SVENSKA INSTITUTEN I ATHEN OCH ROM
INSTITUTUM ATHENIENSE ATQUE INSTITUTUM ROMANUM REGNI SUECIAE

Opuscula

Annual of the Swedish Institutes at Athens and Rome

9
2016

STOCKHOLM

MELISSA VETTERS, ANN BRYSBAERT, MARIA NTINOU, GEORGIA TSARTSIDOU & EVI MARGARITIS*

People and plants

Piecing together archaeological and archaeobotanical data to reconstruct plant use and craft activities in Mycenaean Tiryns

Abstract**

Archaeobotanical data are often employed to reconstruct a site's or a region's palaeoecology, human use of plants such as agricultural regimes, and the interplay between vegetation and anthropogenic factors in the palaeoenvironment. This paper aims to show that a context-specific integration of such data helps to guide the focus beyond the macroscale and may thus add significantly to the reconstruction of microscale activity areas. New archaeobotanical data from four different find spots in the Lower Citadel of Tiryns, Greece, dating to the Mycenaean Palatial and Post-Palatial periods highlight the importance of combining the analysis of the fruit/seed macroremains with anthracological and phytolith studies and integrating these results in their archaeological contextual study. Based on the data from botanical non-wood macroremains, wood charcoal, and phytoliths, the paper discusses methodological issues such as differential preservation of archaeobotanical remains that only becomes evident if more than one analytical method is employed. The paper additionally presents a contextual interpretation of archaeological finds and archaeobotanical remains that adds to a holistic picture of specific activity areas, production sequences, and the multifunctional use of installations.

Keywords: Mycenaean Tiryns, archaeobotany, anthracology, phytoliths, pyrotechnology

Introduction

The Aegean consists of very diverse ecological niches. Together, plant remains, palynological studies, and iconographic and epigraphic analyses of plants in use by various communities over time provide a general picture of the palaeoecology of several regions within the Aegean.

This paper presents a localized analysis of plant remains from the Late Bronze Age site of Tiryns in the Argolid, Greece (*Fig. 1*), in order to investigate questions of people-plant interactions in select 13th–12th century BC contexts. Tiryns is one of the most important sites of the Mycenaean period and has been archaeologically investigated for more than a century. During the Late Helladic (LH) period Tiryns probably acted as one of the main harbours of the Argolid. The site, located near the sea, comprised several settlement areas in the lowlands around the fortified citadel, which features one of the best preserved Mycenaean "palaces" of the 14th and 13th centuries BC (LH IIIA–B) on its highest plateau, the Upper Citadel. After the collapse of the Mycenaean palatial societies *c.* 1200 BC, Tiryns is one of the few sites on the

* MV and AB were responsible for the initiation, funding, and implementation of the project's content, contextual information, and overall editing of the paper. MN, GT, and EM contributed their specialist reports on the analyses of the anthracological, phytolith, and archaeobotanical macroremains respectively. The discussion of the results and the conclusions were a joint effort by all contributors.

** *Acknowledgements*

Research for this paper was carried out as part of the larger project "Cross-Craft Interaction in the cross-cultural context of the late Bronze Age Eastern Mediterranean" within the Leverhulme-funded Tracing Networks programme which we gratefully acknowledge. In addition, funds from the German-Israeli Foundation (grant no. 1080-132.4/2009, Research Project "Negotiating Change – Cultural and social transformations in the late 2nd millennium BCE East Mediterranean: case studies from Tiryns, Greece, and Tel es-Safi/Gath, Israel") were made available for laboratory and field-based analyses and we thank Professor Joseph Maran for facilitating this. We are very grateful for the permit to study material from the Lower Citadel and for continuing support by the director of the Tiryns excavations, Professor Joseph Maran. We especially thank the Ephor of the 4th Ephorate of Classical and Prehistoric Antiquities, Alkestis Papadimitriou, who provided us with the sediment samples from Room 10 and facilitated our sample applications, permit (permit no. Φ 7/815, 11.02.2013) and work in the Tiryns' storerooms. Georgia Tsartsidou would like to thank the M.H. Wiener Laboratory of the American School of Classical Studies in Athens for the use of their facilities. Ann Brysbaert would like to acknowledge her ERC Consolidator Grant (Project SETinSTONE, Grant no. 646667, duration 2015-2020) during which the majority of this paper was written and took its final shape. We thank our anonymous reviewers for their useful comments. Any errors remain our own.

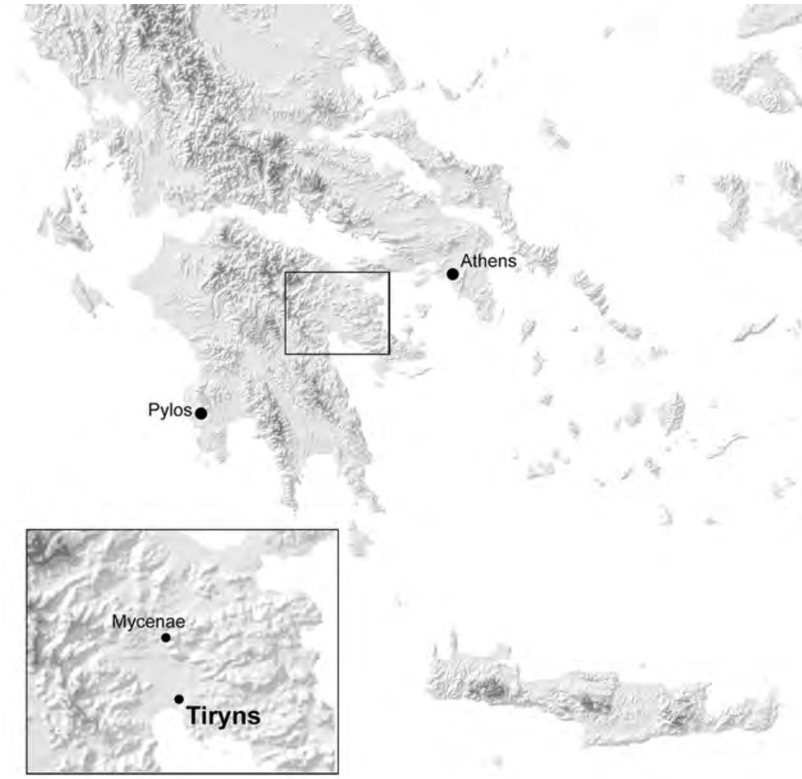


Fig. 1. Map of Greece indicating Tiryns in the Argolid; by Anavasis editions/Hans Birk, adapted by M. Vetters.

Greek mainland that seem to have witnessed an extension of its settlement area that flourished throughout the 12th century BC (LH IIIC).[1]

Heinrich Schliemann was the first to mention archaeobotanical finds from the Upper Citadel in Tiryns; in 1886 he reported "grape pips of unusually large size".[2] Almost a century later, Helmut Kroll published a detailed report on plant remains of the Mycenaean Late Palatial and Post-Palatial periods from various contexts in the Lower Citadel and from a settlement area outside and north of the citadel. Kroll also used the archaeobotanical evidence from Tiryns to discuss traits of Mycenaean agriculture and plant use in general.[3] A short report on plant finds from another Post-Palatial settlement area north-east of the citadel was published in 2006.[4] A brief general review based on the archaeobotanical residues in Tiryns recently summarized the evidence hitherto published.[5]

All these studies have in common a site-wide but not context-specific overview of the identified species and taxa. They are thus important for a general reconstruction of ecological and environmental conditions, agricultural regimes, and the use of specific plants in the later part of the LH period in Mycenaean Tiryns. From these, it seems that barley (*Hordeum* sp.) constituted the main cereal crop,[6] followed by einkorn (*Triticum monococcum*) and emmer (*Triticum dicoccum*); cereals were apparently stored in husked form to prevent damage to the seeds. Legumes were mostly represented by bitter vetch (*Vicia ervilia*) and to a lesser degree by lentils (*Lens culinaris*), chickpeas (*Cicer arietinum*) and peas (*Pisum sativum*).[7] Figs (*Ficus carica*) and grapes (*Vitis vinifera*) are abundantly attested while a notable increase in olive (*Olea europaea*) cultivation during the Mycenaean Palatial period is evidenced by frequent olive stones and charred olive wood representing the dominant taxa in the anthracological remains.[8] The archaeobotanical record has also provided evidence for a few "exotic"' species: pomegranate (*Punica granatum*) seeds were recorded,[9] next to

[1] For a general overview of the site and its history see Maran 2010; for Post-Palatial Tiryns see esp. Mühlenbruch 2013.
[2] Schliemann 1886, 93.
[3] Kroll 1982; 1984. For sampling procedures and methods of identification implemented in Tiryns and Kastanas see Kroll 1983, 21–24.
[4] Pasternak 2006.
[5] Mühlenbruch 2013, 278–281.
[6] Kroll 1982, 468.
[7] Kroll 1982, 476.
[8] Kroll 1982, 484.
[9] Kroll 1982, 477 fig. 1, 3, 482.

honey melon (*Cucumis melo*) seeds[10] and a single uncharred specimen of tentatively identified rice (*Oryza sativa*).[11] Other non-comestible usages of plant parts are observed too in the archaeobotanical record of Tiryns. Of interest are the roots of bugloss (*Echium* sp.), as a likely source of red dye; Kroll notes that bugloss is so common in the samples that it was probably intentionally collected and brought to the settlement for further processing.[12] He argues for intensified agriculture in the Late Palatial period near or even beyond the carrying capacity of the land coupled with intensive horticulture and an essentially similar, but less intensive, agricultural regime during the Post-Palatial period.[13]

Publications of archaeobotanical data for the Late Bronze Age Argolid are still few despite the long-term and large-scale excavations in this region with Tiryns providing most data so far.[14] This lack of data is partly due to the past excavation of large habitation areas without systematic sampling, and as a result archaeobotanical studies of areas within Mycenaean citadels have to deal with partial data sets.

While earlier publications offer a general picture of plant use and palaeovegetation, the analyses reported in this paper focus on the detailed, microscale interpretation of specific contexts. They also contribute towards the macroscale reconstruction of the whole site's or even region's ecology and plant management practices, which, however, in its entirety is beyond the scope of this paper.[15] The archaeobotanical samples described below were subjected to three different analyses: seed and other non-wood plant remains, wood charcoal, and phytoliths.

The major aim of this paper is to present a methodological discussion about the extent to which archaeobotanical remains, extracted from specific contexts indicating craft activities, can add to our knowledge of production sequences and practices reflected in perishable material that are often not integrated into discussions of activity areas or functional interpretations of archaeological features and inorganic finds. In analysing the archaeobotanical remains derived from four different find spots in the Lower Citadel of Tiryns, this interdisciplinary study also aims to throw further light on questions regarding plant-related practices and their local and regional palaeoenvironmental setting, as well as the archaeological interpretation of these contexts.[16] Tackling archaeobotanical data derived from unsystematic or incomplete sampling strategies often constitutes the last means to gain information on already excavated contexts and settlement areas. The current paper thus aims to outline problems, but also to indicate how context-specific archaeobotanical analyses may add important new data for interpretation. The major advantage of an integrated archaeobotanical study involving different categories of plant remains is that each method provides complementary information: woody species are identified by anthracology, seed and fruits are identified by the analysis of non-wood macroremains, while the unburnt parts of the plants (fruits, leaves, stems) can also be detected by the study of phytoliths. Therefore a greater range of past plant uses can be investigated.

Archaeobotanical non-wood macroremains, cultivated plants, fruits, and nuts as well as wild species enter the archaeological record in settlements as remains of specific human activities and are preserved in various ways (carbonization, mineralization, waterlogging, desiccation). In Greece the most common mode of preservation of macroremains is charring so the plants must have come in contact with fire and such a mode of preservation represents differential preservation of fruits and seeds in fires or hearths, which ended up there as refuse of consumption and domestic activities. It is thus important to interpret them by taking into consideration their contextual associations and attributes. Equally crucial is the composition of the samples: what kind of plant remains are present, and in what proportions, as these may be indicative of human activities and behavioural patterns.[17]

Wood charcoal macroremains are common finds in archaeological deposits since wood was used in the past for all kinds of domestic activities (notably as fuel and timber) and craftwork.[18] Different types of archaeological contexts and ways of deposition (e.g., as discarded fuel waste or *in situ* burnt fuel wood and timber remains) may provide information regarding the local vegetation of an area in the past, woodland management, and the use of woody plants in domestic and/or

10 Kroll 1982, 477 fig. 1, 6, 480–481.
11 Kroll 1982, 468, 477 fig. 1, 2.
12 Kroll 1982, 482.
13 Kroll 1984.
14 E.g. Iria and Synoro: Willerding 1973; Midea: Margaritis *et al*. 2014; Mycenae: Hillman 2011.
15 Animal bones and molluscs have been collected during the excavation campaigns, from which our samples derive, but the archaeozoological data have yet to be studied by specialists and thus cannot be incorporated into the current discussion; for a brief summary of previous archaeozoological studies in Tiryns see Mühlenbruch 2013, 273–278 with further references.
16 These contexts were initially selected for study, because the archaeological remains indicated craft activities, which AB and MV investigated on the basis of several case studies in the course of the project "Cross-Craft Interaction in the cross-cultural context of the late Bronze Age Eastern Mediterranean" (see http://www.tracingnetworks.ac.uk/content/web/cross_craft_interaction.jsp) that was part of the larger "Tracing Networks: Craft traditions in the ancient Mediterranean and beyond" research programme.
17 Fuller *et al*. 2014.
18 See Buchholz 2004 for a general overview. We thank Walter Gauß for this reference.

industrial activities.[19] The interpretation of the anthracological assemblages is based on the distinction drawn between:[20]

1. wood charcoal concentrated in hearth, oven, and kiln features, structural timber and/or undisturbed floor deposits with remains of charred furniture or installations. This material reflects short-term events, episodic use of firewood, and specific human activities such as construction;

2. wood charcoal found scattered in deposits that accumulated through time as a result of long-lasting activities (e.g., repeated episodes of fuel waste deposition over long periods of time). In this case wood charcoals represent long-term collection of the plant species available in the environment, mostly for fuel, and are thus likely to provide a representative picture of the past vegetation and its management through time.

Phytoliths, on the other hand, are microscopic inorganic bodies that do need to be charred in order to be preserved in the sediments. They consist of amorphous silica (opal) and develop in the cellular system of living plants.[21] The opal replicates the shape and the size of the cell in which it is formed and thus phytoliths can be classified botanically according to their morphology. They are released and deposited through decay-in-place mechanisms and for this reason the phytoliths constitute, in most cases, *in situ* microremains in archaeological sediments.

Sampled contexts and archaeobotanical methods

In order to discuss how archaeobotanical remains can aid in reconstructing production sequences and practices, both in craft activity areas but also in contexts beyond obvious crafting activities, the archaeobotanical remains of two pyrotechnological installations were investigated and compared with samples from a destruction deposit in an open space and from sediments within a room sealed by a destruction layer. These different contexts were chosen to present a variety of depositional incidents (multiple versus single-event) and, as such, were expected to contribute towards the reconstruction of the site's plant usage and management strategies. Although the samples from the specific case studies may only provide limited data on the general palaeoecology due to their small number, they were specifically selected to identify a variety of workshop and craft activities. The stratigraphy and small finds of these contexts had already been studied in detail.[22] Building on these archaeological studies, an integration of archaeobotanical data as the "least visible remains" in settlement contexts was deemed indispensable to more detailed reconstructions of past practices or *chaînes opératoires* involving people-plant interactions. We believe that an equally detailed study of the archaeobotanical material from these contexts aids in understanding the activities carried out there even better, and that the much more ephemeral people-plant interactions become, as such, more visible.

