4MM3B that there is not much silt present (only 20% silt), though this is more silt than in M4MM3A (only 10% silt). In addition, M4MM3B is more poorly-sorted and has more vesicles than M4MM3A, particularly in the upper part of the section (above the white dashed line). Very small fragments of shell are present throughout, and there are also several grains of glauconite; these features suggest a marine origin of some of these sediments.

Plates 4.49A-B. A: Thin sections M4MM3A and M4MM3B.
Plate 4.50A. MF1 in M4MM3A (in PPL), exhibiting a vugly microstructure and illuvial dusty/limpid clay coating and hypocoating.

Plate 4.50B. MF1 in M4MM3A (in XPL). Note the crystallitic nature of the b-fabric.

Plate 4.50C. MF1 in M4MM3A (in PPL). Closer view of the illuvial dusty/limpid clay coating and hypocoating. The plant material in the centre of the void is evidence of bioturbation, despite the dense (hard-packed) texture of these sediments in M3MM3.

4.4 Summary: Palaikastro ‘urban’ microfabrics

Table 4.15 (below) provides a summary of the main features and basic interpretations of all of the microfabric types identified in the Palaikastro thin sections. While an in-depth discussion of these microfabrics in relation to other proxy and archaeological data will be discussed in Chapter 5, a brief summary of all of the microfabric types may be presented from these observations:

Based on the thin section analysis of the deep stratigraphic exposures in Trench A2 and Trench A3, multiple mass movements of debris appear to have impacted these areas since Protopalatial times, although the exact timing of these events is yet to be confirmed. Such debris flow episodes appear to have impacted the new area of the 2013-2015 archaeological excavations during the Neopalatial and Post-palatial periods as well. The thin section analysis
confirms that most sediments present in the studied contexts are indicative of inland sources and overland flow processes, likely originating from the slopes of Petsophas. This area of the new excavations, and Buildings AP1, AM1, and MP1, located under the slopes of Petsophas, appear to have been significantly impacted by colluvial and alluvial episodes, which could have resulted from events such as earthquakes and heavy rainstorms, causing overland flow events. The topographic location of much of the settlement revealed during earlier excavations (to the west of Trench A2) should have protected it from major slope disturbances. Despite this evidence for significant influences of overland flow processes, evidence from the thin sections across several site areas for bedding, laminations, and slaking crusts, interspersed with these more chaotic, overland flow processes, indicates that there were indeed periods of stability during which surfaces remained exposed for periods of time, including during the period in which the site had inhabitants.

Overall, the 2014 thin section samples from Buildings AP1, AM1, and MP1 indicate that different post-depositional processes have affected the ‘occupied’ area of the site. For example, sections from Building AP1 indicate that multiple wetting episodes occurred in Building AP1 between the LM I and LM III occupations. The thin sections from the area of Building AM1 contain indications that colluvial (overland/debris flow) processes occurred post-LM IB and prior to LM III re-occupation; indications of possible beaten or trampled surfaces/floors may have been preserved between the LM IB and LM III occupations. The thin sections from outside of Building MP1 provide evidence of different reconstruction practices (a lack of rebuilding) compared to Buildings AP1 and MP1. Whether its abandonment was triggered by mass movement events, other natural processes, or social choices, it is clear that debris flows and

492 Conclusions of these more gradual processes of transformation support findings from soil samples taken during the 2003 excavations at Palaikastro. Vertical sediment blocks were obtained to study the individual floor layers that were uncovered; each sediment block was taken in an overlapping sequence from inside Buildings 4 and 7, and immediately outside of Buildings 6 and 7. A portion of the analysis of these samples was studied by Rachel Kulick (University of Toronto), and the remaining samples are to be studied by Frank Carpentier (Katholieke Universiteit Leuven). Preliminary analysis of these samples by the author demonstrated that individual archaeological fill layers were as fine as 2-3 cm; the layer of Theran tephra located in Street BM outside of Building 7 was 5-6 cm in thickness. Further thin section analysis, to be amalgamated with the archaeological reports, suggested that, based on the tephra and surrounding layers, the forces that deposited the tephra, sediments, and archaeological debris in this location were not severe enough to have violently displaced the underlying street surface. In contrast to previous studies (e.g., Bruins et al. 2008), the conclusions of this analysis suggested that events with less energy than a tsunami, such as a storm surge or localized flooding, affected this area of the site during the LM IA period.

493 Pagliai and Stoops 2010: 677.
overland flow deposits impacted the building post-abandonment. However, the timing of these events across the site require further clarification as there is the possibility that subsequent occupation layers have been truncated prior to archaeological investigation.

Notably, some of the thin sections, both from the rooms and spaces in and around Buildings AP1, AM1, and MP1, as well as Trenches A2 and A3, contain microfabrics (MF3r, MF4b) with coarse sand grains. These microfabrics appear to be from different sources than the slopes, since these MF3r and MF4b microfabrics contain coarse component grains that appear to be significantly more weathered than the typical sub-angular grains identified via the control geological samples from the ‘Kastri’ alluvial deposits. These grains appear to be similar in nature to those from Palaikastro river bed and beach control samples, although they could similarly be from aeolian origin as well (aeolian samples were not compared in this study). It is significant that these microfabrics with rounded grains generally occur in finer, sorted layers in the building contexts while the microfabrics with rounded grains tend to occur in thicker, more chaotic bands in Trench A2. In both Trench A2 and the building areas, the microfabric MF4b includes grains of glauconite, which originate from marine environments. Nevertheless, beach sediments may be transported inland via wind or coastal flooding, as well as come from possible paleo-coastal sediments. Therefore, while rounded, weathered grains are present across the site, the processes by which they may have been deposited may differ. Similarly, materials, such as ceramic fragments, charred organic material, bone fragments, and shell fragments, are present in the thin sections from almost all contexts, indicating that a more detailed analysis of these data with additional proxy and archaeological information will be necessary to evaluate the sources of these materials, and whether their depositional location may relate to natural and/or anthropogenic processes. These processes will be discussed in more detail in Chapter 5.

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Table 4.15. Micromorphological descriptions of Palaikastro ‘urban’ microfabrics

<table>
<thead>
<tr>
<th>Microfabric type</th>
<th>Subtype</th>
<th>Summary of micromorphological descriptions</th>
<th>Samples</th>
<th>Archaeological context: Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1c</td>
<td>MF1 with the addition of a greater proportion of coarse sand-size (c.s.-size); c.s./v.c.s./f.g.-size grains frequent (c/f10um is 60/40).</td>
<td>A5EMM1B, M1/A4SMM3B</td>
<td>1c</td>
</tr>
<tr>
<td></td>
<td>1d</td>
<td>MF1v with the additional diagonal-alignment of the elongated vughs/vesicles and increased intrapedal porosity. High silt and sand content and lower clay content, calcitic, crystallitic b-fabric, and iron-rich clay laminations/intercalations/slaking crusts. Inclusion of anthropogenic materials such as bone fragments. A2MM9B, A2MM10C, A2MM11A, A2MM12C, A2MM15B, A3MM3A, A6MM1C, A9MM2D, M1/A4SMM1A, M1/A4SMM3A ‘Vesicular crusts’, indicative of semi-plastic sediment, are formed via two possibilities: liquefaction and movement due to (1) sediment gravity processes (natural mass flows) or (2) human actions (by hand, implement, or foot). If related to human action, 1d may indicate a beaten earth surface/ceiling or constructional support.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1o</td>
<td>MF1 with increased charred organic material.</td>
<td>A5EMM1D</td>
<td>The occurrence of charred organic material with the simultaneous occurrences of waterlain sediments (MF4) might support an association of burning events and alluvial events.</td>
<td></td>
</tr>
<tr>
<td>MF2</td>
<td>Fine-grained, close porphyric c/f10µm-related of moderately to well-sorted silt, sand, and clay, (80/20); much higher proportion of silt-size grains (70%) compared to the higher proportions of v.f.s.-f.s.-size grains in MF1; very low intrapedal porosity of 5-10%; greater crystallic birefringence of the matrix compared to that of MF1.</td>
<td>A3MM4A, A3MM5B, A3MM5C A5EMM1D, A6MM1A, A6MM1C, A6MM2A, A6MM2B, A6MM2C, M1/A4SMM1C, M1/A4SMM3A</td>
<td>Silty components may be aeolian materials transported into the site then possibly settled into dense areas when surfaces were exposed/able to be permeated.</td>
<td></td>
</tr>
<tr>
<td>MF3</td>
<td>Poorly to moderately-sorted chito-gerfuric c/f10µm - related distribution of sub-angular to sub-rounded grains, which appear in larger grain sizes (c.s.-size and larger) than those of the surrounding MF1 groundmass, and with minimal silt-size grains. Dusty clay bridges may connect the coarser grains.</td>
<td>A2MM7B, A2MM7C, A2MM8A, A2MM8B, A9NM2A, A2MM13A, A2MM13B, A2MM14A, A2MM14B, A2MM15A, A2MM15B, A2MM15C, A2MM16A, A3MM3B, A3MM3C, A3MM4A, A3MM5A, A3MM5B, M1/A4SMM1B, M1/A4SMM2, M1/A4SMM3B</td>
<td>It is possible that this may be related to the pebbly layer noted to be ‘nerochoma’ during excavations. However, the dusty clay bridges that characterize this chito-gerfuric microfabric (MF3), and the sub-angular to rounded grains which demonstrate larger sizes than those of the surrounding matrix, suggest that this layer may have been deposited via a debris/overland flow event.</td>
<td></td>
</tr>
<tr>
<td>3r</td>
<td>Poorly to moderately-sorted chito-gerfuric c/f10µm - related distribution of sub-rounded to rounded grains (more rounded than that of standard MF3), which appear in larger grain sizes (c.s.-size and larger) than those of the surrounding MF1 groundmass, and with minimal silt-size grains. Dusty clay bridges may</td>
<td>A2MM9B, A2MM10A, A2MM10B, A2MM11A, A2MM11B, A2MM11C, A2MM12A, A2MM12B, A2MM13A, A2MM14B, A2MM14C, A2MM15A, A2MM16C, A3MM4B, A3MM4C, A3MM5A</td>
<td>Possibly related to overland flow events, but may also be alluvial in origin, attributable to increased weathering (rounding) of grains.</td>
<td></td>
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</tbody>
</table>
connect the coarser grains. Often mixed with MF1v.

| MF4 | Well-sorted chito-gefuric/chito-gefuric-monic c/f10µm related distribution of about 95/5-90/10, of predominantly v.f.s.- and silt-size grains and silt. Sorting exhibits graded bedding (fining upwards), and multiple episodes of beddings may be present. | A2MM3A, A3MM1A, A3MM1C, A5EMM1A, A5EMM1C, A5EMM1D, A5EMM2A, A5EMM2B, A5EMM2C, A6MM1C, A3MM1A | Water-lain graded bedding, indicative of multiple wetting and drying events. These episodes of water saturation occurring simultaneously with, or preceding, colluvial depositions, suggest that they occur during phases of abandonment/no disturbance. |
| 4b | Well-sorted chito-gefuric/chito-gefuric-monic c/f10µm related distribution of about 90/10-80/20, of predominantly v.f.s.- and silt-size grains and silt. No grading/bedding visible. All subrounded to rounded grains; appeared to be very weathered, exhibiting roundedness similar to beach sand grains, but may be aeolian. Not graded like MF4. | A2MM9C, A2MM10A, A2MM11C, A2MM12A, A2MM13C, A2MM14B, A2MM14C, A2MM15A, A2MM15C, A2MM16A, A2MM16C | Deriving from a pre-existing deposition of weathered sands, either from water-rounding or aeolian-rounding. (Possibly an incision into a paleo beach ridge uphill from the site that was subject to incision in MM and channel bank processes incorporated ceramics). |
| 4d | MF4 (+subtype) with the additional diagonal-alignment of the elongated vughs/vesicles and increased intrapedal porosity. Also, planar voids apparent parallel to direction of elongated vughs/vesicles. | A2MM15B | Vesicular elongated microstructure may result from liquefaction due to natural sediment gravity processes (e.g., hyperconcentrated flows, debris flows, or mudflows) or human actions (e.g., a dense mud slurry for the preparation of a floor, a mud brick, or similar construction materials). |
| MF5 | Well-sorted, porphyric, dense distribution with high proportion silt-size grains; cracky/crumby microstructure with long planner voids, high proportion of micritic calcite mixed with clay; possible hematite inclusions; reverse graded bedding below microfabric. | M4MM1 | DEGRADED MUD BRICK (or other earthen construction material); planar voids may suggest shrinkage; micritic calcite may indicate mixing with ash or lime plaster; fine material and reverse graded bedding beneath indicative of mud brick degradation; hematite a possible indication of mud brick burning (oxidation). |
| MF6 | Dense porphyric groundmass with long planar voids, cross-striated b-fabric, and increased fine component c/f10µm-related distribution (40/60): accumulation of silt-size (dust) grains) The fine components may be dust being trampled into the street surface. | M4MM2 | NEOPALATIAL (TRAMPLED) STREET. Long planar voids, cross-striated b-fabric, increased fine (dust) components are indicative of beaten floors/trampling. Location of sample outside building supports this interpretation. |
5 Chapter 5: Results of (urban) micromorphology at Palaikastro

Premise: As discussed in Chapter 2, archaeological soil micromorphology is capable of identifying different occupational activities and transitional phases in settlements or urban contexts. Furthermore, micromorphology can act as a filter for environmental information and can provide information on local urban-rural connections. It is an additional challenge, however, to then use these micromorphological data on buildings and urban-rural connections to access human behaviour across urban centres, at the meso-scale level, and to connect these local sets of observations to broader sociopolitical and environmental trends.

The following chapter discusses how the identification of the Palaikastro ‘urban’ microfabrics and depositional features helps us understand meso-scale processes pertinent to East Crete. By relating microfabrics and depositional features to occupation activities, transitional phases, and local urban-rural (socio-natural) connections, one can connect the sampled contexts of the new excavation areas (from Chapter 4) with other on-site and off-site data, regional data, and data from the wider Bronze Age Aegean and Mediterranean.

5.1 Occupational and Transitional Phases

As discussed in Chapter 2, natural and anthropogenic agencies during occupational and transitional phases leave behind traces that are preserved in the archaeological record. Depositional and post-depositional processes occurring after occupation phases, however, may confound evidence of these activities. Rather than attempting to connect material finds, which may be displaced from their contexts of actual use, to social behaviours, connections could be identified in the “formation processes that occur before, during, and after the use, abandonment,

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495 e.g., Karkanas and Efstratiou 2009; Karkanas and van de Moortel 2014.
496 Davies and M'Mbogori 2013.
498 Schiffer 1987; Christakis 2011.
and possible reuse of the dwelling.”