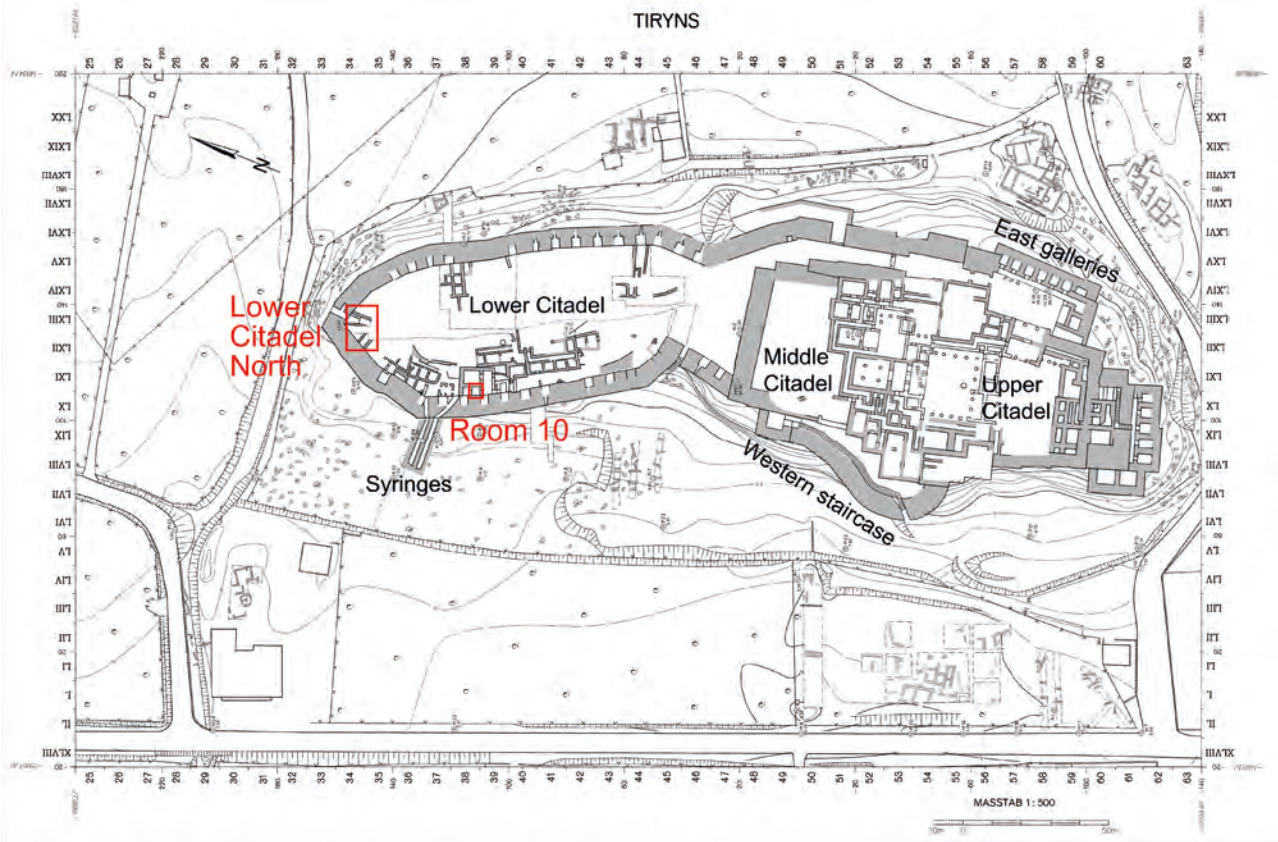
SAMPLED CONTEXTS

The Lower Citadel within the fortification walls constituted a densely inhabited and probably prosperous settlement area in the LH IIIB and C periods. Large-scale excavations in the 1970–1980s provided ample evidence for domestic, craft, and cult activities and the bulk of Kroll's archaeobotanical data from Tiryns stems from here. In 2000–2005 excavations within a larger *anastylosis* programme focused on the settlement area on the western side of the Lower Citadel and investigated several spaces not completely excavated previously. The results presented in this paper are based on analyses of archaeobotanical samples that were retrieved from four different contexts[23] (*Fig. 2*): Room 10, oven no. 46/03, Passageway and oven no. 79/02.

Room 10 (*Fig. 3*)

Room 10 is part of Building Complex A in the western central Lower Citadel and was in use during the Mycenaean Palatial period (phases LH IIIB Developed and Final, stratigraphic horizons[24] 17 a1-18). Building Complex A is the so far most elaborate building within the Lower Citadel during LH IIIB Developed/Final closely imitating palatial-style architecture with its deep foundations and massive walls, a column-flanked entrance, an internal staircase, and monolithic thresholds in all internal entrances.[25] Room 10 is a small interior basement room (measuring *c.* 7.50 m^2 with a ceiling of approximately 1.90 m height) in the north-west part of the building and constitutes a transitory area between Room 9 to the south and Room 7 to the north. The room witnessed two or three floor

[19] Asouti & Austin 2005; Badal *et al*. 2012; Chabal 1997; Damblon 2013; Fiorentino & Magri 2008; Thiébault 2002; Vernet 1992.
[20] Chabal 1997; Chabal *et al*. 1999.
[21] Piperno 2006.
[22] Brysbaert 2014; Brysbaert & Vetters 2010; 2013; 2015.
[23] Room 10: Brysbaert & Vetters 2013; Damm-Meinhardt 2015, 128–129; oven no. 46/03: Brysbaert 2014; passageway: Kostoula & Maran 2012; oven no. 79/02: Brysbaert & Vetters 2015; Vetters 2011.
[24] For the system of stratigraphic horizons in the Lower Citadel of Tiryns, see Rahmstorf 2008, 14; Mühlenbruch 2013, 3, table, 13–15.
[25] Damm-Meinhardt 2015.



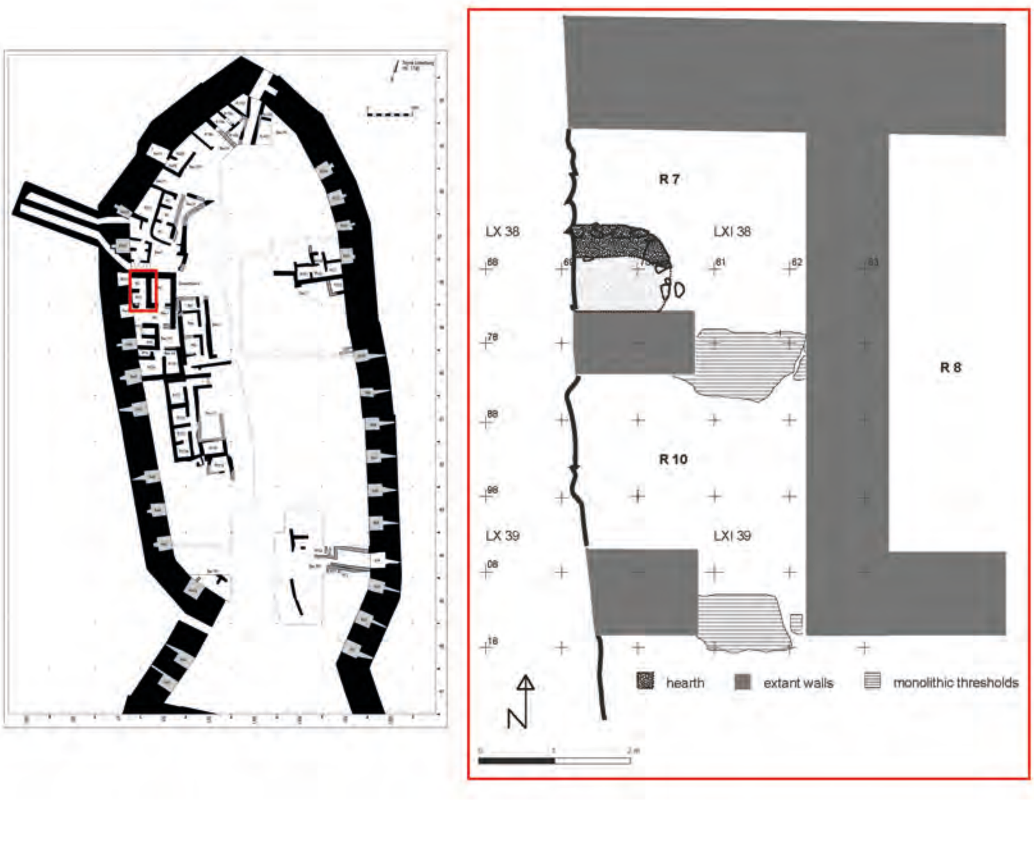


Fig. 2 (above). Plan of Lower Citadel indicating location of Room 10 and Lower Citadel North; plan courtesy of Joseph Maran/Tiryns Archive, adapted by M. Vetters.

Fig. 3 (left). Plan of Room 10 within Building Complex A (hor. 17, LH IIIB Developed and Final); plan based on excavation plans in the Tiryns Archive, adapted by M. Vetters.

renovations during its occupation in LH IIIB Developed and LH IIIB Final. Sediment samples from Room 10 (samples from find spots ΤΙΡΥΝΣ 22/09/2004 Ομάδα 117 *Χώμα από το γκρίζο στρώμα δωματίου* R10 LX 38/100, LXI 38/91.92, LX 39/10, LXI 39/01; at 13.23/13.21–13.11 masl), were taken from a baulk measuring *c.* 1 × 1.50 m and an east–west oriented soil socle beneath a later Archaic wall in an area of *c.* 2 × 0.50 m in the south part of the room, which had been left standing since Klaus Kilian's excavations in the late 1970s and early 1980s. The samples presumably come from what Kilian described as thick, dark, and ashy layers with intervening lighter ash lenses on top of a floor.[26] Apart from this ashy layer, heavy traces of fire were previously noted only in the south-west corner of the adjacent Room 7 (next to the entrance of Room 10), where excavations had unearthed a roughly semi-circular clay platform that was lined by a double row of stones.[27] Based on the finds (a few ground stone artefacts but no evidence for tool kits, no debitage or other production waste, almost no semi-finished objects, a single small lump of metalliferous ore, several terracotta figurines on subsequent floor levels, and drinking vessels in the final destruction debris which had apparently fallen down from an upper storey and were warped due to high temperature exposure),[28] Kilian interpreted Room 10 as a place for small-scale craft activities.[29] Kroll analysed two archaeobotanical samples from the north and north-west part of the room that apparently originate from the ash layer and contained a rather large amount of archaeobotanical remains. He identified abundant fig remains (mostly uncharred), some grape pips and olive stones, emmer and einkorn, fewer barley grains, as well as a few lentils and chickpeas.[30] No mention of storage features was made by Kilian and there is no evidence for built-in storage containers or removable storage vessels in the published reports either, but the room's elaborate thresholds indicating wooden doors held in wooden door frames suggest that the room's contents could easily be safeguarded.

Since Room 10 featured no fireplace or hearth and the small finds are rather ambiguous with regard to metallurgical or at least pyrotechnological activities, the possibility that Room 10 constituted a small space, where pyrotechnological crafts were conducted, appeared to be difficult to establish, given also that the room had been excavated entirely. However, new sediment samples taken in 2004 offered the opportunity first to investigate further this possibility by studying the formation of the ash layer through integrated archaeobotanical analyses, and, second, to reassess the room's function.

The three other sets of archaeobotanical samples (2–4 in the list above) were retrieved in the Lower Citadel North during renewed excavations in the north-west Lower Citadel under the direction of Joseph Maran, in an area that had already been partly excavated by Kilian in 1982–1983. The samples were taken in three different locations within the area of the Final Palatial Building XI and are assigned to three different chronological phases. They derive from Palatial and Post-Palatial layers on the west terrace where Building XI was erected in the Final Palatial period, and from a stratum in the passageway, which, at least by the time of LH IIIB Developed, ran from north to south across the Lower Citadel. Each of these is described in some detail below.

Oven no. 46/03

The stratigraphically oldest archaeobotanical sample (from find spot LXIII 34/21 VIF no. 46/03), was taken from an ash layer inside and around a mudbrick feature in the form of a horseshoe-shaped oven (TN 18;[31] no. 46/03, *Figs. 4–5*) that came to light in a small area underneath the south-east part of the LH IIIB Final Building XI.[32] Since later remains restricted the area available for investigation, only parts of this stratum could be excavated: remnants of an architectural structure consisting of two perpendicular walls with a mudbrick superstructure[33] and a floor between the walls.[34] The north and east borders of this "room" have not been excavated. However, part of a compact surface horizon ("Laufhorizont"), i.e. a trampled and unroofed area which underwent modifications at least once, was found immediately south of these walls and probably formed an exterior well frequented surface horizon of the partially excavated building, provisionally dated to LH IIIB Early/Middle.[35] Oven no. 46/03 was excavated on the older trampled surface, but the younger trampled surface still abutted against its west side. The oven was apparently not covered on the top[36] and opened towards the south. The sampled ashy layer, which surrounded the oven and was also found inside it, sloped from its northern interior face to its southern exterior. One of the main questions with regard to this rather sturdily built oven was whether the small finds and the archaeobotanical remains from its ashy fill may hold clues to its use. In

[26] Kilian 1981, 175–176; Rahmstorf 2008, 251–254; Damm-Meinhardt & Mühlenbruch 2013, plan 22.
[27] Verdelis 1964, 116 fig. 4, pl. 116e; Grossmann & Schäfer 1971, 49 n. 61, pl. 31, 1.
[28] See Rahmstorf 2008, 251–254, pls. 113–115; Damm-Meinhardt 2015, 126, 128–129.
[29] Kilian 1981, 176.
[30] Kroll unpublished archaeobotanical lists.
[31] Tracing Networks Database number.
[32] Brysbaert 2013a.
[33] Maran 2008, 39 fig. 2.
[34] Maran 2008, 38–39.
[35] A detailed ceramic analyses forms part of an ongoing Ph.D. thesis by Soňa Wirghová at the University of Heidelberg.
[36] Maran 2008, 39 fig. 3.

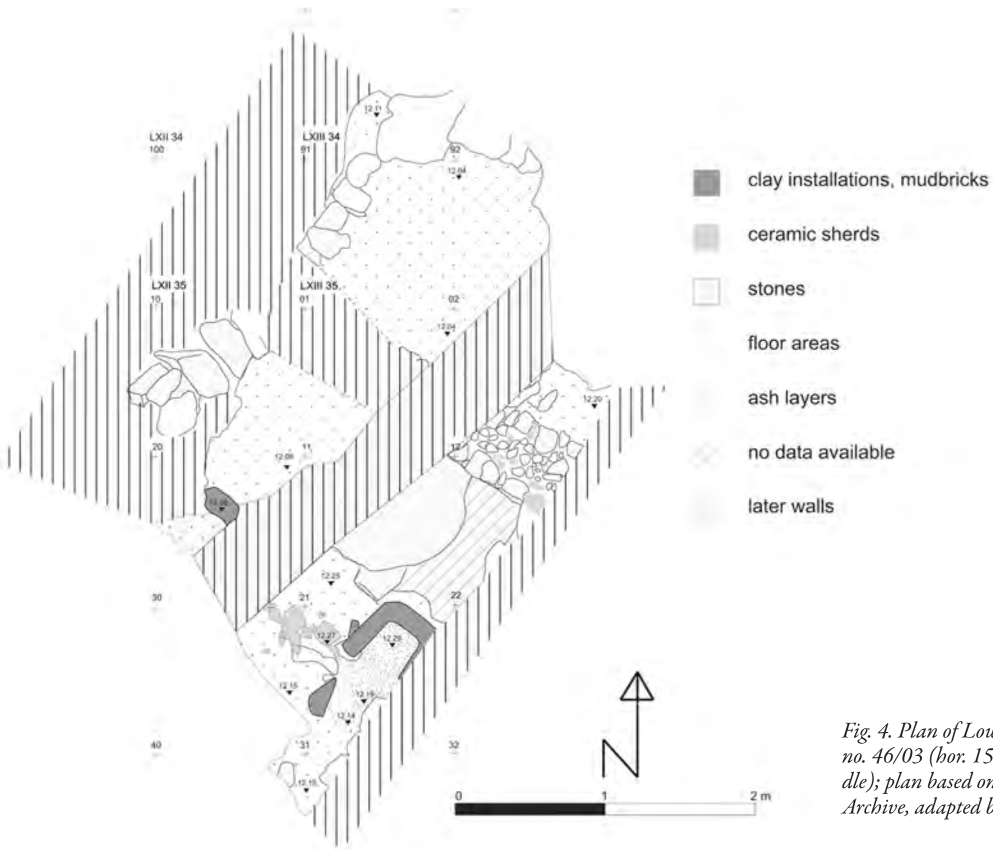


Fig. 4. Plan of Lower Citadel North, area of oven no. 46/03 (hor. 15–16, LH IIIB Early/Middle); plan based on excavation plans in the Tiryns Archive, adapted by M. Vetters.