Thin section micromorphology can inform us of these processes and, therefore, allow us to assess occupation activities and social behaviours.

It has generally been observed that population decline and the abandonment of buildings coincide with extreme natural events. At Near Eastern archaeological sites, researchers have associated “extensive thin water-laid crusts in courtyards prior to deliberate infilling of two monumental buildings, a sequence of wind and water-laid deposits associated with collapsed rubble in a lane,” and “extensive windblown medium and coarse sand infilled buildings and streets to depths of more than one metre” as periods of abandonment. The water-lain graded bedding, silty sandy laminations, and aeolian/beach sediments found in select contexts at the Palaikastro site have also been interpreted (in Chapter 4) as periods of site surface stability or abandonment of particular urban areas; however, these manifestations should not necessarily be interpreted as phases of complete site abandonment. Rather, these ‘natural’ features may correspond to periods of rural activity (e.g., slope and terrace maintenance), despite possible areas of urban abandonment, since indications of surface stability suggest that debris flows during these phases were not disturbing the urban surfaces.

In contrast, the effects of “anthropogenic agencies and processes of deposition” can be observed through the analysis of floors and surfaces, which serve as direct evidence for occupation or construction. Micromorphological analysis of floor contexts or surfaces and the stratum below floors can provide information on actual activities performed on/processes affecting floor surfaces. These activities and processes may be subsequently compared and potential social connections may be hypothesized. While varying types of floors and surfaces

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499 Christakis 2011: 213.
501 These findings were identified at Tell Brak (late third millennium BC), and have been suggested to correspond to a phase of “environmental stress or instability” (Matthews et al. 1997: 288.).
502 These observations were made on samples from Saar in Bahrain (c. 1800 BC) following the final phase of occupation (Matthews et al. 1997: 289).
504 Matthews et al. 1997; Goldberg and Berna 2010; Banerjea et al. 2015.
have been identified from Bronze Age Cretan settlement sites and associated with particular architectural features, these types have not been studied thus far via thin section analyses, nor have they been connected with particular types of activities. Furthermore, in-depth studies of floors from Minoan sites (excluding research at Sissi and a recent micromorphological study on tholos tomb layers) have only been made in relation to paved, plaster, and stone-based floors; packed and earthen floors have not been studied in detail.

The 2013 and 2014 thin sections from the building contexts studied in this dissertation primarily contain the sediments located above floors, and, therefore, are potentially indicative of periods of inactivity (debris accumulation after use), not activity; floors actively being used would not have accumulated sediment. The identification alone of purposefully-made earthen floors has been challenging during excavations, as sediment from subsequent depositional processes may macroscopically appear similar to such floors. Still, since as noted by Christakis, interpretations of social behaviours should be based on processes that occurred surrounding occupational evidence, the present micromorphological study can supply some information on these processes of transformation. It is not currently clear whether occupational and social changes in the new area of excavations were due to natural degradation, colluviation or mass movements of earth, earthquakes, anthropogenic-related destruction, or a combination of factors. The possible catalysts will need to be re-assessed with the future study of the 2015 thin sections.

505 Shaw (2009: 148-155) identifies the varied types of floors and surfaces that have been found at Minoan sites. These include packed, earthen or clay floors, some “with the addition of small stones, pebbles, pottery or seashell fragments to increase durability,” white earth floors, red earth floors, terazza floors, plaster floors, and slab pavements (paved floors).

506 Carpentier (2012) conducted a micromorphological study of contexts from Sissi, although floors were not an area of focus.

507 Boness and Goren (2017) micromorphologically analyzed layers of sediments from an EM/MM tholos tomb from Koumasa.

508 Shaw (2009) does not consider (in publication) earthen floors as a comparable floor type but focuses on stone, plaster, and pebble floors (non-earth floors).

509 This reasoning, that a lack of pottery accumulation signals phases of use or occupation, is already realized by Knappett and Cunningham 2013: 187.

510 Christakis 2011: 213.
As only a few thin sections in this dissertation relate to possible floor surfaces and the stratigraphy below these surfaces, it is only possible to make suggestions (via micromorphology) at this point as to the actual use of rooms and other spaces in Buildings AP1, AM1, and MP1. On-site artifactual and architectural evidence may lend more information, in this case, to the uses of rooms and spaces. Nevertheless, the thin sections provide much more detailed evidence on processes affecting the site than can be understood via excavations alone.

The re-evaluation of occupation floors and surfaces via micro-scale analyses would likely enable the more accurate identification of floor and surface types\textsuperscript{511}, and provide further information on activities and processes affecting floor surfaces. For example, at Phaistos, (albeit Neolithic) beaten earth floors are noted to have been prepared on ‘pure clay’\textsuperscript{512}; whether this is indeed pure clay can be confirmed through thin section analysis. (To date, all clay laminations in the Palaikastro thin sections consist of ‘impure clay’ and silty clay). Comparing floor and surface features, such as these clay features, on an intra- and inter-site basis would be valuable to study trends in occupation activities and related processes.

5.1.1 Cross-phase trends

At Palaikastro, it is apparent that there are commonalities in archaeological evidence for occupational phases, mainly based on floors and surfaces, and for transitional phases, mainly based on an increased accumulation of debris. Micromorphologically, microfabric types and subtypes (at Palaikastro) may reflect these phases, regardless of the inclusion of archaeological materials. While it is presently not possible, from thin section micromorphology alone, to determine the causes (anthropogenic or natural) for particular phase transformations, the identification of these phases micromorphologically can assist in determining the extent to which landscape transformations affected the urban site during particular phases. Subsequently, this evidence may be used to test hypotheses that human-induced and environmentally-induced landscape transformations affected settlement sites.

\textsuperscript{511} Cf. LaMotta and Schiffer 1999; Milek 2012.

\textsuperscript{512} Di Tonto 2011:16.
By comparing the microfabric types and subtypes, trends may be observed in roundedness and sphericity of the coarse grains (suggesting trends in sediment origin) and in the degree of sorting of the coarse grains (suggesting different depositional processes or rates of deposition) (Tables 5.1, 5.2).

Table 5.1. Trends in rates of deposition among microfabric types and subtypes (*indicates that microfabric type/subtype may be related to either rapid and/or slow depositional and post-depositional processes).

<table>
<thead>
<tr>
<th>Microfabric type/subtype*</th>
<th>Rate of deposition (determined by degree of sorting, microstructure)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MF1, MF1a, MF1c, MF1d*,</td>
<td>Rapid (dominantly poorly-sorted sediments; vughy/vesicular microstructure may have formed through debris flow processes)</td>
</tr>
<tr>
<td>MF1o, MF1v, MF3, MF3r,</td>
<td></td>
</tr>
<tr>
<td>MF4d*</td>
<td></td>
</tr>
<tr>
<td>MF2, MF1d*, MF4, MF4d*</td>
<td>Gradual (dominantly moderately- to well-sorted sediments; increased content of silty components possibly indicative of aeolian derivation)</td>
</tr>
</tbody>
</table>

Microfabrics MF1 (all subtypes, except possibly MF1d), MF3, MF3r, and possibly MF4d may be indicative of phases of rapid deposition of sediments. As noted in Chapter 4, the chaotic, poorly-sorted nature and vughy/vesicular microstructure of the sediments suggests that they were deposited by debris flows, overland flows, slope processes, or alluvial processes. Triggered by gravity, debris flows travel down slopes when disturbed and saturated by water. Therefore, it is possible that such water-saturated debris would form vughs/vesicles post-flow and that these vughs/vesicles could be horizontally aligned, as seen in the MF4d and MF1d microfabric types.

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513 Boggs 2006: 46-47.
514 Iverson 1997: 245.
515 Iverson 1997.
Sediment gravity flows, including debris flows and overland flows, may result in rapid accumulations of larger quantities of coarse sediment.\textsuperscript{516} Such large accumulations would fit with those observed across the site, particularly in Trenches A2 and A3. It is notable that debris flows exhibit features similar to floods in that they “are fluid enough to travel long distances in channels with modest slopes and to inundate vast areas.”\textsuperscript{517} Furthermore, “[l]arge debris flows can exceed $10^9$ m$^3$ in volume and release more than $10^{16}$ J of potential energy, but even commonplace flows of $\sim 10^3$ m$^3$ can denude vegetation, clog drainageways, damage structures, and endanger humans.”\textsuperscript{518} While it is not possible to calculate the exact quantity of sediment nor the force with which the possible debris flows were deposited across the new excavation areas (due to the unknown nature of subsequent sediment truncation), such forces could have caused the collapse of site structures.

For example, the depositional state of the collapsed stone slabs in Building AM1, associated with LM IB levels, the “smashed pithoi” in Rooms 6 and 14, and the collapse of Wall 15, could have been caused by significant debris flow events which may have resulted in the collapse of the structures.\textsuperscript{519} Such a debris flow would not necessarily have been triggered by an earthquake; a heavy rainfall would have been sufficient. In arid and semi-arid regions, subaerial debris flows are frequent, and are regularly triggered by substantial rainfalls (or rainfall during droughts).\textsuperscript{520} If a period of drought or aridification was occurring during the LM IB occupation, which has been suggested based on the LM IB wells in Block M,\textsuperscript{521} it is feasible that debris flows after rainfalls contributed to issues in maintaining the structures and open spaces.

\textsuperscript{516} Boggs 2006: 37.
\textsuperscript{517} Iverson 1997: 246.
\textsuperscript{518} Ibid.
\textsuperscript{519} PALAP BSA Report 2015: 33.
\textsuperscript{520} Boggs 2006: 45.
\textsuperscript{521} MacGillivray et al. (2007: 224) note that both possible aridification (cf. Moody 2005) and post-Theran ash fall (Driessen and Macdonald 1997) may have contributed a ‘prolonged period of uncertainty’, during which the LM IB wells were constructed.
In contrast, microfabrics MF2, MF4, and possibly MF1d and MF4d, may indicate periods with more gradual accumulation of sediment, and perhaps more stable slope conditions. As noted in Chapter 4, sorting features, such as graded bedding, may be formed (on exposed surfaces) when a surface is saturated but then undergoes sudden drying. Additionally discussed were the silty clay laminations associated with MF4, which suggest slow water action rather than the rapid deposition seen in debris flows (see Section 4.3.1.1). Phases of gradual accumulation may also be indicated by the mineral components of the MF2 groundmass, which include a high proportion of silt, about 70%, as well as low intrapedal porosity (~5-10%); these silty components may be aeolian materials that settled into dense areas when surfaces were exposed and able to be permeated.

Microfabrics MF1d and MF4d, discussed above in regards to their possible association with debris flows, may alternatively be reflective of other, more gradual sediment accumulation processes. The horizontally-aligned, vesicular microstructures of these microfabric types are features of semi-plastic sediment, which may result from directional pressure caused by human action or natural mass flows. The particular context of microfabric MF1d is possibly indicative of anthropogenic packing formed during the LM IB occupation of an upper floor phase of Building AM1. The 2015 sections (to be studied) will hopefully clarify this feature.

It is significant that these microfabric types (MF2, MF4, and possibly MF1d and MF4d), which demonstrate sorting, bedding, or laminations indicative of gradual accumulations, occur across site contexts, but are best preserved in association with the bottom of Postpalatial (LM III), Neopalatial (MM III-LM I), and Protopalatial levels of sediment accumulation. Also corresponding to these bottom levels of Post-palatial (LM III), Neopalatial (MM III-LM I), and Protopalatial sediment accumulation are weathered (aeolian, beach, or river type) sediments, typical of MF3r and MF4b (Table 5.2).

522 Courty et al. 1989; Miller and Goldberg 2009: 79.
523 Kühn et al. 2010: 381-382.
Table 5.2. Trends in degree of roundedness and sphericity of coarse grains of microfabric types and subtypes, possibly indicating different grain origins.

<table>
<thead>
<tr>
<th>Microfabric type/subtype*</th>
<th>Origin (determined by degree of roundedness and sphericity of coarse grains)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MF1, MF1a, MF1c, MF1o, MF1v, MF2, MF3, MF4, MF4d</td>
<td>Alluvial/slope (sub-angular to angular grains)</td>
</tr>
<tr>
<td>MF3r, MF4b</td>
<td>Aeolian/beach/river (sub-rounded to rounded grains)</td>
</tr>
</tbody>
</table>

Microfabric types MF3r and MF4b may indicate sediment input via coastal, river, or aeolian processes, rather than slope processes, due to the degree of roundedness (sub-rounded and rounded) and sphericity (smooth) of their coarse grains. The characteristics of the coarse grains appear to be similar to those from the river or beach sand contexts (or may alternatively be aeolian), in contrast to the generally sub-angular to sub-rounded coarse grains found in the red ‘Kastri’ alluvial materials. Furthermore, the presence of glauconite in microfabric type MF4b suggests derivation from a marine environment. Since these microfabric types, as well as types MF2, MF4, and possibly MF1d/MF4d, are found immediately under debris sequences (i.e. generally at the bottom of larger ceramic/debris sequences), it is possible that periods of gradual accumulation (and more stable slope conditions) coincided with active use of the site area or initial abandonment and that periods of rapid sediment accumulation (slope instability) coincided with gaps in active occupation or prolonged abandonment.

This potential correlation between occupation of the site area and slope stability may be significant when considering socio-natural connections between the urban site and the local site landscape. However, any correlations are difficult to evaluate with complete accuracy because the exact dates of the depositional layers across the site are unknown; sediment containing

526 Aeolian sediments can also be later redistributed by water flow processes.

ceramics from particular phases may have been deposited during or after that particular phase. For example, accumulations of sediment containing LM III ceramics may have occurred at any point during or after LM III occupation of the site area. Therefore, causal factors for increases in sedimentation rates cannot be attributed to specific processes, particularly as both environmental (heavy rains or earthquakes) and anthropogenic (vegetation denudation or lack of terrace maintenance) factors could contribute to debris flows. The following sections will consider additional factors that could have influenced the sedimentation rates and sediment sources seen in the new excavation areas.
Figure 5.1. Trench A2.
Figure 5.2. Trench A3.
5.1.2 Protopalatial (MM I - II)

As the micromorphological thin sections in this dissertation have only been associated with major architectural features that relate to Postpalatial and Neopalatial contexts, the sole micromorphological evidence from the Protopalatial occupation of the new area of excavations comes from the thin sections associated with ceramic fragments in Trenches A2 and A3 (see Section 4.2.2) and Exterior Space 10 (Context 10.2) (see Section 4.3.3.2). At other Bronze Age Cretan sites, Protopalatial occupation floors and surfaces have been noted (macroscopically), but some floor and surface identifications have recently been reinterpreted as fill contexts rather than floors or surfaces.\(^{528}\) In the recent excavation at Palaikastro, tests in Building AM1 demonstrated that beneath a “thick burnt clay floor” of LM IB construction was another “very hard and compact floor packing” or “packing/levelling fill” (in Room 3, this was related to units #1153 and #1157; in Room 4, this was related to unit #1135).\(^{529}\)

In Block M at Palaikastro, occupation evidence in EM III to MM IIA consisted of scattered walls and floors, with a ‘town-wide’ episode of construction (Phase 1) taking place after MM IIA.\(^{530}\) Floors during Phase 1 in Block M were noted to be “well-beaten yellowish clay,” with “reddish orange plaster floors” being associated with MM IB and MM II.\(^{531}\) A “very fine floor, of a hard orange plaster” has been associated with MM IIA contexts.\(^{532}\) Understanding additional trends in the development of floor construction practices has been noted as an area requiring further examples for study.\(^{533}\) At some point following MM IIA but before MM IIIB (bridging Protopalatial and Neopalatial), another construction phase (Phase 2) was identified in Block M, and it was noted that Palaikastro took on its ‘urban character’ during

\(^{528}\) In the analysis of MM IB houses at Phaistos, surfaces of beaten earth were noted, but then not considered as actual floors, and interpretations were later critiqued to instead have been “fills composed of MM IB ceramics mixed with Prepalatial and late MM IB/early MM II material” (Caloi 2011: 74-75).

\(^{529}\) PALAP BSA Report 2015: 42, 46.

\(^{530}\) Knappett and Cunningham 2012: 82.

\(^{531}\) Ibid.

\(^{532}\) Ibid.

\(^{533}\) Ibid.
this phase.  Floors in this phase were noted to include a “mosaiko paving of red schist with fine white plaster interstices,” “red and green schist ‘crazy paving’, ” sideropetra slab paving, hard beaten earth, and white plaster floors. Other Protopalatial sites, such as MM IB Galatas, have exhibited fine plaster and slab-lined floors.

As indicated above, no Protopalatial-related contexts are associated with the 2013 and 2014 thin sections, except for those in Trenches A2 and A3 and Exterior Space 10, north of Building MP1. Within these sections associated with Protopalatial ceramics fragments, no readily-made surfaces or packings were visible, but indications of exposed (un-used) surfaces were evidenced through silty sandy laminations in Trenches A2 and A3 and via a possibly compacted area of sediment (used space?) in Exterior Space 10 (see Sections 4.2.1.4, 4.2.2.2, and 4.3.3.2). The presence of MM I and MM II ceramics in Trenches A2 and A3 in context with silty sandy laminations, could indicate that there was a period of some slope stability during Protopalatial use of the general site area. In general, the microfabric types in the sections associated with Protopalatial ceramics in Trenches A2, A3, and Exterior Space 10 were likely deposited via colluvial and alluvial processes, rather than anthropogenic ones, possibly incorporating both slope and river, beach, or aeolian sediments. These findings suggest that both slope processes and coastal flooding potentially impacted the new area of excavations during or after the Protopalatial period.

5.1.3 Protopalatial to Neopalatial (MM III)

The transition to the Neopalatial period is typically associated with MM IIIA, but the processes that led to the shift in material (and social) practices identified as Neopalatial are unknown. MM III and its sub-phases have been given varying degrees of attention since Evans’ original labeling of these sub-phases. MM IIIA and MM IIIB phases have not been studied

534 Ibid.
535 Ibid.: 85.
536 Christakis and Rethemiotakis 2011: 178.
537 Macdonald and Knappett 2013: 1.
consistently, and have sometimes been grouped together as MM III/LM IA\textsuperscript{538}, despite MM IIIA being viewed by Evans as a key transitional period from Protopalatial to Neopalatial\textsuperscript{539}. Macdonald and Knappett note that there was not a “standard response in MM III to Protopalatial destructions” (at the end of MM IIB),\textsuperscript{540} individual sites demonstrated different types of transformations. Meanwhile, Cadogan suggests that east-central Cretan sites generally demonstrate: “a (localized) period of abandonment or disuse after the MM IIB destructions.”\textsuperscript{541} Macdonald and Knappett further question whether MM III should be split between Palatial periods, termed an \textit{intermezzo}, or an \textit{Act} (a phase in its own right).\textsuperscript{542} The authors note areas and types of artifacts that may be used to help evaluate this period and these changes,\textsuperscript{543} but do not mention micro-scale geoarchaeological studies, which can (as discussed in Chapter 2) contribute information on transitional processes.

In contrast to demonstrating a phase of abandonment and disuse, evidence for reconstruction in MM III exists at Palaikastro, in Block M. Moreover, at Palaikastro, there is no evidence for any significant MM IIB destructions.\textsuperscript{544} In Room 8 of the SE Building, there is a gradual accumulation of silt (depositional), suggesting that gradual accumulation occurred in the post-MM IIIA period, and possibly indicating continued slope stability or maintenance in the Neopalatial period.\textsuperscript{545} In another room in the SE Building of Block M, Room 6, there is evidence of waterborne layers above a potential MM IIIA surface: 2-4 cm of sand with fine gravel (nerochoma).\textsuperscript{546} While the architectural layout of Block M, with a large street and semi-

\textsuperscript{538} For example, in Driessen and Macdonald 1997.
\textsuperscript{539} Macdonald and Knappett 2013: 1.
\textsuperscript{540} Ibid.: 2.
\textsuperscript{541} Cadogan 2013: 180.
\textsuperscript{542} Macdonald and Knappett 2013: 2.
\textsuperscript{543} Ibid.: 3.
\textsuperscript{544} Knappett and Cunningham 2013: 183.
\textsuperscript{545} Knappett and Cunningham 2012: 22-25.
\textsuperscript{546} Ibid.: 20.
basement rooms around its course, is significantly different than that of the new area of excavations, such accumulations may be interpreted as periods of abandonment. Regardless of the reason for this type of sedimentation in Room 6, the presence of potentially waterborne materials relates to slow accumulation processes, in contrast to rapid debris flow processes, and may be related to the slow accumulation processes noted in the Neopalatial levels in Trenches A2 and A3. Also in Block M, the main phase of use in the NW Building has been noted to be during MM III, while more specifically, MM IIIA and LM IA construction is apparent in the SW Building.

Researchers have pointed to the absence of MM IIIB materials from Block M as indicative of the “continuous nature of occupation [from MM IIA] through MM IIB and MM IIIA.” While a ‘snapshot’ of the MM IIB occupation is lacking, the fact that MM IIIB destruction layers (attributed to seismic destruction in the SE Building) are found above MM IIIA layers does not necessarily point to continuity; such ‘absences’ may point to repeated re-use, which allowed accumulation of materials in stratigraphic sequence.

The thin section evidence from this phase is currently limited at Palaikastro, particularly as is it based on only the 2013 and 2014 samples. However, if the debris accumulations discovered between the major accumulations of Protopalatial and Neopalatial ceramics in Trenches A2 and A3 are indicative of this transitional phase, then they may correspond to (1) slope stability, or (2) an increased input of finer, coastal sediments (possibly wind-transported), or both (see Section 5.2). These two processes are significant when considering how the newly excavated site area may have been used during the Protopalatial to Neopalatial transition. The processes may indicate that the transition between these two phases was a smoother transition in which slope stability prevented significant debris flows; this could indicate the continuation of

547 Ibid.: 60.
549 Knappett and Cunningham 2013: 185.
550 Ibid.: 194.
slope or terrace maintenance practices.\textsuperscript{551} The fact that Building MP1 may have been constructed in the LM IA period, partly between the slopes of Petsophas and Building AM1, could have prevented additional slope sediments from covering earlier landscape surfaces.

5.1.4 Neopalatial (MM III - LM IA) and LM IB

In contexts associated with Neopalatial architecture and ceramics in the new areas of excavation, floors are comprised both of earth and stone slabs.\textsuperscript{552} Fragments of plaster and pebble floors were also found, but these were not \textit{in situ}.\textsuperscript{553} In Building AP1, in Room 6, the excavators noted that “plaster fragments (some painted) mixed with bits of terrazza and small stones” and “compact and clayish soil” suggested a fallen (plaster and terrazza) floor that had dropped from a second story onto a clay, ground-level floor.\textsuperscript{554} Excavations in Room 7 in Building AP1 also uncovered a possible Neopalatial, prepared earthen surface, lying underneath an LM III pebble floor; however, this material may equally have been Neopalatial debris from a collapsed upper story.\textsuperscript{555}

Building MP1 appears to have been constructed and used only during the LM IA period.\textsuperscript{556} Surfaces in and surrounding this structure are composed of uneven, stone- and earthen floors, such as those in Spaces 1, 2, and 4.\textsuperscript{557} There may have been multiple Neopalatial surfaces constructed (which, as noted below, are observed at other Neopalatial sites); this is

\textsuperscript{551} Different grades of slope instability could also result in these various depositional processes. Overland flow, if persistent, could indicate disruption of the vegetation and the initial stages of slope instability.

\textsuperscript{552} PALAP BSA Report 2015.

\textsuperscript{553} Ibid.

\textsuperscript{554} (Unit #1151) PALAP BSA Report 2015: 19.

\textsuperscript{555} PALAP BSA Report 2015: 21.

\textsuperscript{556} Ibid.: 68.

\textsuperscript{557} Ibid.: 69, 72, 76.
suggested by a possible ephemeral or thin floor in Space 4 (between units #7113 and #7115).\footnote{558Ibid.: 76.}
Due to the less robust architecture of Building MP1, in comparison to Buildings AP1 and AM1, it is unlikely that there was an upper story to Building MP1. The surface of small, rounded pebbles and compact sediment (in units #7125 and #7124) that was found lying across Wall 75, in both Spaces 3 and 6,\footnote{559Ibid.: 73-75.} may have been from the roofing construction or transported from another site area.

In Building AM1, in Room 3, a paved Neopalatial floor (unit #1124) was observed beneath a possible clay upper-floor deposit, which was poorly preserved.\footnote{560Ibid.: 37-38.} This second Neopalatial surface consisted of a “yellowish red clay floor” (units #1114 and #1120).\footnote{561Ibid.: 38.} Room 4 in Building AM1 exhibited a different type of floor, which consisted of “very small stones and pebbles” as well as terrazza fragments along Wall 29.\footnote{562Ibid.: 44.} A potential second Neopalatial floor was also noted to consist of “a hard packed layer made of small pebbles and stones” (#1131) in the corner of Room 4 between walls 12 and 28.\footnote{563Ibid.: 46.} Earthen floors were observed in Rooms 8, 10 and 14 in Building AM1, with a single paving slab in the centre of Room 8, a couple of paving slabs in the centre of Room 10, and a few paving slabs in Room 14, as well as some small stones lining the edges of Room 14.\footnote{564Ibid.: 27, 31, 48.}

Comparing these macroscopic findings to those of other, earlier excavated areas, in Block M, some similarities may be (macroscopically) observed. In Block M, the types of floors constructed in the MM IIA and MM IIB periods may have continued to be used into the MM III periods.\footnote{565Knappett and Cunningham 2012: 85.} However, LM IA floors, designated as part of a new building phase (Phase 3), may...
have only consisted of earthen floors.\(^{566}\) (This observation of LM IA floors relates to the LM IB earthen floors common in Building AM1, although additional pebble and stone surfaces may suggest the incorporation of different sediments in the area). While Block M does not demonstrate evidence for any significant occupation in the LM IB period (Phase 4),\(^{567}\) two wells were cut through the remains of earlier structures in Block M during this period.\(^{568}\) Knappett and Cunningham have suggested that, in Block M, in the LM IA period (Phase 4), there may have been sporadic occupation, contemporaneous with new constructions in other areas of the site.\(^{569}\) The possible reasons behind the construction and subsequent abandonment of these wells have not been readily apparent through local evidence, although it has been suggested (without local proxy evidence) that aridification and Theran ash fall may have been contributing factors (see Section 5.2).\(^{570}\) Prior to the LM IB period, evidence of widespread flooding in Block M has been considered to have been related to the LM IA Theran eruption event\(^{571}\); LM IA flooded contexts with tephra have been macroscopically identified in Buildings MP1 and AP1, but have not yet been micromorphologically studied (see Section 5.1.4).

Well-construction is not noted for this phase at other Minoan sites,\(^{572}\) but multiple and varying types of Neopalatial floors have been observed. At Mochlos, four distinct floors have been observed in MM III, LM IA and LM IB contexts.\(^{573}\) In the Chalara quarter at Phaistos, a paved floor is noted for the MM IIIA period,\(^{574}\) and paved and plaster floors are noted in the

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\(^{566}\) Ibid.: 87-89.
\(^{567}\) Ibid.: 92.
\(^{568}\) Ibid.: 45; MacGillivray et al. 2007: 223.
\(^{569}\) Knappett and Cunningham 2012: 92.
\(^{570}\) MacGillivray et al. 2007: 223-224.
\(^{571}\) Knappett and Cunningham 2012: 89.
\(^{572}\) MacGillivray et al. 2007: 1.
\(^{573}\) Brogan and Barnard 2011: 192.
\(^{574}\) Girella 2011: 91.
MM III Palace. At Malia, the Neopalatial building ΔβIII was connected to an open paved space and included a paved stone entrance and terrazza floor in its vestibule. Other Neopalatial surfaces at Malia consisted of earthen floors, a “single layer of plaster and small sea pebbles,” plastered floors with stone slabs, and plastered floors with “small- and medium-size stones fitted tightly together.” At Karoumes, “the top surface of the substratum” may have served as LM IA floors. MM IIIIB to LM IA/IB floors at Prophitis Ilias, Praisos, consisted of leveled bedrock or slab or cobble pavements.

At Palaikastro, LM IA floors and surfaces have also been associated with deposits of Theran tephra. Although related to events in the LM IA period, the presence of Theran tephra is not necessarily indicative of direct occupation activities; rather, the accumulation of tephra in particular areas may indicate dis-use or abandonment. Tephra was found in the new area of excavations in Buildings AP1 and MP1 during the 2015 excavations; these sections have yet to be analyzed micromorphologically. The fact that there are no tephra layers in the Neopalatial contexts in Trenches A2 and A3 indicates that different processes likely impacted the areas of the site that lacked architecture. Furthermore, the fact that, among the structures in Block M, there is evidence of clear stratification of MM IIIA and MM IIIB and, in the new area of excavations, clear stratification of LM IA and LM IB layers but, in the gully, the MM III layers are jumbled with LM IA (and perhaps LM IB), suggests either that the filling of this gully took place after the end of the Neopalatial period, or that the site contexts were undergoing different post-depositional processes.