Fig. 5. Photo of oven no. 46/03, courtesy of Joseph Maran/Tiryns Archive, Tiryns excavation photograph film-2003-29-25.

other words, do the data suggest various contemporaneous or sequential uses, i.e. perhaps as a multifunctional installation, and are they solid enough to support such an interpretation? Starting with an archaeological assessment of the context, horseshoe-shaped clay installations or box-oven constructions are not a frequent feature in the domestic architecture of the Lower Citadel and elsewhere. A concentration of such ovens, attested in the Post-Palatial Lower Citadel North, evokes the impression that they were used on an industrial scale[37] (e.g., as metallurgical kilns) rather than as simple hearths and fireplaces. Yet Kilian posited multifunctional uses, even for an oven that clearly contained fragmentary metallurgical debris.[38] The small finds associated with the LH IIIB Early/Middle oven

[37] For a more detailed discussion about the meaning of "industrial scale", see the forthcoming monograph on the Tracing Networks project (in preparation).
[38] Kilian 1988, 126–130.

Fig. 6. Photo of destruction debris on passageway; courtesy of Joseph Maran/Tiryns Archive, Tiryns excavation photograph film-2002-2-2.

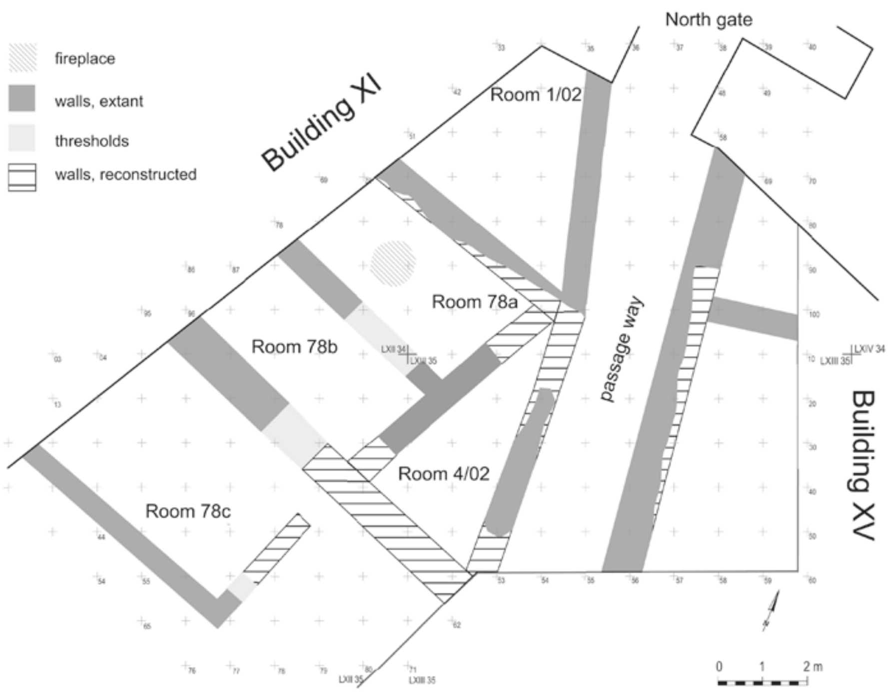


Fig. 7. Plan of Lower Citadel North excavation area indicating the location of the passageway (hor. 17 a5, LH IIIB Final); plan courtesy of Joseph Maran and Maria Kostoula/Tiryns Archive, adapted by M. Vetters.

no. 46/03 do not suggest its use for metallurgical activities, as neither metal artefacts nor slag or crucible fragments were retrieved from it. However, a burnt ostrich eggshell fragment[39] may indicate other craft activities associated with it.

Passageway

Samples from the passageway (find spots LXIII 35/24.34 IVH, LXIII 35/33.34.43.44 V, LXIII 35/34 VA) derive from an ashy layer on top of its last Palatial surface ("Laufhorizont") (*Fig. 6*) connecting the North Gate of the Lower Citadel with the Middle and ultimately the Upper Citadel (*Fig. 7*). The passageway dissects the Lower Citadel from north to south

[39] See the discussion in Brysbaert 2013a.

Fig. 8. Photograph of LH IIIC Developed courtyard with ovens; courtesy of Joseph Maran/Tiryns Archive, Tiryns excavation photograph film-2002-17-13.

and connects the settlement in the Lower Citadel with the suburbs outside the fortified hill via the North Gate. During the Late Palatial period (LH IIIB Final, stratigraphic horizons 17 a5-18) the northern part of the passageway was flanked by Building XI on a lower terrace to the west and Building XV on a higher terrace to the east. In recent publications Building XI has featured as one of the clearest archaeological contexts for a craft workshop area in Tiryns.[40] The building is situated immediately south-west of the North Gate and is bounded on its western side by the inner façade of the fortification wall. No built ovens or hearths were excavated in Building XI except for the central fireplace in Room 78a that yielded unique finds not attested elsewhere in Tiryns and Mycenaean Greece and evidence for intricate and highly specialized craft activities.[41] South-east of Building XI's façade an approximately 20 cm thick ashy layer[42] was discovered on top of the LH IIIB Final surface of the passageway[43] and comprised burnt debris from the Final Palatial destruction layer (stratigraphic horizon 18). During excavation, no fallen mudbricks from collapsed walls (from an upper storey of Building XI to the west or Building XV to the east) were recorded in the destruction deposit of the passageway.[44] Also, the walls of Building XI do not seem to have supported an upper storey and there are no indications within that architectural structure of finds or features that could have collapsed from an upper storey. Within the ashy layer, several largely preserved vessels, *inter alia* a Canaanite amphora with Cypro-Minoan signs[45] on its handles, a wall bracket, a so-called Levanto-Helladic chalice, and fragments of a faience rhyton in the form of an animal's or demon's head were excavated.[46] These finds, and even more so the combination of such rather "exotic" objects[47] point to close contacts beyond mere trade with other communities within the Eastern Mediterranean basin, likely Cyprus or the Levantine coast, during the end of the Palatial period.[48]

Oven no. 79/02

The remaining samples derive from a horseshoe-shaped, well-built Post-Palatial mudbrick oven (TN 367, excavation no. 79/02) discovered in layers above Building XI (find spots LXIII 35/21 VA no. 79/02: surface above/around oven; and LXIII 35/11 VC no. 79/02, LXIII 35/11.21 VI no. 79/02: seven samples in and outside the oven). The Post-Palatial occupation during LH IIIC Developed (stratigraphic horizon 20) partially reused the walls of Palatial Building XI and consisted of a suite of two rooms with an interior courtyard that was bordered by a terrace wall to the east,[49] which separated this area from the passageway (*Fig. 8*). At least three mud-

[40] E.g. Kilian 1984; Maran 2008; Kostoula & Maran 2012; Brysbaert & Vetters 2010; 2013; 2015, 164, 167 fig. 4; Brysbaert 2014.
[41] Rahmstorf 2015, 146.
[42] Maran 2008, 56.
[43] Maran 2008, 55 fig. 33.
[44] Maran 2008, 56 *contra* Kilian 1988, 108.
[45] On the frequent occurrence of Cypro-Minoan signs in Tiryns see recently Davis *et al*. 2014 with further references.
[46] Maran 2008, 56–57 figs. 35–38; Kostoula & Maran 2012.
[47] For a discussion of the "exotica" concept see Brysbaert & Vetters 2013.
[48] See also Maran 2009, 246 figs. 2–3, 247.
[49] Again a reused Palatial wall, Maran 2008, 67.

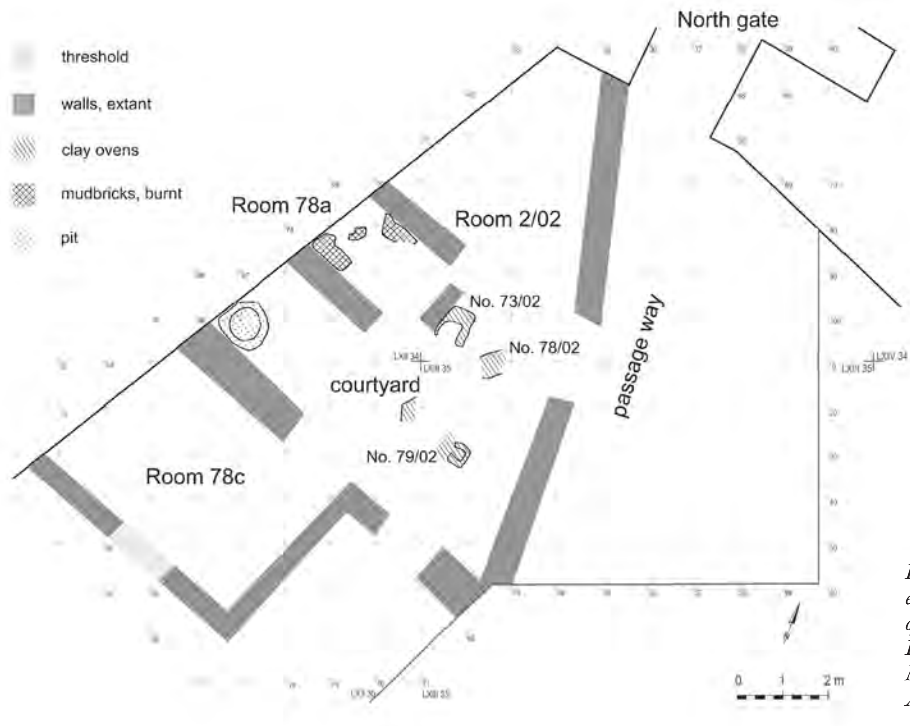


Fig. 9. Plan of Lower Citadel North excavation area indicating the location of oven no. 79/02 (hor. 20 a3, LH IIIC Developed); plan courtesy of Joseph Maran and Maria Kostoula/Tiryns Archive, adapted by M. Vetters.

brick ovens cluster in the north and east of the courtyard (*Fig. 9*).[50] Other fragmentarily preserved rectangular clay installations were found near oven no. 79/02.[51] The concentration of such mudbrick installations in a single area is without parallel in the Post-Palatial Lower Citadel and, supported by the finds reported from it (especially copper alloy scraps and lead spills),[52] suggested these features to be installations for long-lasting and varied pyrotechnological activities. The sampling of the ash from oven no. 79/02 (*Fig. 10*) set out to test this assumption by determining which materials were burnt in the oven, to probe into what temperatures may have been attained during firing, and whether the archaeobotanical finds might indicate a metallurgical use for this oven.

Fig. 10. Photograph of oven no. 79/02; courtesy of Joseph Maran/Tiryns Archive, Tiryns excavation photograph film-2002-9-13.

SAMPLING METHODS

The sediment samples from the baulk in the southern part of Room 10 were collected by archaeologists of the 4th Ephorate of Classical and Prehistoric Antiquities in September 2004. The ashy sediment samples stem from a *c.* 10 cm thick layer,

---

[50] Maran 2008, 67–68, figs. 56–57.
[51] Maran 2008, 67 fig. 56, no. 78/02, and TN 366; Maran 2008, 67 fig. 56, no. 73/02.
[52] Brysbaert & Vetters 2010; 2015, 173–175 with fig. 5; 177 fig. 6.

constituted *c.* 98 litres of sediments (*Table 1*), and were processed with machine-assisted water flotation in 2013.

The archaeobotanical samples from the Lower Citadel North area were retrieved during excavations in 2002 and 2003 as part of a larger sampling programme directed by Professor J. Maran. Samples were taken from every destruction or floor deposit and from any sediment rich in charred remains or organic content, especially from areas with ash concentrations. Two different types of samples were collected: (1) sediment samples (15 from the LH IIIC Developed oven area and the LH IIIB Final passageway ranging from 4–60 litres)[53] and (2) so-called "archäobotanische Proben" from ash concentrations, i.e. the ashes in and around ovens no. 46/03 and no. 79/02, as well as hand-picked charred wood remains. Macroscopically visible wood charcoal, other charred remains, ash concentrations around the mud-brick installations, and an ostensible destruction ash layer on top of the passageway were specifically sampled to investigate in more detail the pyrotechnological installations and ashes in destruction layers and were stored separately. These 17 samples from the Lower Citadel North (seven from the passageway, nine from oven no. 79/02 and one from oven no. 46/03) were processed for analysis within the Tracing Network (TN) programme that aims to investigate craft and especially pyrotechnological activities in the Lower Citadel in more detail. This paper presents the results of the analyses of all those separately kept archaeobotanical samples, which consisted of *c.* 0.5 litre of ashy sediment and several hand-picked charred wood remains from the clayey matrix on the passageway, *c.* 6 litres of ashy sediment from oven no. 79/02, and a single ash sample from oven no. 46/03 (*Table 1*). Therefore, we present partial data to complement both our own TN data[54] for more in-depth knowledge of the case studies and Dr Pasternak's broader work on the archaeobotanical macroremains. Although the sample size is small, the "archäobotanische Proben" actually comprised all ashes found within (and immediately outside) the ovens and the main concentration of charred wooden pieces on the passageway.

Despite the small sample size the separately kept samples from the Lower Citadel North area offered the only sediments still available for archaeobotanical analyses (i.e. fruit and seed macroremains, wood charcoal, and phytoliths) and thus allowed the testing of different analytical methods to reconstruct the formation and properties of the respective ashes. The situation was slightly different for Room 10: here, the analysed samples constituted the last chance (because the room had been excavated entirely) to probe into the ash layer and the interpretation of the room's function based on it. However, one advantage of our samples from the Lower Citadel North area is actually their small volume and their collection from circumscribed and macroscopically easily visible ash concentrations. They stem from either well-protected spaces within the ovens or, when from the oven's exterior or the passageway, from distinct ash concentrations on floors, where no perturbations were observed during excavation; vertical or horizontal displacement of botanical remains is thus very unlikely. Samples from Room 10 do not stem from such controlled sampling as the baulk area in the southern part of the room had stood exposed for more than 25 years before samples were taken and some vertical displacement of archaeobotanical remains by insect or small animal perturbations may have occurred. However, the large volume of the sample from a mere 10 cm thick layer and the analytical results which are in good agreement with results from other samples (see below) both militate against contamination.

The samples discussed in this paper pose several methodological problems but these issues merit being tackled explicitly and in detail, instead of being relegated to appendices that are not well integrated to their main publication reports. We believe that combined analyses of seed and plant remains and anthracological and phytolith studies, which had not yet been implemented in Tiryns, could significantly help fill some gaps in the archaeological interpretation.

Seed/fruit and anthracological remains

A total of 21 samples (sediment and hand-collected charred botanical macroremains) were available for archaeobotanical analyses (*Table 1*). Of these 15 were sediment samples from ash deposits (eleven were labelled as "archäobotanische Proben" and were collected from the area of the Lower Citadel North and four were recovered from Room 10) (*Table 1*). The remaining six samples, labelled "Holzkohleprobe", were collected by hand during the excavation in the Lower Citadel North (*Table 1*).

The volume of the sediment samples was variable (*Table 1*). All the samples from the Lower Citadel North were small, their volume ranging from 100 ml to 1 litre maximum. We therefore considered that water sieving with a 300 μm sieve was preferable for these small samples. Larger samples (24–26 litres each) from Room 10 were processed by flotation using the same sieve mesh for the flots while 1 mm mesh size was used for retaining the heavy residues. The flots and the heavy residues, once dry, were sorted for wood charcoal and non-wood charred macroremains. Wood charcoal fragments >2 mm were separated from the flots and heavy residues for anthracological analysis. For non-wood charred macroremains

[53] The plastic-bagged sediment samples had already been processed by water flotation and analysed by Dr Rainer Pasternak and will be published separately.
[54] Brysbaert & Vetters 2010; 2013; 2015.

Table 1. List of analysed archaeobotanical samples from the Lower Citadel North.

Location	*Context*	*Description*	*Sample type*	*Volume*	*Method*
LX 38/100, LXI 38/91.92 LX 39/10, LXI 39/01	Room 10, OM 117	elevation 13.23–13.21/13.11	sediment	26 lit	flotation
LX 38/100, LXI 38/91.92 LX 39/10, LXI 39/01	Room 10, OM 117	elevation 13.23–13.21/13.11	sediment	24 lit	flotation
LX 38/100, LXI 38/91.92 LX 39/10, LXI 39/01	Room 10, OM 117	elevation 13.23–13.21/13.11	sediment	24 lit	flotation
LX 38/100, LXI 38/91.92 LX 39/10, LXI 39/01	Room 10, OM 117	elevation 13.23–13.21/13.11	sediment	24 lit	flotation
LXIII 35/21 VIF	oven no. 46/03	oven, ash outside	sediment	200 ml	water sieve
LXIII 35/33 V	passageway	ash	sediment	200 ml	water sieve
LXIII 35/34 V	passageway	ash	sediment	300 ml	water sieve
LXIII 35/24 IVH	passageway	ash	wood charcoal		
LXIII 35/34 IVH	passageway	ash	wood charcoal		
LXIII 35/44 V	passageway	ash	wood charcoal		
LXIII 35/34 VA	passageway no. 46/02	ash	wood charcoal		
LXIII 35/43 V	passageway	ash	wood charcoal		
LXIII 35/11 VC	oven no. 79/02	ash	sediment	100 ml	water sieve
LXIII 35/11 VI	oven no. 79/02	northern wall, interior	sediment	100 ml	water sieve
LXIII 35/11 VI	oven no. 79/02	inside	sediment	1 lit	water sieve
LXIII 35/11 VI	oven no. 79/02	outside	sediment	900 ml	water sieve
LXIII 35/21 VI	oven no. 79/02	outside	sediment	800 ml	water sieve
LXIII 35/21 VI	oven no. 79/02	inside	sediment	a) 700 ml b) 600 ml c) 200 ml d) 300 ml e) 400 ml f) 200 ml	water sieve
LXIII 35/21 VI	oven no. 79/02	inside	sediment	250 ml	water sieve
LXIII 35/21 VI	oven no. 79/02	oven, rear wall, interior	sediment	300 ml	water sieve
LXIII 35/21 VA	oven no. 79/02	surface above/around oven	wood charcoal		

the flots were sorted in their entirety and so were the heavy residues.

In general the macroremains were few (number of items per litre of sediment floated) with the exception of the samples from Room 10. This is certainly related to the small volume of sediment samples from the Lower Citadel North studied in our project. Moreover, in all samples the wood charcoal remains were very brittle and small (mostly <2mm with very few charcoal fragments 2–4mm). This is perhaps the effect of persistent and strong fire that affected the deposits resulting in thick ash concentrations.

The botanical identification of the wood charcoal remains recovered by means of the above-mentioned processes as well as of the "Holzkohleprobe" was carried out at the Tiryns storerooms with an Olympus BH2-UMA metallurgical dark/bright field incident light microscope (X50–X500 magnification). Schweingruber's wood anatomy atlas was consulted for comparisons with the archaeological material.[55] The wood charcoal pieces were fractured by hand and the three basic anatomical planes, transverse, tangential longitudinal, and radial longitudinal were observed. Some of the specimens were identified to species level[56] and others only to genus level due to great anatomical similarity of the species included in these genera. A few specimens were identified to family level while the prefix "cf" was used in those cases where strong similarity to a particular genus or species was observed but the specific anatomical features for the identification were missing. Due to scarcity of macroremains in most sampled contexts, the results of charcoal identifications are presented in the form of fragment counts per taxon. Following descriptions of the potential and present-day vegetation of the Peloponnese,[57] the identified taxa have been grouped into vegetation types (*Table 3*). This procedure would help to identify the origin of the woods used in the different contexts and to discuss the choices made in relation to different wood uses (timber, firewood) as well as the procurement strategies. In the case of Room 10, where wood charcoal macroremains were more numerous, the results are also presented as percentage fragment counts.

The non-wood plant remains were identified on the basis of botanical atlases[58] and according to the criteria described by Zohary *et al*.;[59] it should be noted that the material is highly distorted and fragmented.

Phytoliths

In total 18 sediment samples (T1–T18; *Table 2*) have been analysed for phytoliths. These samples consist of: (1) the ashy sediment from Room 10. Four bags with ashy sediment stored in the Tiryns store rooms have been analysed. The sediment from each bag was homogenized and then 1 gram was selected for analysis; (2) ash and clay lumps collected from the interior and the exterior of ovens (oven no. 46/03 and oven no. 79/02); and (3) white sediment remains (ash) collected from the passageway. The samples were analysed at the M.H. Wiener Laboratory of the American School of Classical Studies at Athens. The method implemented is outlined below.[60]

The sediment was heated in a furnace at 500° C for 4 hours. The ash was dried and weighed in order to acquire the information of the organic loss after ashing. The ash was then transferred in glass vials and treated with 1N HCl in order to remove the calcite. The solution was dried under a heat lamp and weighed. This constituted the acid insoluble fraction (AIF), i.e. the fraction that contains no organics and no carbonates. The AIF was transferred into a centrifuge tube and 5 ml of non-toxic heavy liquid (Sodium polytungstate) solution with 2.4 g/ml density was added. The suspension was sonicated for 10 minutes until it was well dispersed. It was then centrifuged at 3,500 rpm for 20 minutes. The supernatant was transferred to another centrifuge tube; 1 ml of water was added and again centrifuged as above. This cycle was repeated once more and then the tube was filled with water for the final centrifugation and wash. In so doing the denser minerals (quartz, clay) were separated from the less dense silica which has a density between 1.5–2.3 g/ml in four stages yielding pellets of minerals greater than 2.4, 2.0, 1.7 and 1.5. The last two fractions that contained all the phytoliths were weighed dry. About 1 mg of each of these fractions was accurately weighed and then placed on two slides. Entellan glue (Merck) was added and cover slips were lowered carefully over the well-mixed suspensions. The slides were analysed under a petrographic microscope. The assemblages were studied morphologically and quantitatively: phytoliths were counted and taxa were classified. Ideally 200 phytoliths were counted in each slide, when possible, since it has been demonstrated that the counting of 194 phytoliths gives an error of ±23%. The total number of phytoliths on the slide was then determined and related to 1 gram of sediment and 1 gram of AIF.[61] In terms of morphology, the assemblage of phytoliths is divided into two major categories: those with consistent morphologies and those with variable morphologies.[62] The latter represents in most cases the wood component of a sample.[63] Phytoliths with consistent morphologies are classified in families, genera, and species whenever possible as well as the part of the plant involved (e.g. leaves of dicotyledonous [hereafter: dicot] trees or shrubs, grass stems or grass husk-inflorescence, seeds from dicot plants).

Another proxy that was detected in the samples was spherulites. The latter are calcitic spheres formed in animal guts[64] and are commonly found in dung remains. For investigating their presence in the samples loose sediment was examined under the microscope before chemical treatment using Entellan glue and a cover slip.

55 Schweingruber 1990.
56 The species *Pinus nigra* is clearly distinguished from other Pinus species with the exception of *P. sylvestris*, which is anatomically very similar. However the latter is restricted to the Pieria Mountains and the northernmost mountain ranges of Greece and therefore on ecological grounds could not have possibly grown in the Peloponnese now or in the Bronze Age.
57 Bohn *et al*. 2000/2003; Quézel & Barbéro 1985.
58 Cappers *et al*. 2009.
59 Zohary *et al*. 2012.
60 See also Tsartsidou *et al*. 2008.
61 Albert & Weiner 2001.
62 Albert 2000.
63 See Albert 2000; Piperno 2006; Tsartsidou *et al*. 2007; 2008; 2009.
64 Canti 1999.

Table 2. Phytolith concentrations per gram sediment; the amount of organic as well carbonate component is shown in the table.

Samples	*Provenience*	*Description*	*Starting grams*	*Ash grams*	*Organics %*	*AIF grams*	*Carbonates %*	*Phytoliths/g sediment*
T 1	Clay installation/oven inside TI 02 LXIII 35/21 VI no. 79/02	white spots	0.5431	0.4954	8.78	0.3288	30.68	367225
T 2	Room 10 ομάδα 117 LX 38/100, LXI 38/91.92, LX 39/10, LXI 39/01 13.23–13.21/13.11	grey ashy sediment	1.1226	1.0737	4.36	0.8189	22.70	1931160
T 3	Room 10 ομάδα 117 LX 38/100, LXI 38/91.92, LX 39/10, LXI 39/01 13.23–13.21/13.11	grey ashy sediment	0.9926	0.9594	3.34	0.7134	24.78	3007858
T 4	Room 10 ομάδα 117 LX 38/100, LXI 38/91.92, LX 39/10, LXI 39/01 13.23–13.21/13.11	grey ashy sediment	0.9176	0.8852	3.53	0.6471	25.95	2458920
T 5	Room 10 ομάδα 117 LX 38/100, LXI 38/91.92, LX 39/10, LXI 39/01 13.23–13.21/13.11	grey ashy sediment	0.9605	0.9241	3.79	0.7341	19.78	2310326
T 6	Room 10 ομάδα 117 LX 38/100, LXI 38/91.92, LX 39/10, LXI 39/01 13.23–13.21/13.11	grey ashy sediment	1.1174	1.0645	4.73	0.8191	21.96	2788167
T 7	Clay installation/oven inside TI 02 LXIII 35/21 VI no. 79/02	clay matrix of sample T 1	0.5395	0.5206	3.50	0.4039	21.63	297225
T 8	Clay installation/oven inside TI 02 LXIII 35/11 VI no. 79/02	white spots	0.6535	0.6280	3.90	0.3875	36.80	570378
T 9	Clay installation/oven inside TI 02 LXIII 35/11 VI no. 79/02	clay matrix of sample T 8	1.0529	0.9952	5.48	0.8773	11.20	522785
T 10	Clay installation/oven outside TI 02 LXIII 35/11 VI no. 79/02	white spots	1.0342	0.9944	3.85	0.7467	23.95	624289
T 11	Clay installation/oven outside TI 02 LXIII 35/11 VI no. 79/02	matrix of sample T 10	0.7487	0.7171	4.22	0.5661	20.17	40500
T 12	Clay installation/oven outside TI 02 LXIII 35/21 VI no. 79/02	white spots	0.3513	0.3358	4.41	0.1907	41.30	735968
T 13	Clay installation/oven outside TI 02 LXIII 35/21 VI no. 79/02	matrix of sample T 12	0.9578	0.9155	4.42	0.6647	26.19	795239
T 14	Clay installation/oven inside TI 02 LXIII 35/21 VI no. 79/02	all sediment	1.1719	1.0407	11.20	0.7073	28.45	847742
T 15	TI 03 LXIII 35/21 VIF no. 46/03	ash inside oven	1.0569	1.0384	1.75	0.4380	56.81	45830
T 16	TI 02 LXIII 35/33 V passageway	ash and charcoal scratched from the surface of clay chunks	0.9603	0.8550	10.97	0.5924	27.35	118784
T 17	TI 02 LXIII 35/34 V passageway	white spots (not very clean)	0.5251	0.5140	2.11	0.3041	39.97	157332
T 18	TI 02 LXIII 35/34 V passageway	yellowish clay matrix with ashy parts of T 17	1.0538	1.0308	2.18	0.8361	18.48	373392

Table 3. Results of anthracological analysis of investigated contexts in the Lower Citadel North; identified taxa and their absolutely frequency are shown and the vegetation types to which they correspond are indicated.

Taxa	***Room 10***	***Passageway***	***Oven no. 46/03***	***Oven no. 79/02***		
				Inside	***Outside***	
Abies sp.	1	2		3	1	Mediterranean mountain conifer forests
Cf. *Abies* sp.		1				
Pinus nigra	35				1	
Olea europaea	112	1	1	4	1	Cultivated and/or thermophilous, open woodland
Prunus amygdalus	2					
Fabaceae	16			1		Undershrub, scrub vegetation
Maloideae	6				2	
Prunus spinosa/P. amygdalus	4					
Quercus sp. evergreen	4				2	Mesomediterranean woodland and/or maquis vegetation
Quercus sp. deciduous		1	1	3		
Quercus sp.	5	6		1	1	
Cf. *Fraxinus* sp.		1				
Ficus carica		1				
Cf. *Ficus carica*				1		
Angiosperm	9				1	
Conifer	1	1				
Bark		6				
Unidentifiable	2				1	
Total	**197**	**20**	**2**	**13**	**10**	

Results

The seeds present in the assemblage are very limited in number, although they represent a wide range of cereals, pulses, fruits, and nuts, and also wild species (see *Table 3*). More particularly, cereals are represented by barley (*Hordeum* sp.), emmer (*Triticum dicoccum*), pulses by lentils (*Lens* sp.) and bitter vetch (*Vicia ervilia*), fruits by olive (*Olea europaea*), grape (*Vitis vinifera*), and fig (*Ficus carica*), nuts by almond shells (*Prunus amygdalus*), and wild species only by darnel (*Lolium temulentum*). All the material is very fragmented most likely due to the exposure to high temperatures.

In the case of the anthracological samples presented here, their correlation with the content of ovens and ash deposits inside buildings and/or on top of floors obviously reflects short-term use and specific activities, e.g. firewood use or construction. *Table 3* presents the plant taxa identified in each one of the four different contexts sampled in the Lower Citadel North and the vegetation types (according to modern vegetation maps and surveys)[65] to which they correspond. At least ten arboreal taxa were identified in the sampled contexts: *Abies* sp. (fir), *Pinus nigra* (black pine), *Olea europaea* (olive), *Prunus amygdalus* (almond), Fabaceae (woody shrubs of the pulse family), Maloideae (small trees of the wild pear family), *Ficus carica* (fig), cf. *Fraxinus* sp. (ash), deciduous *Quercus* sp. (deciduous oak), and evergreen *Quercus* sp. (evergreen oak). They are all native to the Peloponnese representing different vegetation types and bioclimatic zones as well as cultivated trees. The lowland and coastal areas would have been characterized by thermomediterranean, sclerophyllous forests with xerophytic scrub in which olive, evergreen oaks, small trees of the *Prunus* and Maloideae, and shrubs of the Fabaceae would have grown among others. Mesomediterranean woodland with evergreen oaks and xerophytic scrub would have grown on the hinterland hills and the lower parts of the mountain slopes. Deciduous oaks would have also grown in these wood-

[65] Bohn *et al*. 2000/2003; Polunin 1980; Quézel & Barbéro 1985.

Table 4. Results of anthracological analysis in Room 10.

Room 10: ομάδα 117 , LX 38/100, LXI 38/91.92, LX 39/10, LXI 39/01						
Samples	***1***	***2***	***3***	***4***	***Total Room 10***	
Taxa	***n***	***n***	***n***	***n***	***n***	***%***
Abies sp.			1		1	0.51
Fabaceae		3	7	6	16	8.21
Maloideae	1	2	2	1	6	3.08
Olea europaea	18	39	32	23	112	57.44
Pinus nigra	6	8	12	9	35	17.95
Prunus amygdalus		2			2	1.03
Prunus spinosa/P. amygdalus	1			3	4	2.05
Quercus sp.	3	1		1	5	2,56
Quercus sp. evergreen	1	1	2		4	2.05
Angiosperm		2	4	3	9	4.62
Conifer		1			1	0.51
Total	**30**	**59**	**60**	**46**	**195**	**100**
Unidentifiable			2		2	

Table 5. Results of anthracological analysis from the passageway and oven no. 46/03.