575 Ibid.: 93.
578 Mavroudi 2011: 122.
579 Vokotopoulos 2011: 141.
580 Mantzourani and Vavouranakis 2011: 129.
581 Preliminary analyses of the 2015 thin section samples confirms that the ash found in the Neopalatial contexts in the new area of excavations is indeed tephra comparable to the 2003 tephra samples.
The thin sections originating in and around Building AM1 and Trenches A2 and A3 can help connect the Neopalatial contexts of the new area of excavations with those of the earlier excavations, and potentially with Neopalatial evidence from other sites. Two thin sections from Exterior Space 9 (M4MM1 and M4MM2), which contain two microfabric types, MF5 and MF6, demonstrate aspects of active Neopalatial occupation. MF5 is representative of mud brick or some similar earthen construction material, and examination of the thin section additionally reveal that this material degraded or collapsed directly onto MF6. MF5 also indicates that different construction methods and materials were possibly employed in this structure, Building MP1, as compared to the other two buildings, AP1 and AM1. MF6 is representative of street packing or trampling, and serves as a prototype for identifying other packed street surfaces on the site. It incorporates an increase in silt-size particles, likely tracked in, as well as cross-striated b-fabrics, perhaps related to soil formation process (e.g. vertic soils).

Thin sections from Building AM1, Room 4 and Room 12, provide further evidence on the use of this structure, even though they do not include an in situ LM IB floor. Section A6MM1A in Room 4 contains plaster with rounded pebbles, which can be identified as Neopalatial terrazza, “a particularly hard, durable mixture of lime and small rounded beach pebbles of uniform size.”\textsuperscript{582} Terrazza is typical of Neopalatial floor architecture, and has been found in various rooms and spaces at Minoan sites, including possibly in upper floor rooms.\textsuperscript{583} At both Archanes and Zakros, for instance, it is thought to have been used to pave floors of upper-story rooms.\textsuperscript{584} At Zakros, the presence of terrazza in “high positions in the fill” was determined by researchers to suggest that the terrazza might have fallen from an upper level.\textsuperscript{585} This could mean that the terrazza (plaster and pebbles) found in section A6MM1A of Building AM1 at Palaikastro came from an upper floor collapse of the LM IB structure, rather than from subsequent LM III occupation.

\textsuperscript{582} Shaw 2009: 149.
\textsuperscript{583} Ibid.
\textsuperscript{584} Ibid.: 149-150.
\textsuperscript{585} Ibid.: 150.
Furthermore, the matrix surrounding the _terrazza_ has a well-developed, cracky microstructure, in contrast to the vughy microstructure in the bottom of the section; this development may be the result of trampling on an upper floor surface, prior to collapse. The very small fragment of ash aggregate at the bottom of the section, as well as two conifer wood charcoal fragments, may, therefore, relate to the collapsed subfloor or floor joists beneath the _terrazza_ upper floor. In thin sections taken from Rooms 4 and 12, the presence of the MF1d microfabric, which exhibits the preservation of directional pressure, could possibly reflect the pressure of an upper story having fallen on water-saturated sediment below, or, alternatively, indicate some preservation of a fragmented earthen surface or beaten floor related to the fallen LM IB _terrazza_ floor.

The observation of a significant quantity of sediment (>28 cm in depth in Room 4) between the fragments of the potential LM IB upper floor and the LM IB ground floor suggests that sediment was transported into the room (and building) before the upper floor collapsed. The input of sediment could not have been caused by an earthquake alone. It is possible that a massive debris flow, perhaps initiated by a flooding event or earthquake, crashed into the LM IB structure, causing the deposition of sediment across the ground floor, prior to the collapse of the upper story above it. Modern case studies of debris flows, mud flows, and landslides demonstrate this type of structural collapse (Plates 5.1A-D).587

Such a massive event would likely have affected other areas of the settlement. Perhaps the large deposits in the bottom of the LM IB-constructed wells (Wells 605 and 576) in Block M could be interpreted as further evidence for a massive debris flow event. Additionally, the chaotic nature of the mixed Neopalatial (MM III to LM IB) ceramics and debris in Trenches A2 and A3 would be supportive of such a forceful event.

Recent research has demonstrated that multiple factors can trigger debris flows, such as rain and earthquakes (which may also trigger landslides), but “post-fire debris flows generally are triggered by one of two processes: surface erosion caused by rainfall runoff, and landsliding

586 Charcoal identified by Llorenç Picornell-Gelabert, pers. comm. 2016.
587 NOAA/NGDC 2016.
caused by infiltration of rainfall into the ground.”\footnote{USGS 2016.} It has been observed that “fires [anthropogenic or wild] commonly reduce the rate at which water can seep into the soil, which increases runoff and erosion,”\footnote{Ibid.} and “wildfires can also result in the destabilization of pre-existing deep-seated landslides over long time periods.”\footnote{Ibid.} Furthermore, “Post-fire landslide hazards include fast-moving, highly destructive debris flows that can occur in the years immediately after wildfires in response to high intensity rainfall events, and flows that are generated over longer time periods that are accompanied by root decay and loss of soil strength.”\footnote{Ibid.} Such debris flows can occur suddenly and “can exert great impulsive loads on objects in their paths, can strip vegetation, block drainage ways, damage structures, and endanger human life.”\footnote{Ibid.}

It should also be considered that, if the presence of the LM IB wells (used through the LMIIIA period) indicates a phase of aridification, perhaps weather/climatic events, such as droughts or fires, could have triggered such a massive debris flow. In the future, analyzing the terrace structures on Petsophas and the slopes above the site, as well as charcoal remains from the urban site, will be important in clarifying whether arid conditions, fires, and/or slope erosion were impacting factors in the LM IB occupation, and in the destruction of Building AM1.

\footnote{USGS 2016.} \footnote{Ibid.} \footnote{Ibid.} \footnote{Ibid.} \footnote{Ibid.}
Plate 5.1. Debris flow- “Boulders partially bury a house from a debris flow triggered by rapid snow melt in late May, 1983. The rapidly-moving debris flow emerged from a canyon and...destroyed or severely damaged five homes, and buried a highway” (NOAA/NGDC 2016, U.S. Geological Survey).

Plate 5.1B. Earth slump- “Recently reactivated slump/earthflow below Chalet Du Fer Leysin, Switzerland. The flow consists of colluvium on sloping bedrock. Area of older flow is marked by grassy area and young trees. Most recent flow covers road in foreground. Red soil shows extensive weathering” (NOAA/NGDC 2016, B. Bradley, University of Colorado).

Plate 5.1C. Mud flow- “This house was damaged by a mudflow along the Toutle River about 40 km west-northwest of Mount Saint Helens. The May 18, 1980, eruption of the volcano triggered lahars-volcanic debris flows-which, combined with mud, caused great damage in the region. Nine highway bridges, miles of highways, and many public and private buildings were destroyed. The mudflow height is recorded by mud coatings on tree trunks” (NOAA/NGDC 2016, D.R. Crandell, U.S.). Geological Survey).

Plate 5.1D. Landslide and debris flow -“La Conchita is a small seaside community along Highway 101, north of Santa Barbara. This landslide and debris flow occurred in the spring of 1995. Many people were evacuated because of the slide, and the nine houses nearest the slide were heavily damaged or completely destroyed. Fortunately, no one was killed or injured. Note the crescent-shaped scarp at the head of the slump” (NOAA/NGDC 2016, R.L. Schuster, U.S. Geological Survey).

Plate 5.1A-D. Photographs from NOAA/NGDC (2016) of contemporary mass sediment/soil movements. A: Debris flow; B: Earth slump; C: Mud flow; D: Landslide and debris flow.
5.1.5 Neopalatial to Postpalatial (LM IA/IB to LM II/III)

The end of the Neopalatial period occurred in the LM IB period, and has generally been considered as “a period of decline for Crete when palaces, towns, villas, and villages are destroyed in the 15th century BC… a huge watershed for the island.”\textsuperscript{594} On a Cretan-wide scale, Christakis states that much of what we see from LM IB are “pictures of destruction” and not actual activity.\textsuperscript{595} Most researchers have viewed the fires as indicative of “human action during a period of social and political instability or during raid or invasion.”\textsuperscript{596} Some researchers have supported the hypothesis that “fires [at the end of LM IB] followed a massive natural disaster, perhaps an earthquake and/or a volcanic eruption for others.”\textsuperscript{597} Events following the Theran eruption (which occurred in the LM IA period) have also been considered to have contributed (indirectly) to the end of the Neopalatial phase.\textsuperscript{598} The likelihood of multiple impacts of the Theran eruption, and the varied evidence across the island for LM IB activities, have recently led to LM IB events and sequences being reconsidered by researchers, and viewed as potentially having occurred in multiple phases.\textsuperscript{599}

Evidence for the LM IB destructions has been associated with deposits that may represent building collapse features. At Petras, an LM IB destruction has been associated with plaster, burned wood, and “many architectural fragments fallen from the upper floor.”\textsuperscript{600} An “extensive destruction horizon” has been observed at Zakros at the end of the LM IB period (Zakros V), but has largely been based on the identification of pottery types and fire destructions, rather than

\textsuperscript{594} Macdonald and Knappett 2013: 2.
\textsuperscript{595} Christakis 2011: 214.
\textsuperscript{596} Ibid.: 215.
\textsuperscript{597} Ibid.
\textsuperscript{598} This evidence is discussed by Driessen and Macdonald (1997), who clearly demonstrates that multiple factors may have changed after the Theran eruption event; no single event necessarily resulted in the end of the Neopalatial period.
\textsuperscript{600} Shaw 2015: 76.
actual occupation surfaces. The events that occurred in the transition from LM IB to LM II/LM IIIA1 are not clear at Zakros, but it has recently been suggested that there may have been two separate phases of destruction at the end of the LM IB period, as has been postulated at Mochlos and Pseira. At Mochlos, a short hiatus in site occupation occurred after an LM IB destruction event (or LM IB/LM II) and reoccupation in LM II/LM IIIA1, although the events that occurred during this hiatus, and the exact timing of the hiatus, lack significant evidence.

The events and processes that occurred between the Neopalatial (LM IA/IB) and Postpalatial (LM II/IIIA1) periods at Palaikastro are similarly unclear; apparent ‘transitional’ evidence is generally lacking. However, some evidence for two separate LM IB destructions at Palaikastro has been suggested through previous excavations. Both Building N and Building 5 may have endured two separate LM IB destructions, evidenced by changing architectural features and separate LM IB debris fills within the LM IB period. Nevertheless, Platon points out that these two possible, separate LM IB phases, both at Mochlos and at Palaikastro, could not be differentiated on the basis of stratigraphy.

In the previous excavations at Palaikastro, Buildings 2, 3, 4 and 5 were believed to have been constructed in the Neopalatial period (MM IIIB/ LM IA), and it was determined that the construction of Building 1 was started over LM IA fill layers. Fire destructions were noted for all of the structures at the end of LM IB, but separate destruction phases were not identified;

601 Brogan and Hallager 2011; Platon 2010a: 243-244.
607 Platon 2011: 610.
608 MacGillivray et al. 1988: 444-445; Cunningham (2007: 143, fn. 147) notes that the ‘deep fills’ below Building 1 contain LM IA materials that were laid in early LM IB, but that “there is also evidence that construction may have started already prior to the Theran eruption.”
all of the buildings were reoccupied during the LM II/LM III A1 periods, but no information on the transition between the LM IB destructions and LM II/IIIA1 reoccupation was offered. For Building 7, however, MacGillivray and colleagues suggest that, following its Neopalatial occupation, there was “immediate reoccupation of the building in the LM II period,” based on the “lack of floor deposits of the Neo-palatial period, as these were most likely cleared away and the early floors themselves reused.” Of course, besides immediate reoccupation, other reasons for lack of sedimentation and debris are possible, such as truncation of the earlier deposits, a period of slope stability, and/or a short period of abandonment.

In Block M, following the Neopalatial period, there is minimal evidence for re-use of the structures. However, as noted below, there is some evidence for LM III occupation activity in Block M in the form of terraces or street walls. Indications of the phases (LM IB and LM II/IIIA1) following LM IA occupation and tephra deposits in the SE Building include silt accumulations, described as “silty, gravelly wash” throughout open areas in the latest levels in Block M. This sequence of layers may indicate abandonment following an LM IA flooding event. In Street BM, Theran tephra was deposited into a ‘rivulet bed’ that was subsequently “covered with a layer of fine gravel and then silt.”

Buildings AP1, AM1, MP1, and Trenches A2 and A3 in the new area of excavations provide further information on what occurred at Palaikastro between LM I and LM III. As noted above (see Section 5.1.4), tephra has been found in the new area of excavations in Buildings AM1 and MP1 during the 2015 excavations; these sections are yet to be analyzed. However, no tephra layers are present in Trenches A2 and A3, demonstrating that different processes were

611 Knappett and Cunningham 2012: 92.
612 Ibid.: 37, 42.
613 Ibid.
614 Ibid.: 49.
615 Preliminary analyses of the 2015 thin section samples confirms that the ash found in the Neopalatial contexts in the new area of excavations is indeed tephra comparable to the 2003 tephra samples.
affecting these contexts. In Building AP1, in Room 3a, there was minimal Neopalatial (LM IB) or LM II material below the LM III floor, and some LM IA material farther below.\textsuperscript{616} In Building AP1 in Room 4, a stone collapse level (unit #3144) associated with an earlier architectural phase was possibly related to MM II-III ceramics.\textsuperscript{617} What is unclear is what happened between these earlier and later contexts in Building AP1.

In Building AM1, however, thin sections were taken from the contexts between LM IB and LM III occupational evidence. As discussed above (see Section 5.1.4), the observation of a significant quantity of sediment (>28 cm in depth in Room 4) between a potential LM IB upper floor and ground floor indicates that sediment was transported into the room before the upper floor collapsed. Theoretically, such a collapse could be interpreted as a two-phased collapse, as any LM IB material on the upper floor would have been separated by sediment and architectural debris from that on the ground floor. However, in contrast, observations of actual architectural re-alignments in other LM IB structures (Buildings N and 5) could not be confused with similar two-phased collapses of a single structure. Building AM1 was also located in a unique landscape position (immediately next to the Petsophas slopes) that differs from the other two structures (Buildings N and 5), which were further northwest. Therefore, Building AM1 may have gone out of use after an earlier LM IB phase (Palaikastro Period XI), while occupation activities continued in Buildings N and 5. It is possible that Building AP1 experienced a period of abandonment following its LM IA occupation, but further excavations (and micromorphological analyses) are needed to understand its Neopalatial phase.