	Passageway								*Oven no. 46/03*
Taxa	*LXIII 35/33 V*	*LXIII 35/34 V*	*LXIII 35/24 IVH*	*LXIII 35/34 IVH*	*LXIII 35/44 V*	*LXIII 35/34 VA*	*LXIII 35/43 V*	*Total*	*LXIII 35/21 VIF*
Abies sp.		1		1				2	
Cf. *Abies* sp.			1					1	
Ficus carica						1		1	
Cf. *Fraxinus*	1							1	
Olea europaea					1			1	1
Quercus sp. deciduous							1	1	1
Quercus sp.	5	1						6	
Conifer		1						1	
Bark	6							6	
Total								**20**	**2**

lands and probably other deciduous trees such as ash. Fir and black pine would have grown in the supra- and oromediterranean forests of the higher mountain ranges to the north-west (Kyllini, Oligyrtos, Farmakas, and Lyrkeion), west-south-west (Mainalo and Artemision) and south (Parnon). The majority of the taxa could have easily been procured from the surroundings of the site to serve various purposes. However, taxa such as *Pinus nigra* and *Abies*, the montane conifers, were non-local to the site and its surroundings but brought to Tiryns, located near the coast, from the mountains. The results for each of the sampled contexts are presented separately in *Tables 4–6*.

The analysis of the phytolith samples provides quantitative and qualitative data. *Table 2* shows the quantitative data including the number of phytoliths per gram of sediment, the organic and carbonate component (percentages). The qualitative data are shown in *Figs. 15–19*, *22*, and *24* (see below). In the following section, the results of the non-wood archaeobotanical macroremains, anthracological and phytolith analysis for each of the sampled contexts are presented separately.

ROOM 10

The nature of the non-wood plant assemblage in Room 10 differs from Kroll's previous analyses, as no cereals, pulses, or crop processing residues are present. Instead, only fruits were attested: grape, olive, and figs come from four samples and were retrieved by flotation from the thick ash layer in this

Table 6. Results of anthracological analysis from oven no. 79/02.

	Oven no. 79/02								
	LXIII 35/21 VI	***LXIII 35/11 VI***	***LXIII 35/11 VI***	***Total inside***	***LXIII 35/11 VI***	***LXIII 35/21 VI***	***Total outside***	***LXIII 35/11 VC***	***LXIII 35/21 VA***
Taxa	***Inside***				***Outside***				
Abies sp.	2	1		3		1	1		
Cf. *Ficus carica*	1			1					
Fabaceae	1			1					
Maloideae					1	1	2		
Olea europaea	3	1		4	1		1		
Pinus nigra						1	1		
Quercus sp.			1	1	1		1		
Quercus sp. deciduous	2			2				1	
Quercus sp. evergreen		1		1					1
Angiosperm						1	1		
Unidentifiable						1	1		
Total				**13**			**8**		

Table 7. Plant remains from Room 10 and the passageway; complete/fragmented.

	Room 10	***Passageway – ash***	***Passageway – ash***
Taxa	***LX 38/100, LXI 38/91.92, LX 39/10, LXI 39/01***	***LXIII 35/33 V***	***LXIII 35/34 V***
Vitis vinifera	0/11		
Olea europaea	0/9	0/5	0/7
Ficus sp.	0/7		

basement room. The samples come from the same context and therefore the material has been amalgamated into one sample (*Table 7*).

The recovered archaeobotanical remains are likely to represent food residues from the floor of the room and come from fruit trees that most likely existed in the vicinity of the site, as suggested by both the charcoal data from the site, and by the pollen analyses from the wider area of the Peloponnese.[66] The fragmentation of the material but also its limited number does not allow any attempt to determine whether the grape and olive belong to the wild or domesticated variety, although studies based on numerous materials have advanced the research on the topic.[67] The olive remains did not appear to be crushed in antiquity, on the basis of the criteria established by Margaritis and Jones,[68] and their numbers are too low to suggest processing for olive oil and their subsequent use as fuel. However, during the Late Bronze Age it is most likely that cultivated plants prevail, which by then played a major role in the economy and agriculture of Mycenaean society.[69] Their intensive cultivation however began much earlier.[70]

Anthracology

Four samples from Room 10 revealed the presence of at least six taxa in the anthracological study. *Table 4* shows the presence and absolute abundance of the identified taxa in each one of the sediment samples. Three taxa, namely *Olea europaea*, Maloideae, and *Pinus nigra* are present in all the samples while evergreen *Quercus* sp., Fabaceae, and *Prunus* are present in three out of four samples. *Abies* appears in only

66 Zangger *et al*. 1997.

67 See the discussion in Kroll 1982, 477 fig. 1, 1. 7; 479, 480 fig. 2; 481 fig. 3; Kroll 1984, 211, 215–217, which is based on a larger sample; Pagnoux *et al*. 2015; Braadbaart *et al*. 2016.

68 Margaritis & Jones 2008.

69 E.g. Zangger *et al*. 1997, 589.

70 Margaritis 2013.

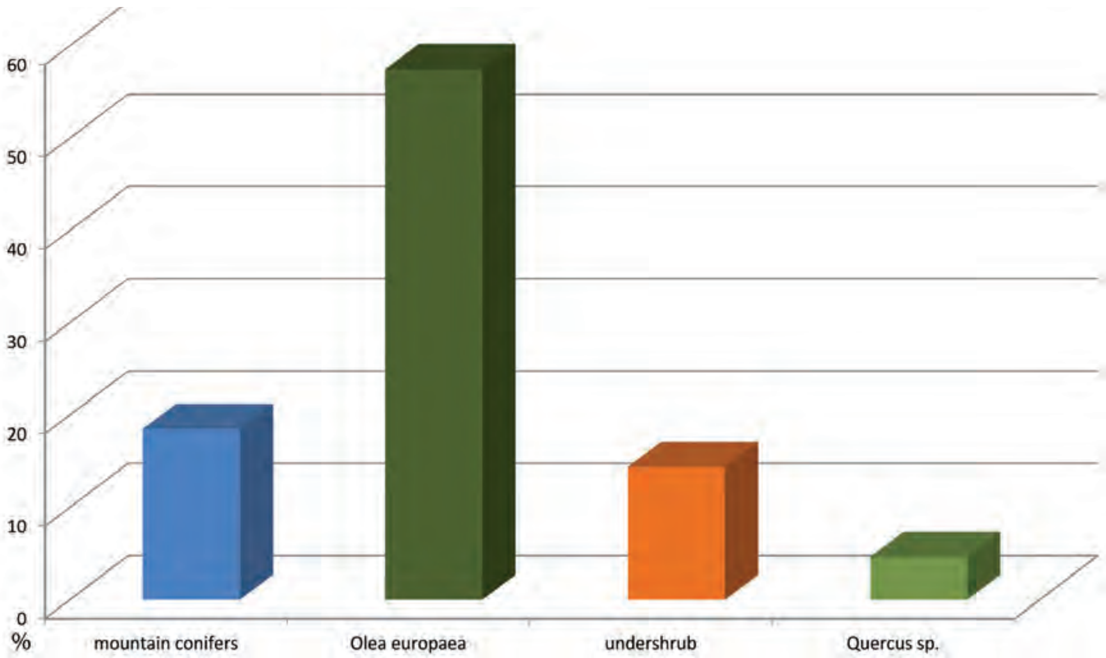


Fig. 11. Quantitative representation of the different vegetation types and woody taxa reflected in the anthracological assemblage of Room 10.

one sample. In absolute fragment counts, *Olea europaea* is by far the most abundant taxon in all four samples, followed by *Pinus nigra* and Fabaceae. Total absolute and percentage fragment counts for each one of the identified taxa in the samples of Room 10 document the same order of dominance with *Olea* (57.44%) dominating the assemblage followed by *Pinus nigra* (17.95%) and Fabaceae (8.21%).

The anthracological assemblage of Room 10 shows a combination of taxa that represent two or three very different vegetation types (*Fig. 11)*. The anatomical characteristics of the wood of *Olea europaea* do not allow the differentiation between the domestic and the wild type. At present *Olea europaea* is a characteristic element of lowland coastal areas of the Peloponnese (the thermomediterranean zone).[71] However, the presence of the wild olive during the early part of the Holocene in the broader Aegean area is not clearly defined.[72] Wood charcoal analyses document the absence or very sporadic appearance of *Olea* only during the Late Neolithic even in the southernmost part of the Peloponnese such as Alepotrypa Cave.[73] The taxon becomes conspicuous in the pollen record of southern Greece and the Aegean only from the end of the Neolithic onwards and during the Bronze Age.[74] Relevant to this discussion is the absence of *Olea* non-wood macroremains from Neolithic contexts in the Peloponnese[75] and the prominent presence of both wood charcoal and stones in the Early Bronze Age site of Kassaneva, Achaea.[76] It has been suggested that either olive was introduced[77] or that it existed in very low numbers in Pleistocene refugia and its role became prominent with the onset of the cultivation of the tree.[78] It is therefore possible that natural (late expansion from refugia) and anthropogenic (management, cultivation) factors played their role in the proliferation of the tree in the landscape after the Neolithic, even more so given the easiness with which *Olea* produces feral forms in the wild.[79] The overall abundance of the taxon in the samples from Tiryns suggests that olive wood could have been collected from the wild and/or from prunings of cultivated orchards. Fabaceae, Maloideae,

71 Bohn *et al*. 2000/2003; Quézel & Barbéro 1985.

72 Carrion *et al*. 2010.

73 Badal & Ntinou 2013; Ntinou 2011; Ntinou & Stratouli 2012; Ntinou & Tsartsidou 2015.

74 Atherden *et al*. 1993; Bottema & Sarpaki 2003, Moody *et al*. 1996; Weiberg *et al*. 2015.

75 For the Neolithic Alepotrypa cave non-woody macroremains Margaritis pers. comm.

76 Colaianni *et al*. 2012.

77 For Crete Bottema & Sarpaki 2003.

78 Atherden *et al*. 1993; cf. Bottema 1990; Moody *et al*. 1996.

79 Zohary & Hopf 1988.

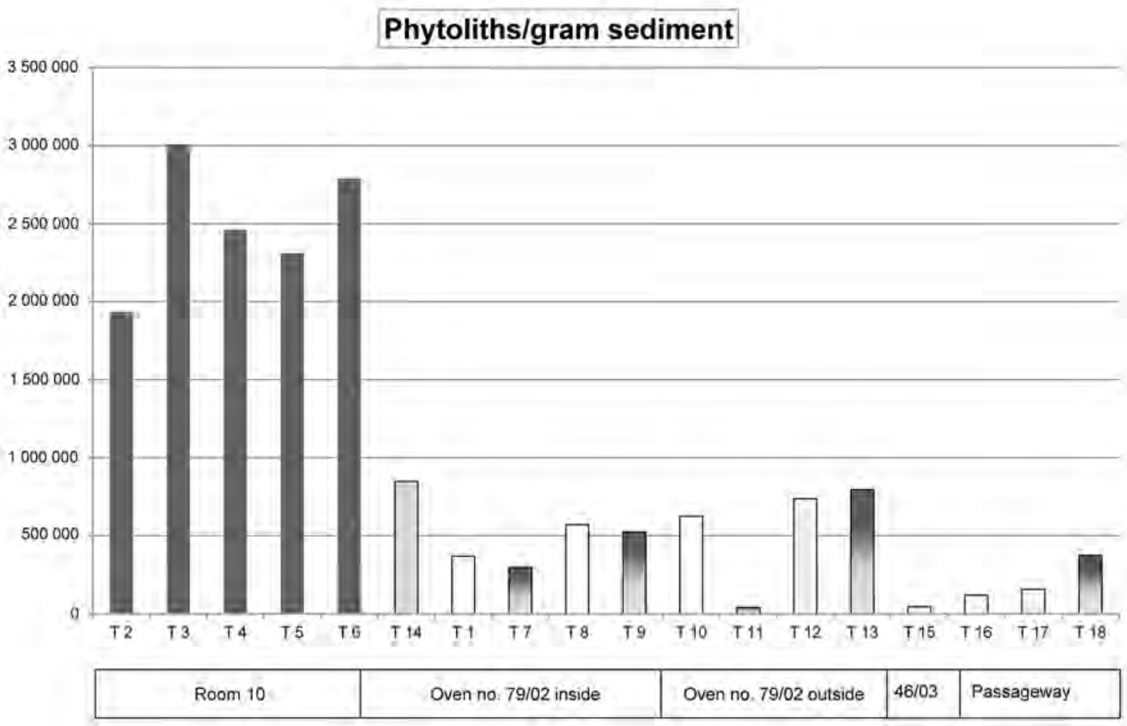


Fig. 12. Number of phytoliths per gram sediment; grey columns stand for ash sediment, gradient columns are for the clay lumps and white columns are for the white ashy spots collected from the surface of the lumps; the black columns are for the ashy sediment of Room 10.

evergreen *Quercus*, and *Prunus* would have been characteristic of the natural open vegetation around Tiryns and their wood would have been collected from the wild for various purposes. *Pinus nigra* and *Abies*, the montane conifers that represent the mountain vegetation of high altitudes in the Peloponnese, would have been brought to the settlement from the mountains closest to the site (e.g. Farmakas, Lyrkeion, and Artemision) that could have hosted fir/black pine forests according to modern vegetation data. The distance to the timber procurement areas was considerable (minimum *c*. 30 km in straight line) but transportation[80] could have been facilitated if the river systems (e.g. Inachos) that flowed towards the Argolic Gulf were used.

The presence of wood charcoal macroremains and a thick ash deposit on top of the floor in the basement Room 10 may suggest the collapse, due to burning, of some wooden structure—possibly the wooden frame of the ceiling and/or an upper storey. Furthermore, wooden objects or furniture inside the room may have also been burnt and reduced to wood charcoal and ashes. Therefore, the taxa identified in the samples from Room 10 could represent the remains of construction timbers, other construction elements, and/or objects or furniture. It is difficult by the taxa alone to specify uses. However, the presence of non-local timbers such as black pine and fir, procured and transported from a considerable distance, indicates deliberate selection for specific purposes. Black pine and fir have straight, long trunks that may grow to more than 20 m at maturity, especially when they grow in closed forests, and their wood is suitable for roof beams and poles. Olive wood is abundant in the samples, probably because it was easily procured locally and because it was routinely used as fuel and timber. It is possible therefore that black pine and occasionally fir timber would have been used for the long beams of the roof/ceiling/upper storey, while olive wood could have been used for the shorter poles of the roof. Shrub taxa such as the Fabaceae may have filled the space between poles and/or beams, thus creating a thick, solid layer for an upper storey or ceiling, which if additionally covered with plaster, would have protected the building from humidity and adverse weather conditions. All other tree taxa, like evergreen oak, *Prunus*, and Maloideae could

[80] On the transportation logistics of heavy duty building materials and resources in Tiryns, see Brysbaert 2015.

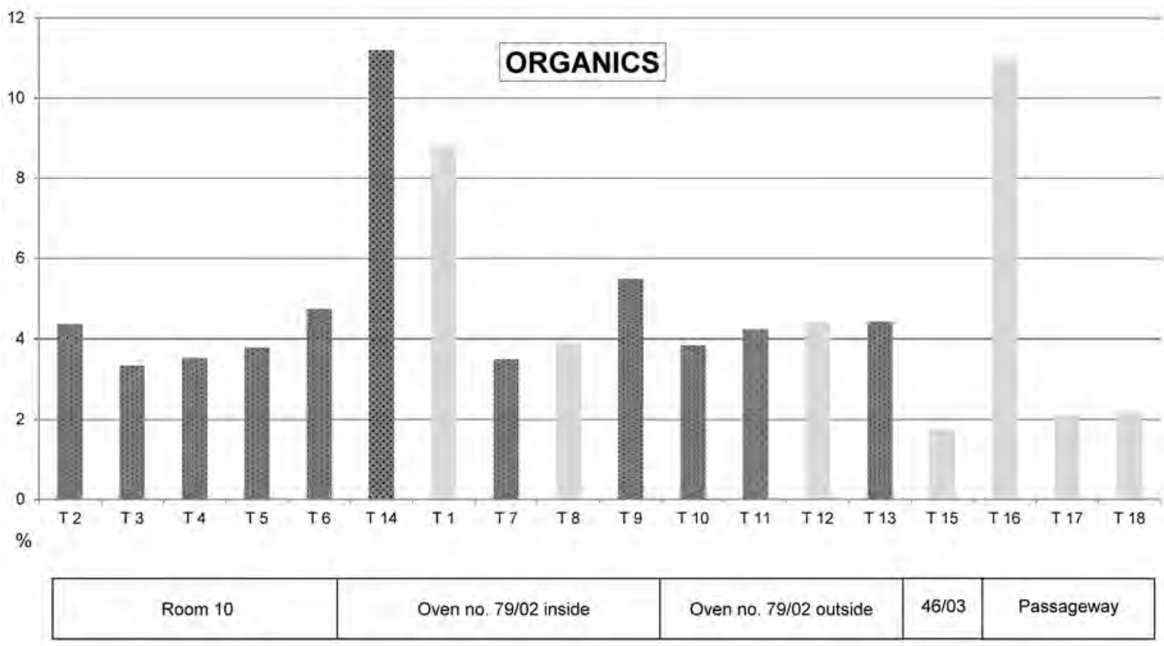


Fig. 13. The organic component of the sediments analysed; the dark spotted columns show the presence of spherulites; the grey columns show absence of spherulites.

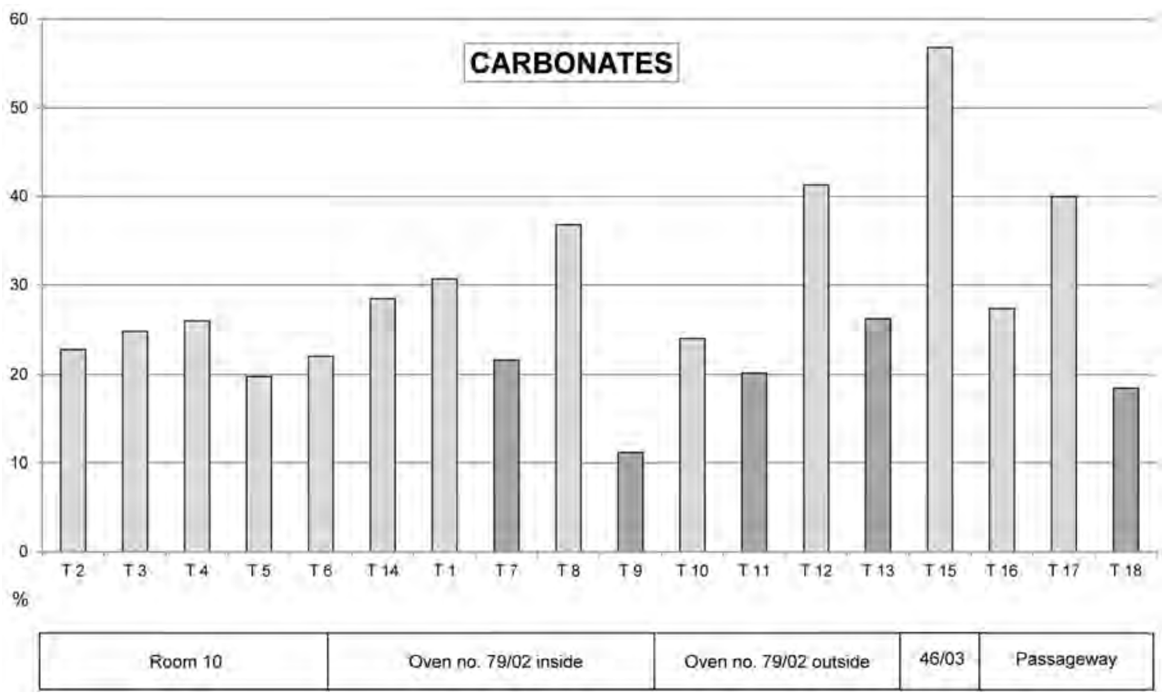


Fig. 14. The carbonate component of the sediments analysed; light grey columns are for ashy sediment and dark grey is for clay lumps.

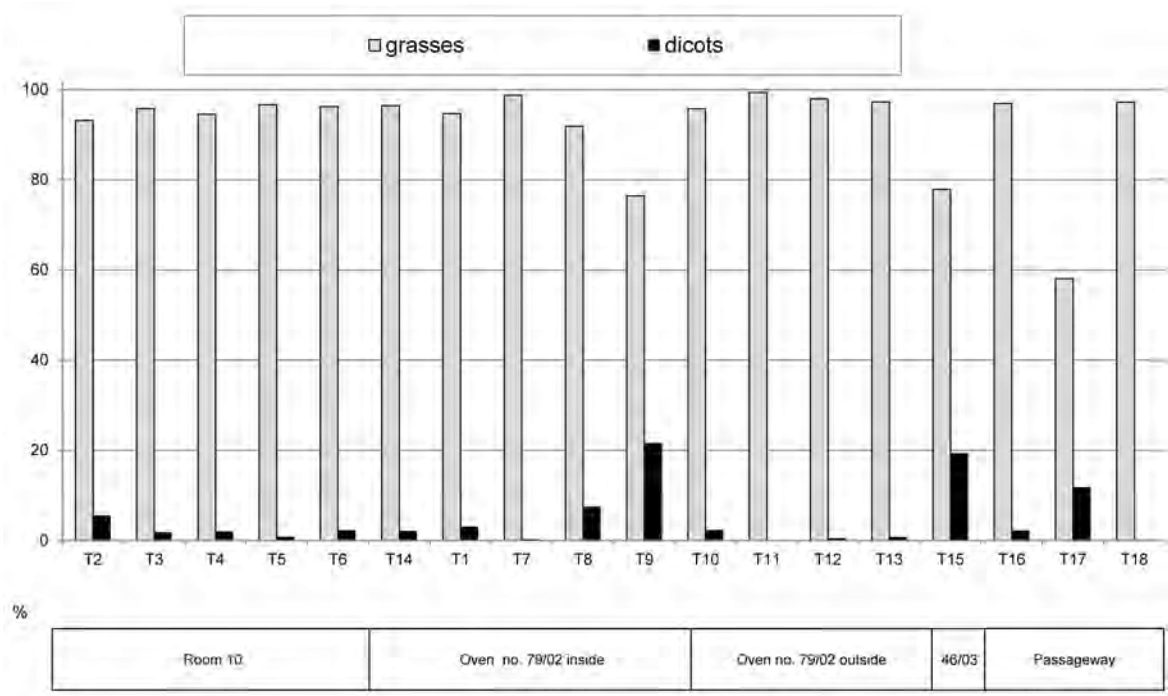


Fig. 15. Frequencies of phytoliths identified in the sediments that belong to grasses and dicot plants.

have also been utilized as construction timbers, for different other parts of the structure, e.g. door frames, or furniture and objects, e.g. shelves. Nevertheless, it is possible that in this destruction layer fuel wood waste was also mixed with the remains of timber.

Phytoliths

Quantitatively, the four ashy samples of Room 10 (T2–T6) are quite similar to one another. They are in the same order of magnitude ranging from 2 to 3 million phytoliths per gram sample (*Fig. 12*). Their organic as well as carbonate component is also very similar and moderate in frequencies (*Figs. 13–14*). They range from 3–5% and 20–26% respectively. All are much richer compared to the samples from the ovens. They also preserve rich accumulations of faecal spherulites (*Fig. 13*) indicating the presence of dung.

Qualitatively, the ashy sediment samples of Room 10 are also similar to one another. They preserve mostly grass phytoliths (above 90%) and very small amounts (up to 4%) of dicot leaf phytoliths (*Fig. 15*). Small frequencies of cereals (up to 2%) and higher frequencies of wild grasses (up to 9%) have been recovered (*Figs. 16–17*). The cereals identified belong mostly to *Triticum* sp.. *Hordeum vulgare* has been identified only in T2. Among the wild grasses Festucoids, Chloridoids, and Panicoids have been identified (*Fig. 18*). The Chloridoids are almost equally preserved (4.5–4.7%) with the exception of T2 (2%). With regard to the identified grass parts we notice that stem (grass straw) phytoliths dominate the samples (*Fig. 19*). The frequencies of stem phytoliths are almost equal (37–38% in all samples except 31% in T15). The frequencies of the husk (grass inflorescence) phytoliths are also very similar to one another (16–18%). This shows that the grasses have been incorporated into the sedimentary matrix either as a domestic material (roof cover, fuel, basketry) or with the dung of free-ranging animals that have eaten the whole plant supplemented with straw fodder.

Figs, olives, and grapes do not inherently have higher rates of preservation than other plant remains such as cereals or pulses, because the fruits could have been eaten fresh. The presence of only those species in Room 10 is connected with the consumption or storage of these specific crops there, indicating perhaps a lack of cooking in the room, required for cereals and pulses. The major difference between the new analyses and Kroll's data is the lack of cereal macroremains in the new seed samples. Animal faeces could also incorporate some of these retrieved remains, since the phytolith study and most specifically the presence of spherulites indicated dung in the ashy layer of the room. The room may have been used

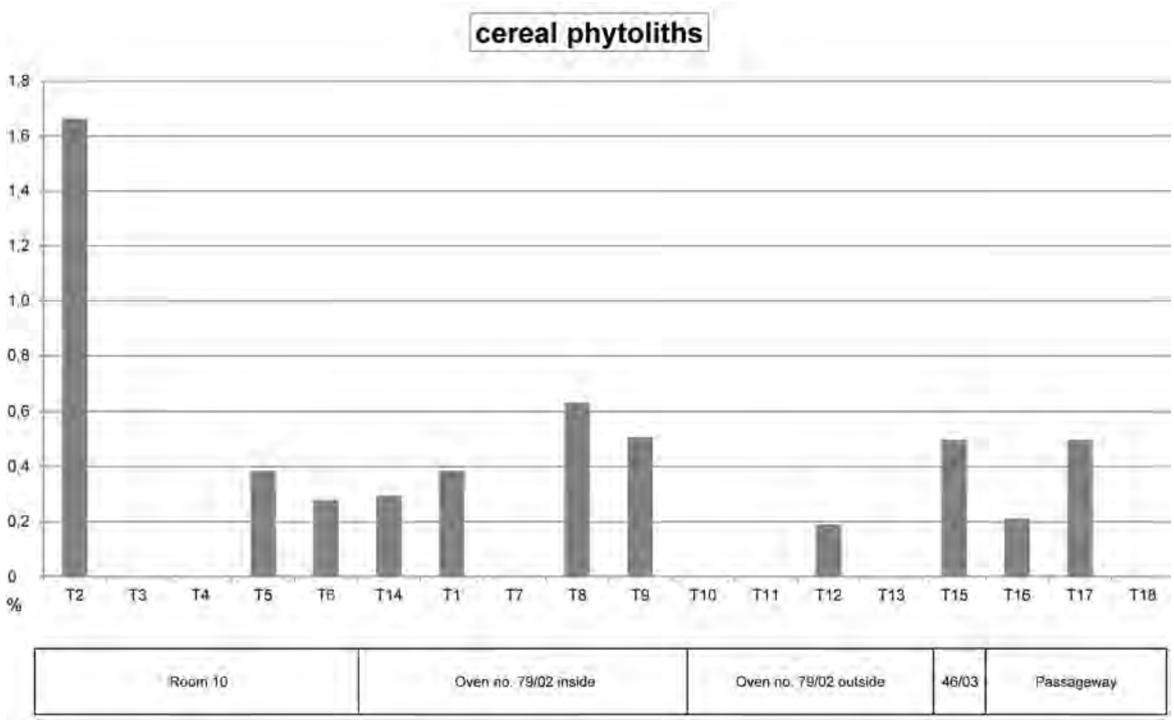


Fig. 16. Frequencies of cereal husk phytoliths recorded in the sediments.

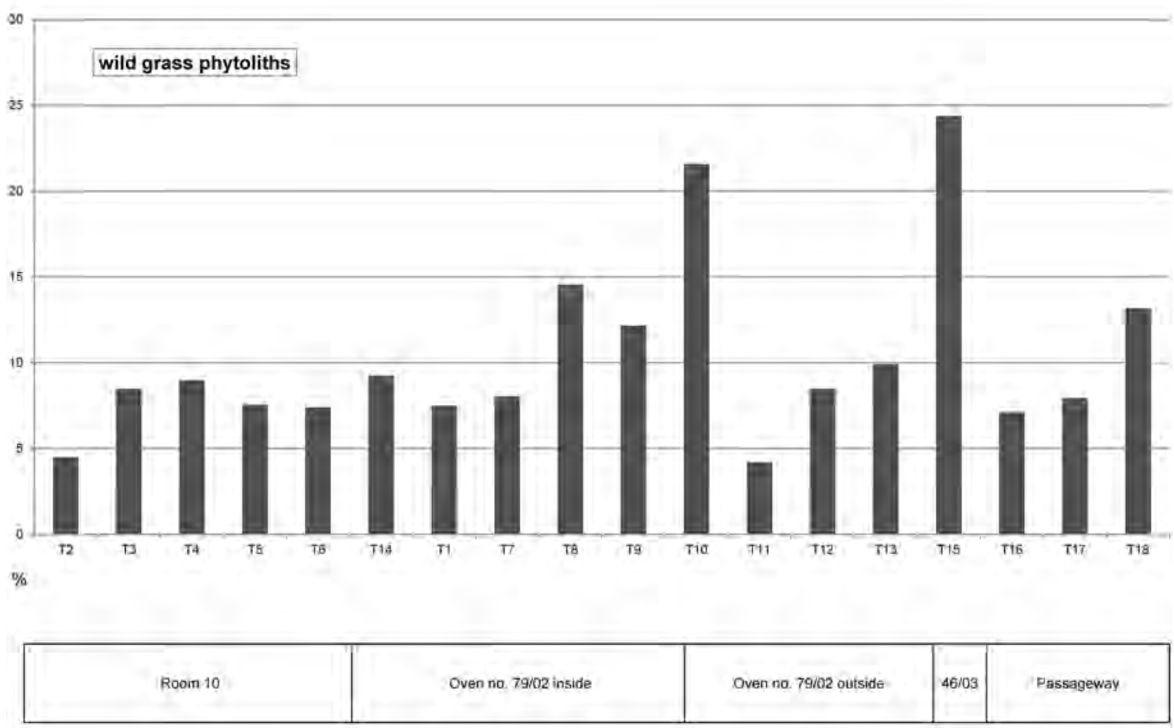


Fig. 17. Frequencies of wild grass husk phytoliths recorded in the sediments.