Thin section samples from immediately outside Neopalatial Building MP1 (in Exterior Space 9) have demonstrated that the building’s mud brick architecture, identified in thin section analysis, was likely not washed away immediately following abandonment of the structure; rather, some of the mud brick walls either decayed \textit{in situ}, or fell on the Neopalatial street immediately north of the building prior to decay, possibly forced by slope sediments or flooding. Macroscopic evidence that certain areas within and around the structure (Spaces 2 and 6) experienced flooding, which may have deposited silt accumulations immediately over the fallen

\textsuperscript{616} PALAP BSA Report 2015: 11-12.

\textsuperscript{617} Ibid.: 13.
Theran tephra, suggests that, for a period following tephra deposition, these rooms or spaces were not actively used, allowing the silt and tephra to display sorted bedding properties (Plate 5.2A).618

For tephra to enter Spaces 1 and 2, it would either have needed to be washed in through an opening (doorway or window), or Building MP1 would have had to be roofless (Fig. 5.3). The fact that anthropogenic material and architecture collapsed on top of the tephra in Space 1 indicates that the tephra was deposited, likely through a flooding event, while the structure was still standing (Plate 5.2B). Therefore, the structure may have fallen out of use after the LM IA flooding event that deposited the tephra, allowing the mud brick to degrade slowly onto the Neopalatial street, and subsequently resulting in eventual collapse of the structure. Alternatively, a separate, post-flood debris flow may have triggered a more rapid collapse of the structure. A prolonged collapse of the derelict Building MP1 may have protected Building AM1 from coverage by slope processes (debris flows) that led to the accumulation of significant quantities of Neopalatial sediments in Trenches A2 and A3.

From thin section analysis, it is also apparent that the accumulation of Neopalatial debris in Trench A2 occurred in at least two phases; one following the LM IA period, or part of it, and one following the end of the period, perhaps at the end of the LM IB phase (Fig. 5.2). The first phase of deposition (units #2010-2012) included MM III and LM IA ceramics, and some possible tephra, mixed with sediments that indicate gradual, water-related and sorted depositions and rounded (aeolian/beach) sediments; the second phase of deposition (units #2008/2009) notably included LM IB materials (such as a possible ogival cup) and sediments that indicate more mass flow processes, such as debris flows. Therefore, this micromorphological evidence reflects gradual accumulation processes affecting the site through the Theran-related flooding event (not rapid, massive events), and only towards the end of the LM IB period does it indicate more massive accumulations of sediment. As noted above, and as will be discussed further below, mass flow processes, such as debris flows, are typical in drier conditions, a factor that may reflect potentially drier conditions in LM IB that may have necessitated well construction

618 This silty bedding occurs in laminations within which the tephra is visible macroscopically but it awaits micromorphological analysis in the 2015 thin section samples.
(see Section 5.2). It is not possible to decipher multiple depositional events during the LM IB period on the basis of the thin section evidence from Trenches A2 and A3.

Plate 5.2A. (Fig. 102 in BSA Report 2015). Multiple layers of tephra from the top of unit #7136. Note the alternating bands of tephra dominant sediment with silty sandy sediment, beneath the hard silty-clay sediment of #7134. Also observable are vesicles (small spherical voids), which can be related to air bubbles forming in conditions subjected to water influence (Stoops 2003: 64-65).

Plate 5.2B. (Fig. 100 in BSA Report 2015). A concentration of partially intact, ceramic vessels occurs towards the bottom of unit #7116. The nature of compaction of the vessels (most identified as LM IA types) suggests their deposition in a single event, following the deposition of tephra.

Plates 5.2A-B. Tephra deposits from the area of Building MP1 in 2015.
In order for tephra to have been deposited in Building MP1 in Spaces 1 and 2, the tephra would have to have been washed in through openings in the structure, or the structure would have had to have been uncovered. As the collapsed material in Spaces 1 and 2 was deposited after the tephra was deposited, one may conclude that the tephra was deposited via a flooding event, and a subsequent event triggered the collapse of the building. (In Building MP1, green shading indicates likely interior spaces, and yellow shading indicates exterior spaces.)

5.1.6 Postpalatial (LM II/III)

In contexts associated with Postpalatial architecture and ceramics in the new areas of excavations (mainly Building AP1, also AM1), paved, pebble, and earthen floors are present. In Building AP1, LM III ceramics are found over “a very neat paved floor” (unit #3130) in

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Room 2.\textsuperscript{620} Also in Building AP1, in Room 3a, an earthen floor was discovered to relate to the lower floor revealed in 2014 (unit #3059),\textsuperscript{621} designated as LM III based on LM III ceramics above. Room 7 in Building AP1 is described as having an “LM III pebble floor”.\textsuperscript{622}

Above the LM IB Building AM1, some evidence of LM III activity has been tentatively linked to the construction of walls and packings, but these are also noted (macroscopically) as possibly corresponding to displaced materials from other areas of the site.\textsuperscript{623} In Building AM1 in Room 7, a stone surface has been interpreted as an LM III floor; it was not preserved in the western portion of the room down to the level of the LM IB floor.\textsuperscript{624} Also in Building AM1, Room 9 was noted to have been reused in LM III; the excavators observed that the floor packing that existed below the LM III floor was identical to the floor packings in Rooms 6 and 14.\textsuperscript{625} It has been suggested, therefore, that all of these floor packings indicate LM III activity having removed earlier LM IB activity.\textsuperscript{626} Additionally, in Room 9, “sub-floor signs of earlier or intermediary phasing” were apparent to excavators, but it was not possible to correlate them definitively with early activity.\textsuperscript{627}

In earlier excavations in Block M, the major LM III indication of occupation activity (Phase 5) appeared to be the “massive N-S terrace or street Walls 569 and 525.”\textsuperscript{628} Other activity, however, was generally dated according to LM III ceramic finds, and demonstrated similar possible terraces and walls to those described above in Building AM1. For example, in

\begin{thebibliography}{99}
\bibitem{620} PALAP BSA Report 2015: 8.
\bibitem{621} Ibid.: 10.
\bibitem{622} Ibid.: 21.
\bibitem{623} PALAP BSA Report 2013, 2014.
\bibitem{624} PALAP BSA Report 2015: 47. This warrants further study to determine whether this floor was \textit{in situ} or may represent a LM IB upper story collapsed floor.
\bibitem{625} Ibid.: 31-32.
\bibitem{626} Ibid.: 31-32.
\bibitem{627} Ibid.: 31-32.
\bibitem{628} Knappett and Cunningham 2012: 92.
\end{thebibliography}
Rooms 36, 37, and 38, “the continuation S of the massive LM III terrace/enclosure Wall 469 extended over Wall 562 into Room 36.” In the NW Building in Block M, Rooms 55-63 were hypothesized to have been used in relation to the LM IIIA2 occupation of Building 4 to the North. Additionally, Knappett and Cunningham noted an absence of evidence for the “late LM IIIA2/early LM IIIB earthquake and subsequent abandonment,” which had been observed for Buildings 4, 5, and 7 (Blocks Δ, Γ, and Π); Block M instead was suggested to indicate “material withdrawn from use over time.”

This evidence for the potential phasing out of occupation of the areas, combined with the evidence of terraces and walls above Building AM1, could potentially signal changes in occupation activities and land management practices across the site. Further investigation of the relation of cross-site terraces to slope terraces, and to soil erosion or viticulture during this period, may provide valuable information on socio-natural processes (see Section 5.2).

LM III activities at other sites demonstrate similarly varied floor practices, as well as reconstruction over site areas previously occupied. At Quartier Nu at Malia, the “site on which the LM IIIA2 complex was established had been occupied from at least the Middle Minoan (MM) II phase onward by a building with fine paved floors, plastered walls, and several storerooms,” similar to some of the constructions in Quartier Mu. Quartier Nu also included a “large rectangular pebble court” in the early LM IIIB phase, as well as a “portico along its south side that sheltered in the southeast corner a fine pebble mosaic floor (2.60 x 2.60 m) with a geometric pattern (XII).” A “fine clay floor” was also observed in a large room (XII).

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629 Ibid.: 62.
630 Ibid.: 77.
631 Ibid.
632 Driessen and Fiasse 2011: 286-287.
adjacent to the portico. At Ayia Triada, in the eastern sector of Villagio, an earthen floor was dated to LM IIIA1.

The microfabrics observed in thin sections from Palaikastro’s Building AP1 in LM III contexts do not contain a preserved, anthropogenic floor, but may indicate changes in activities during this period. Notably, the laminations and features of graded bedding in thin sections from Rooms 3a and 4 occur in smaller layers (see Section 4.3.1). This indicates that this part of Building AP1 appears to have been uncovered and possibly abandoned, permitting the gradual accumulation of sediment, in contrast to the rooms south of it, which were possibly used during LM III. Furthermore, the graded laminations are indicative of flooding (sorting by water), and not simply silt accumulation. Unique to these contexts is also microfabric type MF1o, which contains higher charcoal concentrations. Charcoal and charred organic material may derive from anthropogenic activities in nearby rooms or from natural or anthropogenic fires in nearby parts of the landscape. With the evidence for construction of terraces and field walls at this time, and lowered sedimentation rates (on site in AP1 and in the A2 gully profile, see Section 5.2), it is possible that these socio-natural processes are indicative of successful erosion prevention and land management, despite the evidence for abandonment in part of Building AP1. It does not appear that any potential landscape fires were large enough to have resulted in massive debris flows at this time, due to the minimal sedimentation in these layers, as well as the lack of major sedimentation visible in Trenches A2 and A3 immediately following (potential) LM IB debris flows. However, truncation must also be considered for the small quantities of debris.

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634 Driessen and Fiasse 2011: 288.
635 Privitera 2011: 266.
636 It is, however, possible that terraces could function for years after being abandoned.
5.2 Urban-rural and socio-natural connections

The micromorphological evidence described above is indicative of multiple (and different) processes of transformation and abandonment at Palaikastro in the new excavation area. Furthermore, the evidence suggests that slope processes had a significant impact on Buildings AP1, AM1, and MP1. Periods of increased slope aggradation may relate to abandonment phases as they seem to occur after indications of abandonment manifest on the site. Additionally, this slope aggradation (phases of landscape instability) seems to have impacted the overall site area, but is most apparent in archaeological contexts in the LM IB phase in the new area of excavations. Phases of slope instability, observed in debris flow or overland flow process features, appear to have occurred at the end of occupation phases or during transitional phases (between MM IIB and MM IIIA), in LM IB, between the Neopalatial and Postpalatial phase, and sometime after LM IIIA, following the Postpalatial phase.

Micromorphological analyses also indicate that flooding or aeolian deposition, which have been interpreted as indicative of abandonment at other sites, is also present, but these features do not necessarily indicate that the landscape was abandoned; they may instead indicate active slope or landscape management, including the preservation of previously constructed terraces. Other studies have demonstrated that terraces have continued to function for decades or more after being abandoned. Thus, determining the timing (within the same year or within decades) of these episodes of rapid and gradual accumulations, and the relationship of terrace or landscape management to the occupation of urban structures, is challenging without sediment-specific dates. Phases of gradual accumulation (sorting, bedding, or laminations) occurred across site contexts, but were best preserved in association with Protopalatial (MM I-II), Neopalatial (MM III(B?) - LM IA), and Postpalatial (LM III) phases. Weathered (aeolian or

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638 Research on ancient Cretan terraces has demonstrated their active use during Bronze Age occupations and their ability to aid in slope preservation and water management (Watrous 2012: 535; Bevan 2013; Price and Nixon 2005; Betancourt 2012). Abandoned Mediterranean terraces can continue to act in slope maintenance for up to 50-year periods (e.g., Solé-Benet et al. 2010), while some terraces abandoned for longer periods have been cited as contributors to slope erosion (e.g., Lesschen et al. 2008).
beach-type) sediments were most common in phases of gradual accumulation and with Protopalatial (MM I-II) trench deposits and LM III, Building AP1, contexts.

One may conclude that the initial phases of the abandonment of urban structures occurred during periods of slope stability, but that slope stability (and subsequent instability) may be triggered by causes other than anthropogenic actions. Other proxy evidence is required to determine any potential triggers. As noted by Bar-Yosef and Belfer-Cohen, researchers tend to focus on the same evidential “triggers” to explain social or cultural changes, and, in doing so, they often fail to consider unknown factors that their methodologies do not reveal. The main unknown factor at Palaikastro is the exact timing of these social and natural processes—the spatial and temporal resolutions of local social and environmental shifts. The unique information that the micromorphological data lends to the local data set may shed more light on the socio-natural processes that are suggested by the new excavations.

5.2.1 “Urban Earth”

In Chapter 2 (Section 2.3.2.2), the question was posed as to whether this micromorphological data from Palaikastro could be used to establish a new terminology for Bronze Age Cretan sediments—“Urban Earth.” This query was due to the establishment and utility of studies of “Dark Earth,” soils typified by thick layers that appear homogenous, in urban archaeological sites in northern Europe. The main feature differentiating Dark Earth from the sediment covering most of the site at Palaikastro is the presence in Dark Earth of a significant portion of organic material (humic content), which is responsible for its dark color.

Scholars have already observed that “[d]irect human influences are increasingly prioritised in soil classification systems,” and that this has resulted in the establishment of

640 Borderie et al. 2015: 213.
641 This finding was confirmed by Frank Carpentier (pers. comm. July 2016).
642 Adderley et al. 2010: 906, citing Dudal 1990.
standardized definitions of *anthrosols* and *technosols*. Both soil types are defined as “soils with strong human influence,” similar to the qualification suggested here for “Urban Earth” in its relation to Cretan Bronze Age urban sites. Anthrosols (AT) are further specified as having undergone “long and intensive agricultural use,” while technosols (TC) are characterized by “the presence of significant quantities of artifactual material in the coarse fraction.” However, the processes that have affected the sediments covering urban Palaikastro have resulted in most of the sediments containing a minimal quantity of artifactual materials. The Palaikastro urban sediments (outside of ceramic dumps and floor remnants) are mostly indicative of natural sedimentation processes, but these sediments were possibly indirectly impacted by human activity.

“Urban soils,” a term also applied to soils impacted by human actions, contain “pedofeatures [that] may be associated with soil sealing and soil disturbance during construction of paths, roads or buildings.” It has also been noted that the increased pH of “urban soils” may result from the “additions of calcareous building materials and other waste materials.” While this term would fit the sediment in the Palaikastro sections based on the calcitic features found throughout most of the Palaikastro thin sections in the form of coatings and carbonate depletion features, such features are also typical of non-anthropogenic calcareous or saline soils. Additionally, the processes responsible for other thin section features are not clear. Recent agricultural practices at Palaikastro may have impacted sediments; irrigation in “cultivated soils with degraded structure and clay-illuvial horizons” may cause depletion and impregnative, iron hydroxide pedofeatures, although iron oxide features may also be caused by

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643 Adderley et al. 2010: 906.
644 WRB 2015: 10.
646 Adderley et al. 2010: 923.
647 Ibid.: 922-923
648 Ibid.: 922.
“anoxic conditions below sealed surfaces” in “urban soils.”

Moreover, micritic calcite nodules may naturally increase with depth, as seen in Trenches A2 and A3, rather than as a result of the degradation of building materials.

As demonstrated by the micromorphological data at Palaikastro, many of the sediments, while appearing well-homogenized during excavations, are in fact differentiated by some varying internal microfabrics, which are distinguished by grain types, grain sorting/bedding/laminations, and inclusions of anthropogenic and environmental materials (discussed in Chapter 4). These microfabric types, as demonstrated above, do prove valuable for identifying transformational processes at Palaikastro by discerning phases of various transformation processes (mud brick building degradation, abandonment (gradual sediment accumulation), debris flows, and slope processes [rapid sediment accumulation]) at this urban site. These transformation processes seem more related to inactivity than to activity (while Dark Earth appears to result from urban activity). The difficulty in determining the exact timing of these geomorphological (accumulation and degradation) processes, however, makes it challenging to ascertain whether they relate to significant changes, no matter the cause, in the surrounding environment. Based on the minimal quantities of anthropogenic materials and unclear nature of the history of agriculture over the Bronze Age urban site, it is not appropriate to label these sediments as anthrosols or technosols. Rather, many of the observed micromorphological features possibly relate to the nature of the sediment itself, which is typical of sediment in arid environments.

Therefore, based on the fact that it is not possible to attribute specific Minoan urban activities to these accumulation sediments and processes, the term “Urban Earth” is not a useful term for the Bronze Age sediments currently under investigation. However, subsequent analysis of the 2015 micromorphological samples will provide an opportunity to reconsider this terminology, particularly with samples from possible external activity spaces outside Building MP1.

649 Ibid.
5.2.2 Land management

Many factors, both natural and anthropogenic, may have influenced the sedimentation rates of the new excavation areas. Recent landscape survey research by Hector Orengo\(^{650}\) demonstrates that the urban area of Bronze Age Palaikastro was not the only built area of the landscape, but that stone terraces, enclosures, and other field systems were contemporaneously used. A preliminary survey of the stone terraces and field system walls on the Petsophas slopes that the author conducted in 2015, immediately next to the new area of excavations, demonstrated that substantial terrace systems for water or soil retention may have been constructed in pre-modern periods (Plate 5.3). The accurate dating of these terraces through formal architectural study and excavation involving micromorphological analyses of the sediments behind the terraces is necessary to confirm the terrace construction dates. Minoan ceramics in the sediments around the terraces above the site do suggest use of the slopes during the Bronze Age and additionally demonstrate that ceramic materials may have been carried across the site with debris flows, and did not necessarily originate from the area of the new buildings.

The initial surface surveys appeared to indicate a system of nine or more stone terraces on the slopes immediately south of the new excavation area. These terrace walls continue into the ravines between the backslope and the slope immediately below Petsophas, suggesting that the terraces may have had water management as well as soil-retention functions (Plates 5.4A-D, Plate 5.5, Plate 5.6). Interestingly, Bronze Age terraces, field systems, and an enclosed system of dams and catchment areas were found nearby at Choireomandres, located 15 km south of Palaikastro and 3.5 km north of Zakros.\(^{651}\) Geoarchaeological analyses have suggested correlations between increased erosion rates at Choireomandres (at the end of the LM IA or beginning of the LM IB) and the approximate timing of the rebuilding of Zakros, but no direct connection has been established yet between these erosional and social transformations.\(^{652}\) In addition, research on the island of Pseira, located off the northeast coast of Crete in the Gulf of

\(^{650}\) Orengo and Knappett (forthcoming).

\(^{651}\) Vokotopoulou et al. 2014; Katsavou 2011.

\(^{652}\) Vokotopoulou et al. 2014.
Mirabello, demonstrates that its densely-packed, Bronze Age water management systems (dams) and agricultural terraces may have enabled the island’s occupants to prevent slope erosion and maintain a self-sustaining agricultural system.\textsuperscript{653} Researchers concluded that the ‘degradation’ of the Bronze Age Pseiran landscape did not occur until its abandonment in LM IB.\textsuperscript{654}

If systems comparable to those at Choiromandres and Pseira were also in place at Palaikastro, it is possible that slope-originating debris flows and erosion may have been more common when the slopes and terraces were not actively managed. While it is not presently possible to determine slope management strategies based on the terracing systems at Palaikastro, it may be significant that debris flows were observed during the post-LM IB abandonment phase of Building AM1 at Palaikastro, which is nearly contemporaneous with the increased erosion rates observed at Choiromandres at the end of the LM IA or beginning of the LM IB.\textsuperscript{655} This evidence may indicate that similar socio-natural processes were impacting both Palaikastro and Choiromandres at this time, and that there was some shift in processes following the Theran eruption.

An argument made in relation to the Rapid Climate Changes (RCCs) (discussed in Section 5.2.3.1) in the western Mediterranean is that changes in fire regimes signaled a shift from mainly agricultural to pastoral economies. Given that an economic, social, or political shift in the LM IB period has already been suggested based on changes in architecture and other material culture,\textsuperscript{656} along with the suggested evidence for aridification (see Section 5.2.3.1), it is conceivable that some shift in land-management activities occurred at this time. Subsequently, by the LM III period at Palaikastro, there was an increase in terrace and land management constructions across the site.

Although multiple factors could have caused such transformations, it has also been suggested that the natural response to an increasing population would be the conversion of

\textsuperscript{653} Betancourt 2005: 287.
\textsuperscript{654} Ibid.; Betancourt 2012: 53.
\textsuperscript{655} Vokotopoulos et al. 2014.
\textsuperscript{656} Driessen and Macdonald 1997.
forests to agricultural and pastoral lands.\textsuperscript{657} However, in general, a decline in population across Crete is likely from the LMIA through the LM IB destructions,\textsuperscript{658} although this is not yet translatable to the local level at Palaikastro. At Petras, an increase in evidence for storage in the LM IB period might either indicate increased localized, central control or increased issues with food shortages due to unstable resource production.\textsuperscript{659} However, inconsistent resource production could also have been due to drought events, erosional or aggradational destruction, or other social-political transformations that resulted in lower crop yields.

At Palaikastro, one could also argue that following the debris flows at the end of the LM IB period, the new area of excavations could have become more favourable for agriculture (i.e. terracing, as seen in LM III) since soils can be enriched by deposition of sediments on floodplains and alluvial fans, and by wind-borne deposits. Apparent at the new excavations at Palaikastro, in LM III, when terraces are present across the site, are remains of grass pea (\textit{Lathyrus sativus}) and broad bean (\textit{Vicia faba}), olives, grapes, figs, almonds, and some wild plant species.\textsuperscript{660}

For Bronze Age Crete in general, some information on the anthropogenic use of the landscape is accessible through both archaeological and later textual evidence. For instance, the construction of Bronze Age terraces, dams, and wells is readily apparent on Crete; however, attributing some of these man-made features to particular Bronze Age phases is difficult. Later classical Greek texts describe some of these man-made field systems, using the word \textit{αίμασιά}, which is considered to refer to a dry-stone wall, the land enclosed by a dry-stone wall, or to a terrace, and the word \textit{τειχίον}, considered to be a freestanding wall.\textsuperscript{661} The integration of architectural, material, geomorphological, and environmental data from Pseira Island has demonstrated that Bronze Age terrace and field systems on Pseira were generally sustainable, rather than detrimental to the landscape. Micromorphological studies of terrace soils and

\textsuperscript{657} Meiggs 1982: 372.

\textsuperscript{658} Driessen and Macdonald 1997: 82.

\textsuperscript{659} Ibid.: 53.

\textsuperscript{660} PALAP BSA Report 2014: 53. Publication of the archaeobotanical study of Block M is forthcoming (Sarpaki).

\textsuperscript{661} Price and Nixon 2005.
erosional episodes have led researchers to conclude, as mentioned earlier, that ‘degradation’ of the Bronze Age Pseiran landscape did not occur until after abandonment in LM IB, not immediately following any potential effects of the Theran eruption.⁶⁶²

Plate 5.3. Terrace systems (yellow dots) surrounding the new area of excavations at Palaikastro. Terrace dates need to be confirmed. The blue dots indicate the locations (GIS points) of Plates 5.4A-D, 5.5, and 5.6. Some GIS points occur outside of the high resolution aerial image but are accurate relative to the other GIS points.

Plate 5.4A. View from GIS 231, looking north towards the Palaikastro excavation site. Plate 5.4B. Possible ancient (Minoan) terrace wall (at GIS 231) on Petsophas slopes.

Plate 5.4C. Stratified conglomerate and packed gravels on the Petsophas slopes, south of the site, may be one source of sediments found covering the site (taken at GIS 213).

Plate 5.4D. Zoomed-in view of the packed gravels and conglomerate at GIS 213 on the Petsophas slopes.

Plate 5.4A-D. A: View from possible ancient (Minoan) terrace wall (GIS 231) looking north towards Palaikastro excavation site; B: Possible ancient (Minoan) terrace wall (GIS 231); C: Stratified conglomerate and packed gravels on the Petsophas slopes (GIS 213); D: Zoomed-in view of the packed gravels and conglomerate at GIS 213.
Plate 5.5. View towards the south (from GIS 312), overlooking the site valley. An earth slump (marked by a white dashed line) is visible on the lower Petsophas slopes. Ravines in the slopes are marked by blue dashed lines.
Plate 5.6. View towards the north (from GIS 330), overlooking the site valley. Chiona beach is on the far right, separated from Kouremenos beach, in the centre, by Kastri.

5.2.3 Natural transformations

Deposits typical of arid environments that are found at Palaikastro include aeolian sands, possible flash flood deposits (poorly sorted breccia, debris flows), and silt deposits. These deposits across the urban site demonstrate that there are multiple local processes that are part of normal cycles of arid environment transformation (regardless of human activity) that could have resulted in the urban deposits, and that may have significantly affected the settlement as a whole.

663 Sumner 2014.
Other than these geological indicators of arid environments, the primary, direct evidence presented for the arid nature of the ancient Palaikastro environment has been the construction of wells in LM IB. However, while one may view the construction of wells (and other architectural changes) in the LM IB period as changes made in reaction to environmental changes, without further direct evidence for environmental change, this would be a circular argument.

5.2.3.1 Aridification

Other environmental evidence for aridification to date has mainly been attainable on regional scales (as discussed in Chapter 1). Scholars have suggested, on the basis of regional data that the eastern Mediterranean experienced a sudden aridification around 2300/2000 BC, that East Crete and the Mesara experienced the greatest impact of this change in precipitation. Following this “3rd-millennium aridity event,” global and regional climate data have also suggested a “2nd-millennium Little Ice Age” between 1870/1800 and 1370/1230 (MM IB/II–LM IIIA/B). While natural events such as flash floods are typical of the Mediterranean environment, there was an increased probability of flash floods, debris flows, and drought events during these postulated “Ice Age” conditions.

Therefore, Moody’s global climatic models tentatively support a period of aridification in the LM IB period but local environmental evidence has been lacking. At Palaikastro, the new

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664 MacGillivray et al. 2007.
666 The suggestion of this Ice Age is based on the Löbben glacial advance in the Alps between about 1870/1800 and 1370/1230 cal BC (Moody 2009: 246; Rehak and Younger 2001). The Theran eruption (sometime between 1650 and 1150 cal BC) is also believed to have affected the climate, as indicated by “the possible onset of cooler winter temperatures suggested in deep-sea core LC21 and by the reappearance of Tilia pollen above the deposit of Theran ash and pumice in the Delphinios core” (Moody 2009: 247; 2005: 461).
668 Ibid.: 56.
area of excavations does not contain debris flows from deposits predating the MM I period, although this does not necessarily mean that they do not exist. However, the preservation of the Bronze Age debris flows, as identified in this dissertation, that contain Protopalatial, Neopalatial, and Postpalatial materials could possibly serve as local evidence for a potentially drier, and flood-susceptible, local environment.

Moody suggests that the scarcity of massive flash flood and debris flow deposits for Neolithic, EM, Iron Age, and Byzantine periods in comparison to LM, Venetian, and Turkish periods, indicates that “the magnitude of the Minoan and Venetian events wiped out the preceding flood deposits.”\textsuperscript{670} Furthermore, the ability of Minoan deposits to withstand truncation in the Venetian and Turkish periods indicates that they were “initially more extensive and bigger than those associated with the Medieval Little Ice Age.”\textsuperscript{671} She further implies that the Minoan climate during the “Minoan Ice Age” was distinctly different from that of today and from that of the Medieval Little Ice Age.\textsuperscript{672} Possibly, discrepancies in the timing of this aridification process and the “Ice Age” should be attributed to local environmental variations.

If arid conditions were exacerbated during LM IB, as the greater quantity of debris flow preserved in Trench A2 suggests, then the construction of terraces nearby, on Kato Plako, the construction of LM IB wells, and the potential water management and ancient terracing related to LM activities in the surrounding survey areas would fit the narrative of increased attention to water sources and erosion events. The large earth slump above the new area of excavations at Palaikastro is also a potential result of a flood event, and would have caused debris to flow across the site (Plate 5.5). Nevertheless, the lack of temporal resolution of the terrace and water management structures at this time prevents any definite associations between potential arid conditions and changes in land management practices.

According to some hydrogeological research at Palaikastro by Jonathan Flood, drought conditions may have occurred at the site during the LM IB period.\textsuperscript{673} At least two aquifers were

\textsuperscript{670} Ibid.: 58.
\textsuperscript{671} Ibid.
\textsuperscript{672} Ibid.
\textsuperscript{673} Flood 2012.
present beneath Block M, where the two LM IB wells were placed; one aquifer was located 7 masl, and the other at 3 masl.\textsuperscript{674} In order for the second aquifer (at 3 masl) to have been used, the one above (at 7 masl) would have needed to be depleted.\textsuperscript{675} Following this reasoning, it has been suggested that drought conditions led to the construction of these wells.\textsuperscript{676} However, it is also possible that other conditions could have contributed to the depletion of the first aquifer (see also Section 5.2.3.3).