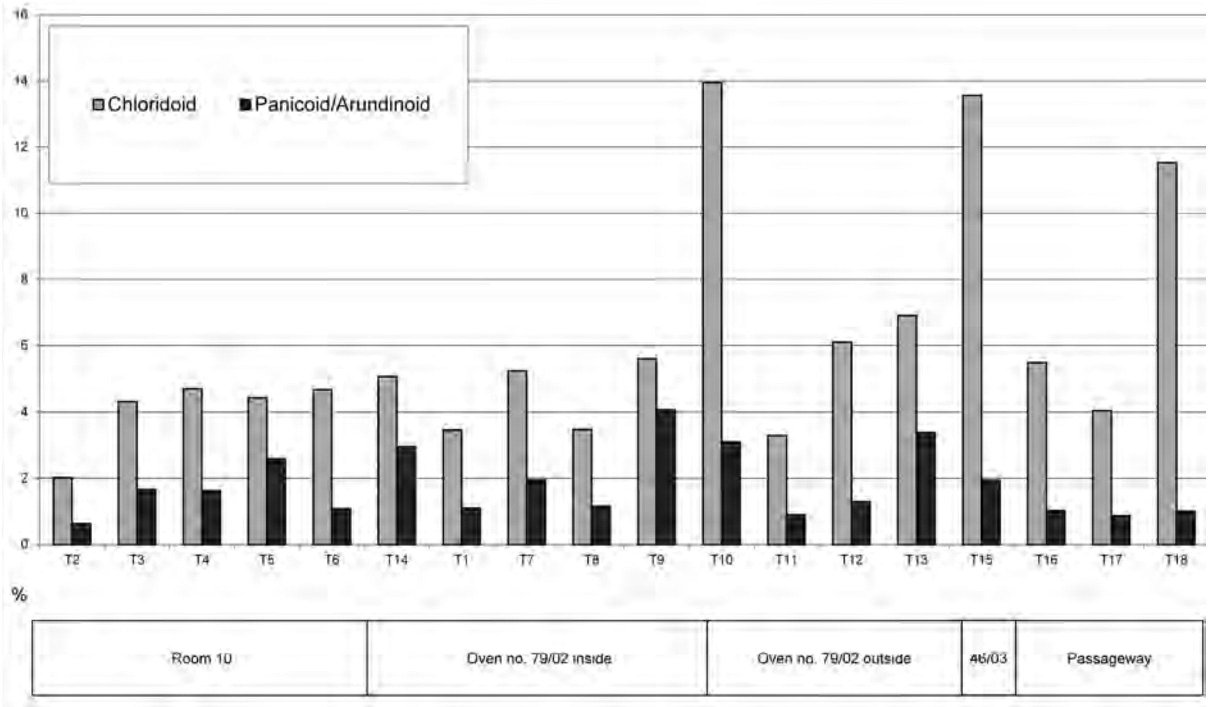


Fig. 18. Frequencies of Chloridoid and Panicoid/Arundinoid grass subfamilies recorded in the phytolith assemblages.

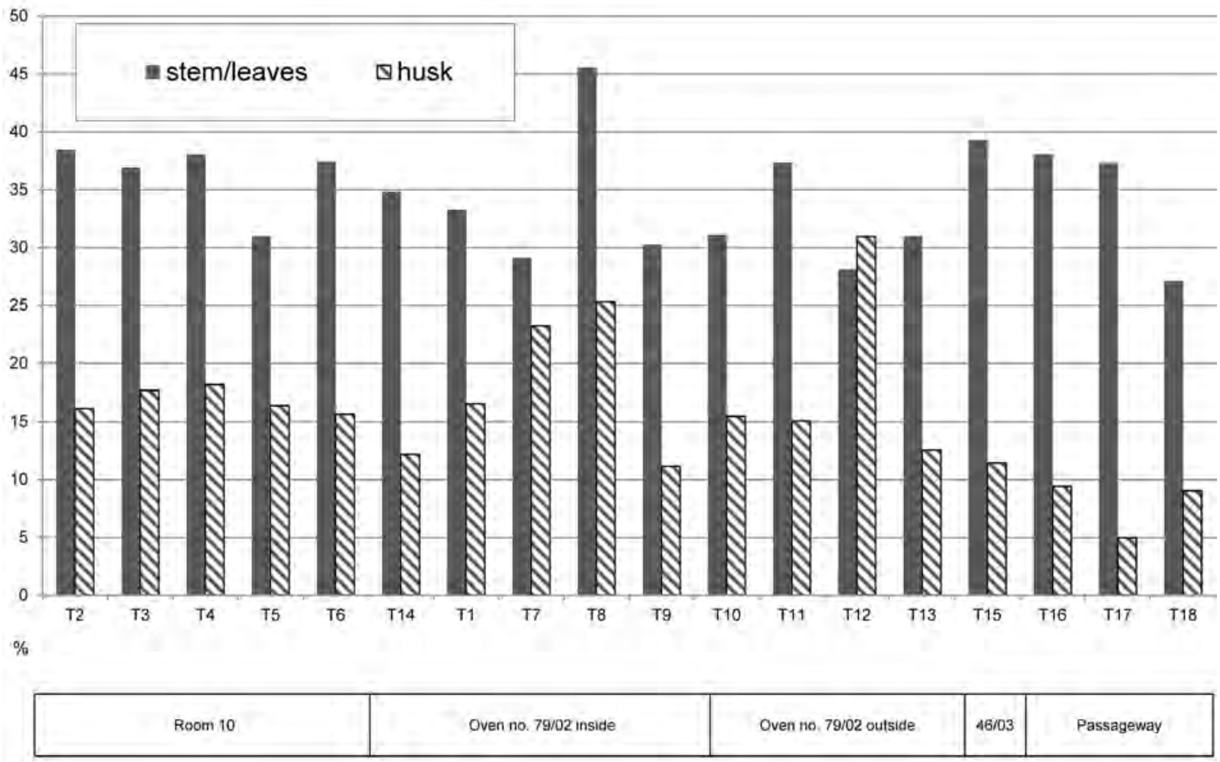


Fig. 19. Frequencies of phytoliths identified in the sediments produced by stem/leaf and inflorescence (husk) of grasses.

for dung storage or dung could have been used either as fuel, or as building material. We favour the second interpretation: Room 10 was a very confined basement room and a transitory area in the rear of Building Complex A, away from the main entrance. It nevertheless possesses two monolithic thresholds (*Fig. 3*), one in the door to Room 9 and one in the door to Room 7, which constitute elaborate architectural features only witnessed in élite buildings in the Lower Citadel. The use of non-local timbers would befit the overall high-quality architecture of Building Complex A, either in construction timbers for the ceiling which supported an upper storey, or for the door frames or wooden doors to which the monolithic thresholds at the northern and southern side of Room 10 attest.[81] The identification of dung by the phytolith analyses may be explained as secondary use of waste products in construction material, i.e. the use of dung as insulating material in ceilings or upper storey floors.

PASSAGEWAY

The second area where plant remains were retrieved is the passageway, east of the Final Palatial Building XI, where only olive stones were recovered in a very fragmented state (*Table 7*). Their fragmentation is the result of post-depositional processes, because the olive stones evidence "modern" breaks;[82] they are present in very limited numbers representing a mere handful of olives.

Anthracology

Seven anthracological samples from the last Palatial horizon (LH IIIB Final) in the area of Building XI were recovered from an ashy layer on top of the passageway. They were analysed and, despite the small number of macroremains of a size suitable for identification, at least five taxa were identified (*Table 5*). Except for cf. *Fraxinus* and *Ficus carica* that appear only in this deposit, all other taxa are also present in partly contemporary Room 10 (dated to LH IIIB Developed and Final), in the nearby but earlier oven no. 46/03 as well as in the later, Post-Palatial oven no. 79/02. The presence of fir and deciduous oak wood charcoal in this deposit indicates that it probably represents destruction debris of architectural structures. Following the same reasoning as in the case of Room 10 it seems logical to interpret the presence of the non-local taxa, such as fir, in relation to construction timber deliberately selected for building material rather than for fuel.

Phytoliths

The three samples for phytolith analyses that come from this area are T16–T18. T16 is charcoal and ash sediment removed from the surface of a clay lump and T17 is white ash on top of T18 that is again a clay lump. T17 and T18 share many similarities but they differ from T16. T16 has the highest component of organics (11%) with the other two not exceeding 2%. No spherulites have been recorded in any of the three samples. The carbonate component is relatively high (27–40%) in the two ashy sediments and lower in the clay lump (18%). The grasses dominate samples T16 and T18 (almost 100%) as opposed to T17 that preserves only 58%, i.e. the lowest amount of grasses of all analysed samples. It preserves 11% dicot leaf phytoliths as opposed to T16 and T18 that did not produce more than 1%. Among grasses the wild ones prevail. The higher frequency is shown in the clay lump sample indicating the admixture of clay sediment with ash where grasses might have been used as kindling and possibly everyday waste such as food remains or discarded wild grasses used for construction or pastoral purposes. No cereals have been recorded in the clay lump as opposed to the ashy samples that preserve small amounts. Stem phytoliths are recovered in much larger percentages than the husk phytoliths indicating that the grasses were mainly used as tinder and only small amounts may be related to food remains (wheat). Finally palm (*Palmae* sp.) phytoliths have been recorded in sample T16 and T17 (*Figs. 20–21*). The higher frequencies are recorded in T16 (28%).

The high amount of clayish matter could perhaps indicate some disintegrated mudbrick or pisé. Grass stems in the phytolith analysis may point to mudbricks or pisé heavily tempered with organic matter. Kilian interpreted the associated pottery assemblage as part of collapsed destruction debris from Building XV on the east side of the passageway, whereas Maran explicitly noted that the breakage pattern of these ceramics did not indicate that they had fallen down from an upper storey. Furthermore, Building XI on the west side of the passageway was probably a single-storey structure and lay on a lower terrace; it thus seems more probable that any inventory of Building XI collapsed onto the floors of this building rather than onto the passageway. At present, it cannot be determined from where the idiosyncratic finds assemblage on the passageway originated. Some of its constituents (i.e. the wall brackets and the faience head-shaped vessel) point to Building XI but the location of the finds makes their association with Building XV more likely.

OVEN NO. 46/03

The oven sample contained ash and charcoal but no macroremains of fruits and seeds were detected. Therefore, the results obtained derive from the anthracological and phytolith analyses only.

[81] For the unique architectural features and once probably rich inventory of Building Complex A, Damm-Meinhardt 2015, esp. 124–125 on monolithic thresholds.
[82] Margaritis & Jones 2008.

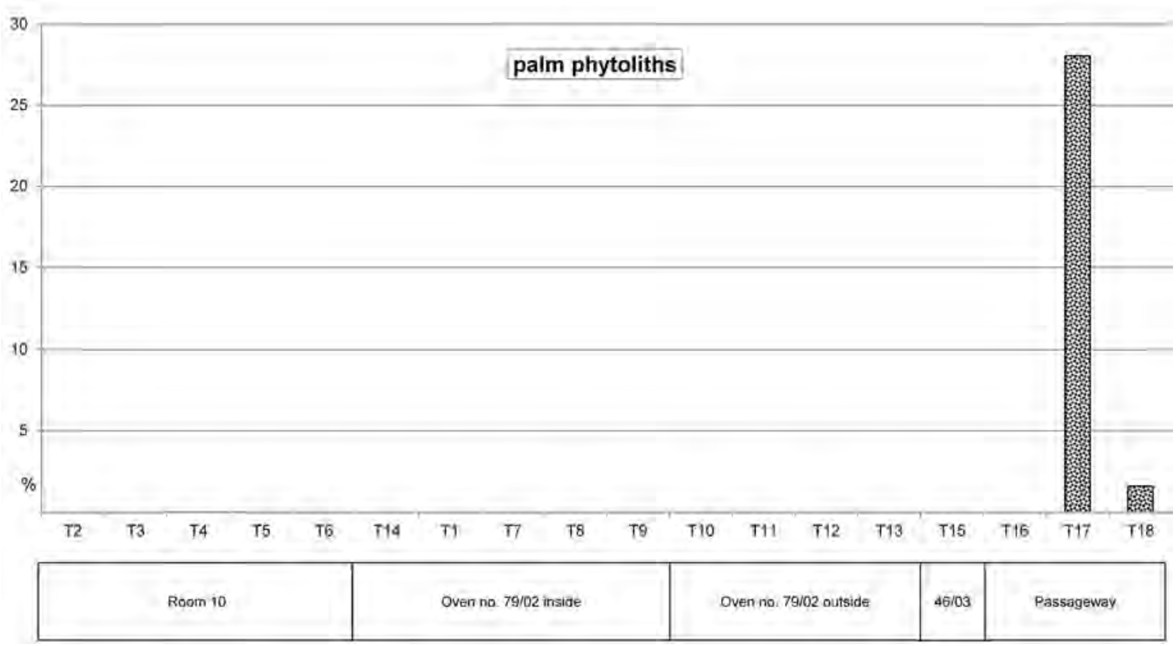


Fig. 20. Frequencies of palm phytoliths identified in the assemblages.

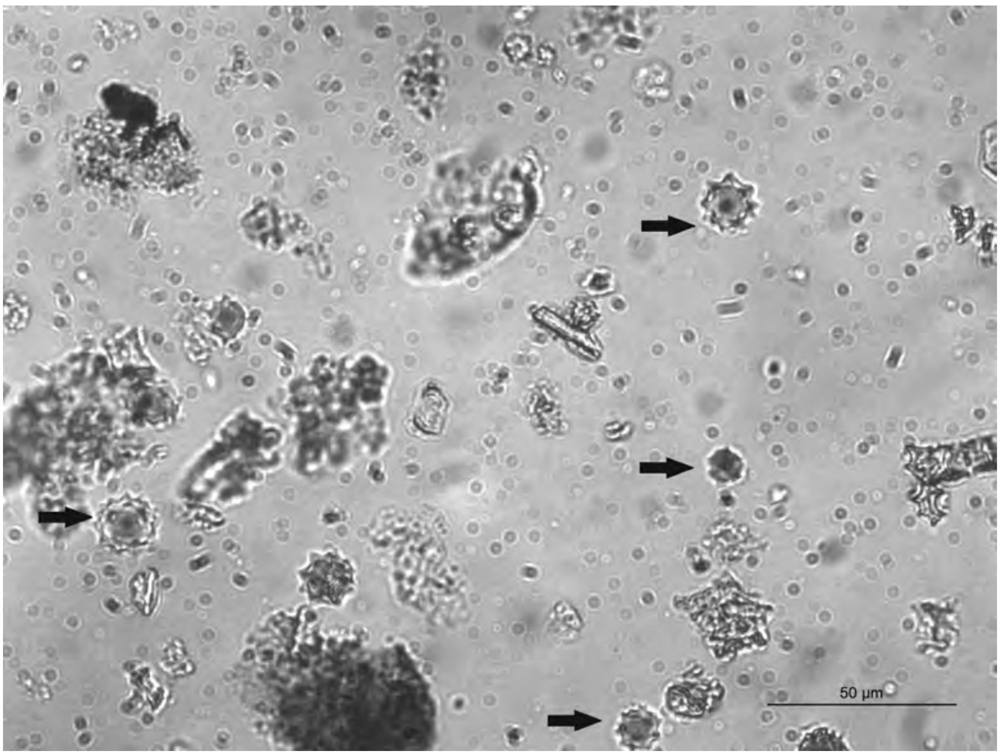


Fig. 21. Microphotograph of palm phytoliths from sample T17; the arrows point to spiny spheroid phytoliths characteristic of Palmaceae; photograph by G. Tsartsidou.

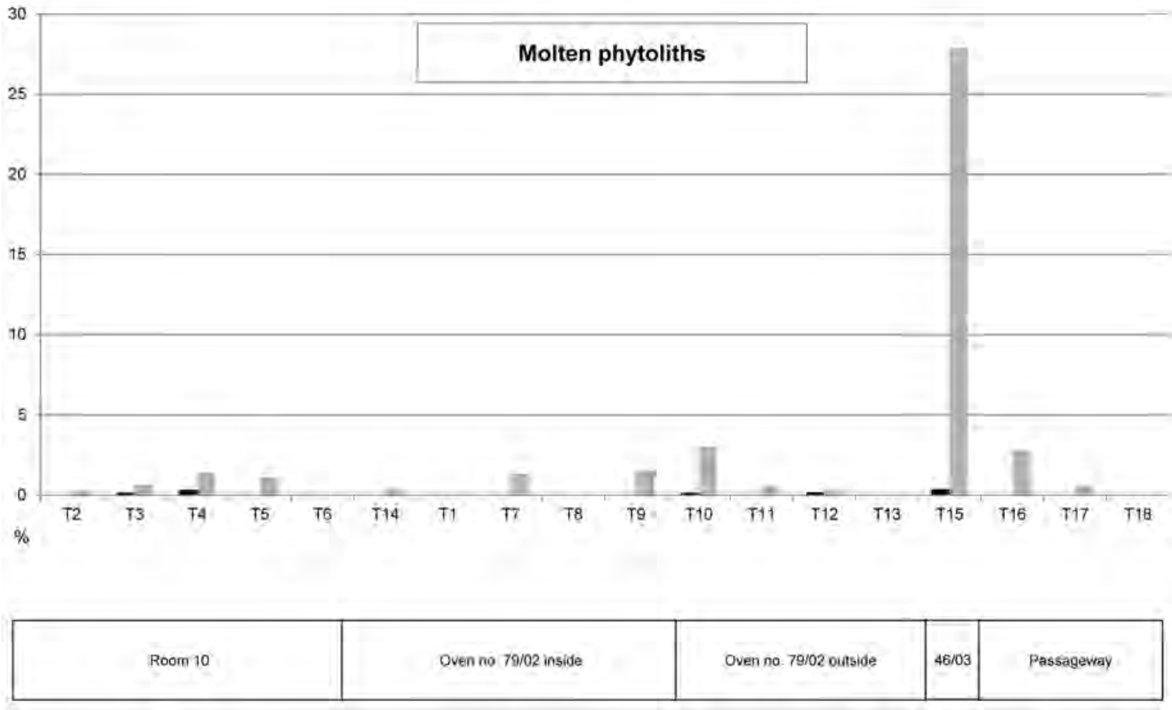


Fig. 22. Frequencies of molten phytoliths recorded in the assemblages.