Other geoarchaeological research on the terrace soils, the field systems, and an enclosed system of dams and catchment areas at Choiromandres, 15 km south of Palaikastro and 3.5 km north of Zakros, supposedly demonstrates that increased flooding and erosion occurred immediately after the Theran eruption,\textsuperscript{677} conditions that an arid environment would have exacerbated. If this is true for Choiromandres, it is possible that Palaikastro was also affected by a post-Theran climate pattern with frequent flood and debris flow events. It would then be understandable for changes in land-use practices at Palaikastro to occur during this period in response to climatic changes.\textsuperscript{678}

Recent research on Holocene climate changes in the western Mediterranean has introduced the term “Rapid Climate Change” (RCC) to “describe Holocene intervals that display geographically broad evidence for climate changes.”\textsuperscript{679} Although the dearth of sufficient quantities of regional data is notable for this region, some authors have suggested that, during RCC intervals in the western Mediterranean, such as that between 3.5–2.5 cal ka BP (1500 - 500

\textsuperscript{674} Ibid.: 39.

\textsuperscript{675} Ibid.: 39-40.

\textsuperscript{676} Ibid.: 40.

\textsuperscript{677} Vokotopoulos et al. 2014.

\textsuperscript{678} Vokotopoulos et al. (2014: 260) suggest that environmental as well as anthropogenic changes may have led to changes in landscapes in LM IB Choiromandres.

\textsuperscript{679} Mayewski et al. 2004 introduced the term RCC after earlier research on “global glacier advance intervals” by Denton and Karlén (1973). Fletcher and Zeilhofer (2013: 16) note this in regards to their research on Holocene RCCs in the western Mediterranean.
(BC), there is evidence for increased soil erosion and transportation of aeolian sediments, which have been interpreted as indications of aridity.680

Significantly, some researchers note that there are “contrasting signals in terms of activity of geomorphological processes and landscape stability.”681 They attribute this difficulty to “comparing records of very different temporal resolution to ascertain whether anomalies in different records are in phase or anti-phase,”682 and it is equivalent to the temporal challenges encountered in understanding the geomorphological processes at Palaikastro when determining whether episodes of abandonment affected slope stability processes, or slope stability processes affected occupation phases, or both.

From the current data in the western Mediterranean, it is not clear how climate change affected runoff processes; it seems that “arid to semi-arid Mediterranean landscapes exhibit decreased flooding under more humid conditions as a result of denser vegetation cover with soil formation and low surface runoff. Arid conditions reduce vegetation cover and result in increased flooding and alluvial activity when rain does occur.”683 Arid conditions are also expected to impact fire regimes; i.e., less vegetation means that there is less fuel to burn (fuel-limited system), although the situation may be even more complicated.684 An increase in arid conditions is additionally thought to increase “sediment mobilization and deposition in a range of environmental settings (coastal, dune, soil, fluvial),” but, as noted above, there are temporal issues in understanding the processes.685 One suggestion has been that the dry atmospheric conditions indicated in the RCCs may be related to “greater seasonal extent and broader geographic impact than those strictly associated with the present-day NAO.”686 Perhaps on

680 Fletcher and Zeilhofer 2013: 25.
682 Ibid.
683 Ibid.
684 Ibid.: 21-23.
685 Ibid.: 21-23.
686 Ibid.: 25.
Crete, significant differences in seasonality should also be considered in models of climate change and erosion processes, resulting in the dramatically different conditions noted by Moody.  

To be able to evaluate accurately the geomorphological processes in the western Mediterranean, Fletcher and Zeilhofer recommend that additional regional studies be conducted, specifically targeted at understanding geomorphological processes in colluvial, fluvial, and alluvial systems, and their relation to “vegetation cover, fire activity, land-use and hydrological regime.” It would be beneficial to organize similar research at Palaikastro—tied to the current palaeoenvironmental research being conducted. For example, identifying charcoal contained in the MF1o microfabrics in tentative abandonment layers, as well as charcoal in other contexts, might inform us about fire regimes or structural or cooking fires. Additionally, information on potential humid and arid periods might result from the molluscan analysis currently in progress, and from future comparisons with ongoing dendrochronological research, which can supply climate and precipitation data and models.

### 5.2.3.2 Deforestation

Deforestation may occur as a result of natural aridification processes. Aridification decreases the water content in soils, which can instigate slope instability; it can also kill trees, which mitigate slope instability. If forested slopes are destroyed by debris flows (regardless of fire regimes or human activity) a positive feedback cycle may initiate further erosion. The hypothesis of a climate-initiated process of deforestation is in contrast to processes of human-

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687 Moody 2009.
688 Fletcher and Zeilhofer 2013: 26.
689 Picornell-Gelabert is conducting charcoal analysis and Krahtopoulou is conducting grain-size analysis of sitesediment samples.
690 The initial process of these charcoal identifications has been accomplished by Llorenç Picornell-Gelabert.
691 Rena Verapoulidou is presently analyzing snails collected as heavy residue via flotation to understand site-formation processes, human activities, and climatic information.
692 Dendrochronological research on Crete is currently being conducted by the Laboratory for Tree-ring Research at the University of Arizona; the Crete component is being directed by Tomasz Wazny.
induced deforestation, and the subsequent erosion of slopes, which early scholars, such as Pendlebury, for the Lasithi Plain, have suggested.693

In terms of early hypotheses on deforestation in the post-Theran landscape, Arthur Evans argued, based on changes in timber-based architectural features at Knossos, that there was a Cretan timber shortage just before the end of the Bronze Age.694 New architectural features in the Neopalatial period included the use of ashlar blocks and gypsum, especially in door frames, where timber had been previously used.695 However, such architectural transformations were not apparent island-wide; at Phaistos, construction practices remained the same as in the previous period, and at Zakros, ten saws, suggested to have been used for timber-cutting, were found in LM IB contexts.696 At Palaikastro, pollen data from LM does not currently exist; the modern Palaikastro landscape is largely without trees.697

In contrast, a view of gradual deforestation is inconsistent with some Classical authors’ writings, which detail that Crete remained heavily forested through Classical and even Venetian times (e.g., Strabo698, Theophrastus699, and Pliny700). While debris flows (regardless of fires or climate change) could themselves contribute to gradual or rapid deforestation, further evidence is needed to support the notion of deforestation during the LM period at Palaikastro (see section 5.3 for further discussion on land management).

694 Meiggs 1982: 98.
697 Recent pollen analyses by Cañellas-Boltà et al. (in prep.) suggest that the EBA landscape was likely similar.
698 Strabo 10.4.4.
699 Theophrastus, Hist. pl. 3.1.6; 3.3.3; 3.3.4.
700 Pliny, NH, 13.15; 16.60; 16.76; 24.32; 31.26.
5.2.3.3 Tectonism

In addition to aridification and deforestation, tectonism is another possible impact natural transformations that may have resulted in the debris flows across the new site areas, as well as on the occupation activities at Palaikastro. Research has suggested an increased phase of tectonic activity in the MM II-III period, and has also connected this phase with the Theran-eruption in LM IA.\(^701\) Earthquakes could certainly have initiated debris flows; arid events would also have increased the likelihood that earthquakes would result in debris flows. Nevertheless, correlations between tectonic effects (uplift/subsidence) with specific earthquakes can only be made “if it can be demonstrated that no other strong earthquakes occurred in a critical time period when the effect occurred.”\(^702\) While some researchers\(^703\) place considerable trust in historical earthquake evidence for Crete, others\(^704\) downplay the accuracy of this textual and archaeological evidence.\(^705\)

Past tectonic activity has produced coastal uplift or subsidence on Crete.\(^706\) Geological data indicates that “strong earthquakes have produced deformation along the western coast of Crete.”\(^707\) Notably, these previous palaeoseismic studies have been limited to geomorphological and biological studies of fossils in rocky, uplifted shorelines\(^708\) and tsunami deposits\(^709\) because

\(^701\) Moody 2009: 246; Driessen and Macdonald 1997. Palaikastro did likely have an MM IIIB earthquake, as observed in Block M.
\(^702\) Stiros and Papageorgiou 2001: 381.
\(^703\) Stiros and Blackman 2014.
\(^704\) Sintubin et al. 2008; Ambraseys 2006.
\(^705\) For example, it is generally agreed that previous seismic events have affected normal uplift and subsidence rates (Stiros and Papageorgiou 2001); however, the extent of impact of the earthquake in AD 365 is debatable; Strobl et al. (2014: 22) believe the AD 365 earthquake to have caused 9 m of rock uplift in western Crete, destroyed all towns, and caused an eastern Mediterranean tsunami.
\(^706\) Stiros and Papageorgiou 2001: 381. Uplift events have been determined based on the observation of uplifted marine sediments of the Last Interglacial and Late Holocene shorelines (cf. Stiros and Papageorgiou 2001: 381; Pirazzoli et al. 1982; 1996).
\(^707\) Stiros and Papageorgiou 2001: 381.
\(^708\) Pirazzoli et al. 1982; 1996.
\(^709\) Pirazzoli et al. 1992; Dominey-Howes et al. 1998.
the majority of Cretan earthquakes are triggered by offshore faults.\footnote{Stiros and Papageorgiou 2001: 384.} Crete, which is located on the central part of the Hellenic Arc, normally experiences “a sequence of episodic small-scale (20–30 cm) subsidence events, recurring approximately every 200 years,”\footnote{Stiros and Blackman 2014: 119.} although atypical events have also occurred, such as the 9 m uplift associated with the AD 365 earthquake (supposedly with a minimum magnitude 8.5).\footnote{Ibid.; Pirazzoli et al. 1982.}

In Block M at Palaikastro, it has been concluded that a major seismic event was responsible for the destruction of the buildings at the end of the MM IIIB period.\footnote{Knappett and Cunningham 2012: 6.} Such an event certainly could have triggered debris flows similar to those seen in Trenches A2 and A3. Moreover, it is important to note that such an earthquake leading to debris flows could be tied to groundwater depletion, and possible arid conditions. Recent hydrogeological research in other geographic zones has demonstrated that uplift, subsidence, and seismicity have been driven by groundwater depletion.\footnote{Amos et al. 2014. In the example discussed here, along the modern California’s San Joaquin Valley, groundwater depletion is caused in by human activity. However, droughts may also cause groundwater depletion, as noted above by the hydrogeological study at Palaikastro (Flood 2012).}

East Crete has been less extensively studied in terms of uplift and subsidence. However, based on the stratigraphy of exposures along the ancient coastline both north and south of Palaikastro, it is possible that significant tectonic shifts occurred in East Crete. It has been noted that Mediterranean harbours provide ideal locations to study uplift/subsidence history because (1) the region is microtidal (e.g., astronomic tide in the modern harbour of Rhodes is approximately 10 cm),\footnote{Pytharouli and Stiros 2012.} (2) environmental changes in uplift and subsidence of ancient harbours, like the one presumed to have existed at Bronze Age Palaikastro, prove valuable in identifying sea-level during past uses,\footnote{Flemming 1978b; Marriner and Morhange 2007.} and (3) textual and archaeological evidence for past

\footnote{Stiros and Papageorgiou 2001: 384.}
earthquakes makes the association of ancient earthquakes with smaller uplift or subsidence events feasible.\textsuperscript{717}

It may be possible to make such correlations at Palaikastro in the future, particularly if study of the coastal and possible underwater archaeological deposits is permitted. Analyses of potential uplift and subsidence events along the rocky shorelines of Tenda and along the sediment-exposed shorelines immediately next to Bronze Age Palaikastro, south of Chiona, would likely provide valuable information on seismic events that may have impacted slope stability and occupation phases at Palaikastro (Plates 5.7A-C). At Palaikastro, it may be possible to associate a particular uplift or subsidence event, which would have had significant impact on slope stability, with an earthquake or destruction layer, in addition to the buildings affected on the coastal promontory (Plate 5.7D). In this sense, natural processes, rather than geopolitical regimes,\textsuperscript{718} may have played a significant role in some of the observed site transformations (related to well constructions, terraces, and debris flows). However, as noted by one researcher, earthquakes themselves “turn out to be incapable of causing the collapse of a community, let alone a civilisation. After all, earthquake disasters are not physical phenomena, but are social phenomena.”\textsuperscript{719}

\textsuperscript{717} Stiros and Blackman 2014: 114-115.

\textsuperscript{718} It is noted that following the MM IIIB earthquake destruction in Block M, the strong connection between Palaikastro and Knossos may have ended (Knappett and Cunningham 2012: 321).

\textsuperscript{719} Shimoyama 2002; in Sintubin 2011: 8.
Plate 5.7A. Cliffs at Tenda, north of Palaikastro, with fossils and indications of uplift, as well as slumping, would be valuable to include as part of a tectonic study.

Plate 5.7B. Truncated silty sandy beach cliff at Chiona. The sheer cliffs may indicate subsidence or uplift events or erosion due to wave action and storms.

Plate 5.7C. Sandy silty beach cliffs along Chiona, showing the partial truncation of buildings, likely due to wave action or storms.

Plate 5.7D. Other Minoan structures on the north side of the promontory illustrate erosion caused by wave action.

Plates 5.7A-D. A: Cliffs at Tenda, north of Palaikastro, with fossils and indications of uplift, as well as slumping; B: Truncated silty sandy beach cliff at Chiona; C: Sandy silty beach cliffs along Chiona, showing the partial truncation of buildings; D: Other Minoan structures on the north side of the promontory.
5.2.3.4 Sea-level change

Despite the microtidal nature of the Mediterranean, submerged settlements across the region demonstrate that there have been changes in relative sea levels since ancient times.\(^{720}\) Notably, on Crete, these relative sea level changes appear to vary dramatically based on local uplift or subsidence. For example, at Mochlos, while Roman constructions have been completely submerged, a “slip way for a warship” at Sitia occupies roughly the same relative sea level as it did around 300 BC.\(^{721}\) At Kommos, partially submerged LM III ship sheds have been destroyed by wave action caused by relative sea level change.\(^{722}\)

As stated in Chapter 3, the modern coastline of Chiona is only 200-300 m away from the new area of excavations. Despite this proximity of the settlement to the sea, the elevation of the archaeological site is significantly above sea level, and a conglomerate ridge that connects with the promontory protects it somewhat from the coastline. This ridge also forms a sort of channel towards the site, however (Plate 5.8). The presence of beach-sand-like sediment in the thin sections from the new area of excavations suggests that coastal floods may have infiltrated the site on various occasions, mostly during periods of active occupation. The topographic location of the new area of excavations of the site (shown in Plate 5.8) does indicate that it would be most susceptible to coastal flooding.

Coastal flooding could certainly have damaged the site, particularly causing the degradation of mud brick structures. The impact of wave action on structures along the coastal promontory (Plate 5.7D) demonstrates the effect that waves (and storms) would have on Bronze Age architecture. Furthermore, coastal flooding could have caused the salinization of the local landscape, which would have had a negative impact on agriculture.\(^{723}\) While it is possible that beach-like sands may have been deposited on the site by aeolian processes (thus suggesting the deposit of these sediments during inactivity or abandonment), and that floods may have

\(^{720}\) Willets 1976: 23.
\(^{721}\) Ibid.
\(^{722}\) Shaw and Shaw 2010: 547-548; Gifford 1995: 78–79; Shaw 2006: 60n203.
\(^{723}\) Baldwin and Mendelssohn (1998) studied the negative effect of salinization on coastal marsh vegetation.
originated inland (from rain), the potential impact of coastal flooding on the site cannot be ruled out as a factor in socio-natural transformations.

Plate 5.8. Topographical elevation plan over site of Palaikastro. Orange indicates highest elevation; blue indicates lowest elevation.

5.3 Conclusions: Soil, Scale, and Sustainability

“Deciphering the temporal and spatial patterning in landscape change and its relation with human settlements remains a major concern for geoarchaeology in Greece by the advent of the twenty-first century.”

This micromorphological study has demonstrated that different types of transformations are visible at different scales. The micromorphology of one ‘neighbourhood’ in urban Bronze

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Age Palaikastro, in fact, provides a lot of information on the surrounding environment. One can observe the differences between transformations related to different abandonment processes, as well as the differences between various sediment sources; it is not possible to determine the underlying causes of these socio-natural processes, however. While the influence of coastal sediments is apparent, the occupation of the urban structures may actually be related to the sustainability of the surrounding slopes. In this sense, sustaining the urban site is truly a question of sustaining the entire urban environment. Nevertheless, the addition of palaeoenvironmental, archaeological, and other complementary data to this study is essential to further understand these complex socio-natural relationships.

The results from this micromorphological study are significant because they show nuances in depositional and site formation processes across the new ‘neighbourhood’ and have established a very local narrative of what the area might have looked liked and experienced in various occupational and transitional phases. In addition to the importance of building this microecological narrative to understand the history of a Mediterranean site (cf. Horden and Purcell, see Section 2.1.1), this microecological narrative of a ‘neighbourhood’ is a step towards solving the Mediterranean “problem” (see Section 2.1) of understanding larger-scale, cyclical changes in environments. While the micromorphological results alone are not capable of distilling cultural behaviours from natural processes, the microecological narrative is valuable in constructing a meso-scale (site-wide, East Cretan, or Cretan) narrative of the pressures that may have led inhabitants to expand to a marginal area of the landscape (see Section 5.3.2 and 5.3.3 for further discussion).

In the future, more micromorphological work is, of course, needed to enable the understanding of each Bronze Age site from this micro-scale perspective. This would include analyzing the sources of sedimentation in greater depth by creating comparative thin sections from geological reference materials and cultural and architectural materials. Nevertheless, from micromorphological analyses of this single site area of Palaikastro, this dissertation demonstrates that, by identifying types of urban microfabrics and connecting processes of transformation, one

725 Horden and Purcell 2000: Chapter 4.
can build up to tackling larger, regional and island-wide questions of socio-natural transformations.

5.3.1 Soil memory and cyclical arguments

Despite the valuable information that urban micromorphology supplies on socio-natural transformations at Bronze Age Palaikastro, including phases of abandonment and slope instability or stability, micromorphology does not, in itself, provide an endpoint to cyclical arguments or positive-feedback cycles on whether anthropogenic or environmental factors initiated these changes.⁷²⁷ This is, in large part, due to the fact that the sediment being analyzed represents “soil memory”—certain features of past surfaces are inherited, and while these features tell a narrative, parts of the narrative may be truncated, as with memories.⁷²⁸

For example, at Palaikastro, evidence for the LM IA Theran tephra is found in some site contexts, but not others. Simple absence does not necessarily point to truncation, as there may be an absence of various phases in particular site areas (e.g., lack of evidence for the LM II phase in the new area of excavations). However, the presence of tephra and LM IA layers in Buildings AP1 and MP1 could indicate that tephra trapped in building contexts was preserved, while tephra in exposed areas was subject to truncation (the material was washed or blown away, or otherwise lost, and so the exact sedimentation history of what occurred in AP1 and MP1 was truncated). This soil memory, therefore, informs us of depositional or post-depositional processes.

Currently, every winter/spring at Palaikastro, there is very apparent seasonal flooding on the new area of site excavations; however, the preservation of these seasonal features may not be fixed into the long-term soil record. This modern process demonstrates that, despite the valuable information that micromorphology can supply on some processes, the soil memory for other significant processes may simply be missing.

In the future, perhaps computational models associated with modern erosion and accumulation, in an experimental study of the Palaikastro slopes, set up next to new site

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⁷²⁷ This is also noted by Tourloukis and Karkanas (2012: 20).

⁷²⁸ Fedoroff et al. 2010: 994-996.
excavations, could assist in assessing the rates of these seasonal and annual processes and their impacts on soil memory. Perhaps there will be aggradation comparable to Bronze Age patterns (evident in silting/bedding/laminations) in the present “abandoned” landscape beneath the slopes, allowing an assessment of the preservation potential for certain sedimentary beds over others.\textsuperscript{729} Is the formation of soil memory at Bronze Age Cretan sites a question of event magnitude?

5.3.2 Scaling-up soil studies

As noted above (Section 5.3.1), the causal factors of the gaps in occupation phases and intervening transitional phases cannot at this time be attributed to particular social or natural pressures. Nevertheless, on the basis of the micromorphological study, one may conclude that periods of slow sediment accumulation may have preceded gaps in occupation phases. In the newly excavated area of Bronze Age Palaikastro, it appears that significant, slope-derived depositional episodes occurred immediately after the MM I-II, MM III - LM IA (possibly with a first debris flow phase occurring post-MM IIIB), during or at the end of LM IB, and at the end of LM III occupations. Furthermore, the micromorphological evidence demonstrates that different processes of disuse and post-depositional features occurred within and between buildings. Therefore, even between different areas of the town at Palaikastro, unique depositional and post-depositional processes appear to have been at work.

How, then, can this micromorphological evidence, which is very location-specific, provide information on meso-scale or macro-scale processes? By identifying types of processes through ‘urban’ microfabrics, certain trends are identifiable across the site, despite building-specific soil and material variations. From this microfabric data, it is apparent that this new ‘neighbourhood’ area is united in the manner in which the surrounding landscape experienced impacts, but that different reactions to the ‘neighbourhood’ disturbance occurred across time. Additionally, while the timelines and histories of these three new buildings (AP1, AM1, and MP1) individually varied during the Bronze Age, events affecting the ‘neighbourhood’ as a whole resulted in different socio-natural responses than in other areas of Bronze Age Palaikastro.

\textsuperscript{729} Boggs 2006: 79.
(whether related to subsequent building restructuring or landscape transformations), as illustrated through variations in the micro-scale soil record and comparisons to earlier excavation data. Some of these variations may be due to changes in the urban environment; others may have been a function of changing populations (generations reacting differently)—or both.

Comparisons between the urban microfabrics identified in this newly excavated area of the site to other site areas, and, in the future, to urban microfabrics identified at other sites may serve to ascertain whether other ‘neighbourhoods’ and urban environments responded similarly (based on micromorphological evidence) to socio-natural transformations. With other urban comparative studies, it may be possible to determine whether trends (via microfabrics) at sites occurred at the level of the neighbourhood, site, or region. If trends in urban microfabrics are apparent at site or regional levels, then perhaps networks of relationships between occupation and transitional phases can be established, beyond the local variations that may exist in material culture and environment (e.g., technologies, geographic location).

Through this approach, the microecological narrative of Palaikastro can be combined with other local narratives to assist in understanding a larger East Cretan narrative. For example, comparing the microecological responses to local aridity events between Palaikastro and Zakros could assist in establishing a regional, East Cretan narrative and in identifying variations in sociopolitical dynamics. At Palaikastro, the evidence suggesting a local aridity event in LM IB— the greater quantity of debris flow preserved in Trench A2, the construction of terraces nearby, on Kato Plako, the construction of LM IB wells, and the potential water management and ancient terracing related to LM activities in the surrounding survey areas— could be associated with evidence for a local aridity event in the Zakros area, at Choiromandres— increased flooding and erosion. In addition to this related evidence for local aridity events, both Palaikastro and Zakros appeared to function respectably, overall, in LM IB. In the North sector of Palaikastro, ashlar buildings (Buildings 1, 3, 4, 5) were constructed. At Zakros, artifactual evidence also indicates significant trade with Knossos as well as other Mediterranean sites and settlements.

Thus, despite the local arid environmental conditions, one could suggest that a shared, perhaps

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730 MacGillivray and Sackett 2010: 574.
Knossian-based, sociopolitical system served as a driving force in East Crete in LM IB, trumping local microecologies. Rather than working down from global climatic models (cf. Moody\textsuperscript{732}) and from Mediterranean-wide or island-wide narratives, this approach of scaling-up from local narratives can establish more detailed local and meso-scale narratives.

### 5.3.3 (Urban) sustainability

Was Palaikastro, overall, more resilient to socio-natural transformations when it was possibly in semi-isolation, or when it was closely-tied to a larger network? At least until near the end of the Bronze Age (LM IIIA2), it appears that the newly-excavated ‘neighbourhood’ at Palaikastro was able to recover (repeatedly) from debris flow or slope processes and other processes that caused sedimentation amid its urban structures. Perhaps this indicates that larger social issues affected these choices to reoccupy an area that was susceptible to unstable environmental conditions.

In analyses of ecosystems, four key features have been observed that dictate the success of these systems: (1) change is episodic (varying between gradual and rapid changes);\textsuperscript{733} (2) trends may be patchy because attributes vary both spatially and temporally (i.e. scaling up does not always work); (3) the factors at any one point that determine equilibrium will vary (‘[d]estabilizing forces are important in maintaining diversity, flexibility, and opportunity, whereas stabilizing forces are important in maintaining productivity, fixed capital, and social memory’);\textsuperscript{734} and (4) fixed or inflexible systems increasingly lose resilience (and may break down when faced with disturbances).\textsuperscript{735} While intended for ecosystems, these concepts of resilience theory may be applied to the socio-natural systems at Palaikastro, or at other urban sites. Because the urban centre itself is fixed in location, it needs to be able to adapt to changing conditions.

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\textsuperscript{732} Moody 2000: 58-59.

\textsuperscript{733} Driessen and Macdonald (1997) note the varying temporalities (long-term versus short-term change) of post-Theran trends.

\textsuperscript{734} Redman and Kinzig 2003: 1.

conditions and “work at scales that are compatible with the scales of critical [environmental] and social functions. These critical scales may themselves change over time.” 736 This means that developing a resilient urban system may necessitate promoting new practices, based on results from previous experiences and events. At Palaikastro, for example, this could mean trying new land-use and governing systems in LM IB after encountering issues in LM IA. In this sense, natural transformations and social transformations need not be mutually exclusive.

It is also notable, in regards to resilience, that it may be valuable to consider ‘living at the edges’ (near the maximum thresholds of sustainability) because this may lead to better circumstances; however, obviously, establishing near-maximum, or ‘near the edge’, systems also includes risks. We might apply this idea to the new area of excavations, perhaps this neighbourhood was ‘pushing the limits’ in its location ‘at the edge’ of the settlement, but the payoff (whether social, political, or economic) was worth facing the risk of slope instability and coastal flooding. In order to be able to learn from past experiences and reoccupy this ‘neighbourhood’ after debris flow events, the neighbourhood system (or site system) would have needed to be resilient. It is not apparent from this study but, on the basis of a paradox in resilience theory, it is possible that increasing social complexity may have had a role in final abandonment: “resorting to increased social complexity to resolve problems (such as slope instability) seems to work in the short run while sometimes undermining the ability to solve them in the long term.” 737

Overall, however, it appears that the local environmental pressures created by slope instability and coastal flooding at the new ‘neighbourhood’ in Palaikastro may have been compensated for by the economic and social support from Knossos, as noted above. This shows that, while establishing local microecologies, it is also necessary to consider both broader environmental processes (such as regional aridity events) and wider sociopolitical dynamics (such as the role of Knossos in enabling urban expansion). In this way, in order to complete the gaps in our understanding of human-environment interactions in Mediterranean microecologies, one must be able to move between different scales of narratives, or have multiple, “sliding

737 Ibid.: 5; Redman 1999: 212.
scales\textsuperscript{738} of narratives. By considering both the local environmental pressures (from micro-scale, micromorphological evidence) and meso-scale, socio-natural pressures (from site-wide, East Cretan, and Cretan artifactual and environmental evidence) on this ‘neighbourhood’, one can build a better understanding of the sociopolitical dynamics that were at play to make urban expansion desirable or necessary.

\textsuperscript{738} Cf. Broodbank 2000:8. (Refer to Section 2.1.2.) In this context, this would not be strictly for island cultural systems (as identified by Broodbank), but for understanding the local socio-natural history of any Mediterranean site.
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Appendices

Appendix 1: Bulk Soil Sample pH Tests (2013 and 2014 samples)

Purpose:
Bulk soil samples from the PALAP excavations were selected for pH testing with the aim of further understanding the taphonomic processes and soil preservation qualities across the site. Specifically, testing the pH of the soil can inform us if we should anticipate differing levels of preservation of archaeobotanical, faunal, and ceramic remains in each trench or area.739

Procedure:
Approximately 20 grams of each bulk sample was stirred with 20 mL of de-ionized water (pH 7.01) in individual, clean glasses for 5 minutes each. Sample solutions were left to sit for 1 hour, after which time sample solutions were lightly stirred and a HANNA Instruments pH meter (HI 98128) was used to record the pH. The pH meter was calibrated with single-point calibration with a pH 7.01 buffer for the 2013 samples and with double-point calibration with pH 7.01 and pH 4.01 buffers for the 2014 samples. Temperatures of the samples solutions varied between 25.6 and 26.1°C. The instrument was cleaned in pH 7.01 de-ionized water in between measurements for each sample.

Results:
All 20 soil samples are demonstrative of alkaline soil environments, ranging from pH 8.03-9.06. These measurements indicate a low alkaline (basic) environment.

2013 Bulk Soil Sample pH Tests

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739 Goldberg and Macphail 2006: 47.
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