Anthracology

Two wood charcoal fragments, one of *Olea europaea* and another one from deciduous *Quercus* sp. were identified in oven no. 46/03 (*Table 5*), the chronologically earliest pyrotechnological feature sampled in the Lower Citadel North, dated to LH IIIB Early/Middle. Their provenance from the ash deposit in the oven indicates that these are the remains of the fuel burnt in the latest or one of the latest uses of the feature. The wood of these taxa could have been systematically procured from woodland vegetation of the hills (>200 m altitude) surrounding the Argive Plain or from olive orchards.

Phytoliths

Quantitatively, the phytoliths from the oven samples are poorer than the samples of Room 10 (*Fig. 12*). Most of them range between 400,000–850,000 phytoliths per gram sediment. The poorest are samples T11 and T15 that preserve less than 50,000 phytoliths per gram sediment. Sample T15 comes from the interior of oven no. 46/03 and contains the ash that has the highest frequency of carbonates (60%) of all the samples analysed. This indicates the presence of wood as a major component of this sample. No spherulites were identified and the organic component is the lowest (2%). The highest amount of molten phytoliths (28%) has been recorded in this sample (*Fig. 22*) in contrast to all the remaining samples that do not exceed 3% of molten phytoliths. These data point to a strong fire fed with wood. The low number of phytoliths is very compatible with this since woody parts of trees produce either no phytoliths or very small concentrations.[83] The sample is also rich in druses, i.e. carbonate crystals that are formed in high quantities in dicot plant leaves. Phytoliths of the latter have also been identified in large quantities (19%).

Regarding grasses, T15 preserves the highest quantity of wild grasses (15%), mainly Chloridoids and stem (straw) phytoliths. They may have been used as kindling to start the fire. Minor amounts of cereal husk phytoliths are also present. No sedges or reed phytoliths have been recorded.

The small finds around oven no. 46/03, mostly obsidian in low numbers, do not provide evidence for the structure's use in specific metallurgical activities since no metal artefacts, slag, or crucible fragments were retrieved from this context.

[83] Tsartsidou *et al*. 2007.

Also, use as a pottery kiln is unlikely, because no ceramic wasters were found and the architecture of the oven does not resemble known examples of contemporary pottery kilns which feature chequer floors. Other hypothetical uses, for instance limestone heating to produce quicklime, or charcoal production, are also not supported by the associated archaeological finds. The fuel remains, however, indicate that high temperatures could have been attained. Wood burning can reach up to 800° C irrespective of the species employed. If we were to look for a direct link between the contextual finds and the oven, the heat treatment of chipped stone in order to facilitate splitting and cracking of the core of such raw material could, for example, be suggested. However, to our knowledge, such treatment has never been recorded in Mycenaean contexts, heat above 200–400° C is not needed or desired for heat treatment of lithics, and when reaching 600° C and higher, adverse effects such as micro-cracking and thus reduced mechanical strength and fracture toughness result. Instead a prolonged and well-controlled heat with well-monitored cooling is crucial to achieve the best results.[84] The literature on heat treatment also seems to indicate that especially flint and chert were undergoing such treatment because they may obtain a higher level of flakeability that renders such materials approximately to the same flakeability levels that obsidian already has in itself.[85] We cannot rule out that there is an operational relationship between the handful of lithics and the oven although an indirect relation is the most we can hypothesize until much larger assemblages of oven features can be examined.[86] The oven might have been involved in certain production processes that required high temperatures, at least for short time stretches, but it remains to be seen what sort of activities these would have been. Finally, in relation to this specific study, it is doubtful whether the few cereal remains in the ashes of the oven are numerous enough to interpret the feature as part of a food preparation area.

OVEN NO. 79/02

The samples from the inside and outside of oven no. 79/02 located in the courtyard represent the Post-Palatial use of the area of former Building XI during LH IIIC Developed. The assemblage consists of small fragments of barley and emmer grains, emmer chaff, bitter vetch and lentils, grape pips, minute parts of olive and almond stones, and fragments of darnel; all of them come from two samples collected during the excavation (*Table 8*).

Table 8. Plant remains from oven no. 79/02; complete/fragmented.

	Oven no. 79/02 – inside	***Oven no. 79/02 – ash***
Taxa	***LXIII 35/11 VI***	***LXIII 35/11 VC***
Hordeum sp.	0/4	
Triticum dicoccum	0/3	
Triticum dicoccum glume bases	0/2	
Vicia ervilia	0/4	
Lens sp.	0/2	
Vitis vinifera		0/2
Prunus amygdalus		0/3
Olea europaea		0/4
Lolium temulentum		0/2

The presence of these plant remains could represent food remains. Barley and emmer are processed and often consumed differently. Emmer wheat is a glume wheat, thus chaff needs to be removed before consumption, most likely by pounding or light parching. Barley is a free threshing cereal, thus requiring little processing following threshing. This means that the processing of emmer wheat (together with einkorn and spelt) is more laborious than barley. Cereals undergo specific stages of processing which have a logical order: for example winnowing cannot precede threshing, and sieving needs to come after winnowing (*Fig. 23*).[87] On the basis of the relative proportions of grain, chaff, and wild/weed seeds, archaeobotanical assemblages can be assigned to various crop processing stages, and, therefore, we can obtain information on agricultural practices. For example, on the basis of their properties (size, weight), different weeds are removed in different stages of crop processing, others are removed by winnowing or sieving.[88]

Most likely, the removal of emmer chaff was done piecemeal during the year, on the basis of the inhabitants' needs. The presence of emmer chaff in the oven indicates the use of this cereal for human consumption, because otherwise the laborious activity of removing the chaff would not be necessary.

The presence of darnel is also linked to the final stages of crop processing. This weed has a size similar to cereal grains, and, therefore, is removed from the grain at the very last stage of processing before human consumption, which is cleaning by hand sorting.

---

[84] Domanski *et al*. 1994, 201–202, 204–205.
[85] Domanski *et al*. 1994, 177–178, 200.
[86] A point strongly advocated by the anonymous reviewer that we gratefully acknowledge.

[87] Stevens 2003.
[88] Hillman 1981; 1984; Jones 1984; 1992.

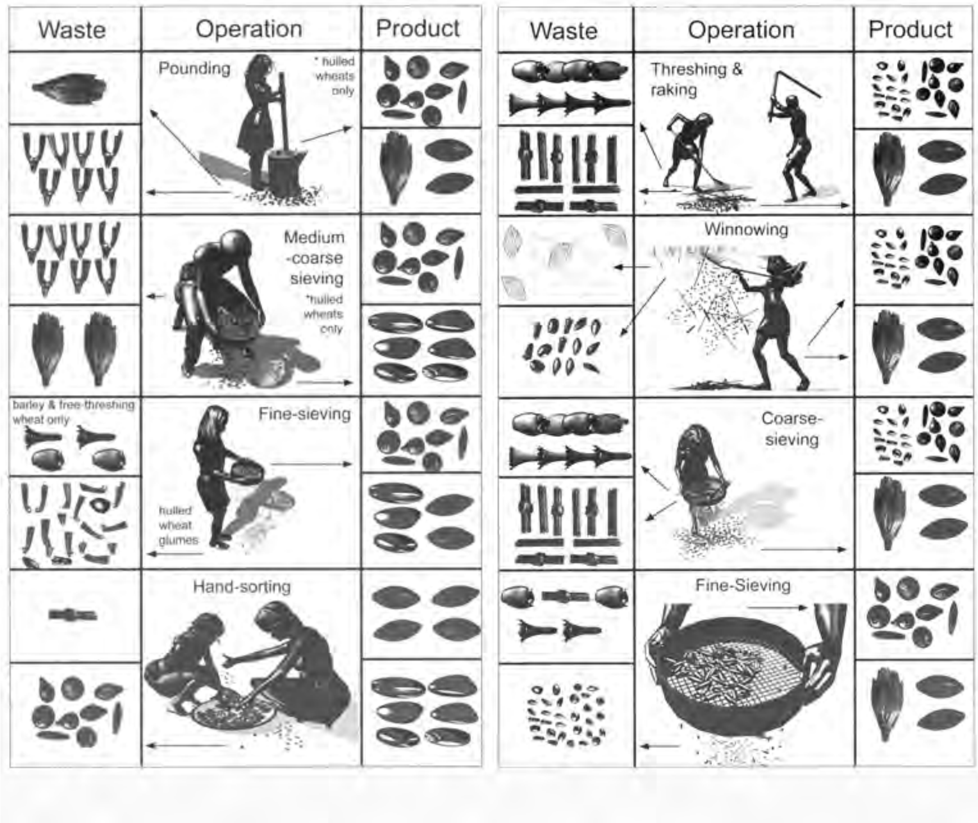


Fig. 23. Crop processing activities, products and by-products of every stage; Wilkinson & Stevens 2003, fig. 74.

The presence of emmer chaff and darnel in the oven points to the utilization of these by-products of cereals' crop processing as fuel.[89] A similar interpretation can be suggested for the olive and almond too; olive stones are perfect for fuel due to the fact that they can reach high temperatures and can burn for a long time, while they produce little smoke.[90] The other remains, cereals, fruits, nuts, and pulses represent refuse of food consumption entering the oven most likely as remnants of food prepared and cooked in the oven.

The presence of bitter vetch, however, requires more attention. Bitter vetch is toxic and during the ripening of the seeds an acid is formed that renders the seeds toxic for both animals and humans. The amount of the acid in the seeds depends on both environmental and genetic circumstances, and toxicity rises under conditions of drought. In order to remove the toxins it contains, bitter vetch, therefore, needs more processing, through soaking, roasting, and removal of the seed coat.[91] In this way, bitter vetch is more labour-intensive than other pulses such as lentils or peas. Because of its toxicity it has been suggested that it might have been used as famine food or fodder, but it is probably also used for human consumption since the Neolithic.[92] It is also depicted on a Late Minoan wall painting found in Building 6 at Palaikastro, east Crete.[93]

Anthracology

The mudbrick structure of oven no. 79/02, located in the courtyard of a Post-Palatial building on top of Building XI, is one of the installations that suggest an intensive use of the area during LH IIIC Developed. The results of the analyses of anthracological samples from oven no. 79/02 are presented in *Table 6*. Two of the samples did not include any remains large enough for identification. In the remaining samples the identified taxa are the same as in Room 10 and the passageway. In general, both the samples from the outside and the inside of the feature are characterized by a paucity of remains, most probably due to heavy burning that consumed wood and embers almost completely. Both the samples inside and outside the oven include at least five taxa each; they have remains of

[89] For information on the formation of an archaeobotanical data set and possible interpretations see van der Veen 2007.
[90] Brun 2003.
[91] Flint-Hamilton 1999, 25.
[92] Valamoti 2004. For evidence of bitter vetch found in Aigeira see Schachl 2006, 191–192. We thank Walter Gauß for this reference.
[93] MacGillivray *et al.* 1992; on the analyses of its pigments and plaster: Brysbaert 2008.

Abies sp., *Olea europaea*, and *Quercus* sp. in common while Fabaceae, deciduous and evergreen oak, cf. *Ficus carica* are present inside the oven, and Maloideae and *Pinus nigra* occur outside it. The majority of the taxa as can be seen in *Table 3* would have grown in the lowland areas around the site and their wood may have been collected from the natural vegetation or as prunings from the olive orchards. In such a case it would be logical to regard them as the remains of the fuel used in the oven. However, the presence of the mountain conifers in the assemblage is intriguing; the time and effort needed to bring wood from a distant location cannot be justified by their use as fuel unless they correspond to timber waste from timber shaping for carpentry. Furthermore if we consider that the calorific properties of wood are mostly controlled by factors such as calibre, state of wood, and humidity content rather than by the properties of the particular species,[94] wood from the natural lowland vegetation could fulfil the purposes of the ovens and there would be no need for distant procurement of fuel wood. Moreover, qualitatively speaking, the results from oven no. 79/02 are almost identical to what we observed for Room 10. Following the same reasoning as in the case of Room 10, the combination of thermophilous taxa and mountain conifers could again indicate the destruction of a wooden superstructure by burning. Taking into consideration that feature no. 79/02 overlies the destruction layer of Building XI, we may consider three possibilities:

1. timbers from earlier structures were recycled as fuel in this oven;
2. the ash deposit observed in the oven superimposes and includes remains of the underlying destruction layer;
3. mountain conifers constituted parts of furniture finally disposed of as fuel in the oven.

In stratigraphic terms, oven no. 79/02 was erected on the "floor" or well-trodden surface of the LH IIIC Developed courtyard and thus *c.* 10 cm above the LH IIIB Final floor of Room 04/02 in the underlying Building XI. As the ash was clearly found on top of the courtyard's "Laufhorizont", it does not seem that parts of the destruction layer at the end of the Palatial period (i.e. ash and charred timbers from collapsed architectural structures)[95] were mixed with the LH IIIC Developed oven's ash deposit. A recycling of earlier building timbers, perhaps even from the decades' earlier Palatial destruction, may have been a possibility. The LH IIIC Developed courtyard area retained several Palatial walls in its layout. The Post-Palatial reuse[96] of these walls built in LH IIIB Final comprises at least their stone foundations and socles; whether parts of the mudbrick and timber superstructure were still extant, is unknown. Yet with regard to the extensive building activities in the Lower Citadel and Lower Town North in the first half of the 12th century BC it appears also feasible that the LH IIIC community in Tiryns still procured construction timbers from distant mountain ranges, which after changes in building layout and even potential recycling in other architectural structures may finally have been used as fuel. Also, the final combustion of parts of disused furniture as fuel cannot be excluded.

Phytoliths

Samples T1, T7–T14 come from the area inside (T1, T7–T9 and T14) and outside (T10–T13) the oven. The samples T1, T8, T10 and T12 are white ashy spots preserved on clay lumps representing the ash from the oven. The samples T7, T9, T13 are clay lump samples. Sample T14 is a mixture of ash and clay sediment. Irrespective of the provenance of the samples (i.e. inside or outside the oven) they show similar results, quantitatively and qualitatively. It is obvious that the ash samples contain more carbonate (calcite) than the clay ones since calcite is the main component of ash. Nevertheless, the clay samples also preserve high amounts of carbonates suggesting that ash was used in their construction as an admixture. Interestingly, spherulites have been identified in all the clay lump samples but only in one ash sample (T10). This means that dung was mixed with the clay in the construction of the clay structure/floor but it was probably not used as fuel.

Qualitatively we notice that the samples are dominated by grass phytoliths recovered almost to 100%. The samples that preserve lower percentages of grasses are the ones that preserve higher percentages of dicot leaf phytoliths. These are mainly samples T8 and T9. All of the samples preserve both small quantities of cereals (only *Triticum* sp.) and higher amounts of wild grasses (*Chloridoid* and *Panicoid*). Straw phytoliths prevail with the exception of T12 which represents an ashy layer

94 Théry-Parisot 2001, 151–159; Théry-Parisot *et al.* 2010, 144–145.

95 The LH IIIB Final floors of both Building XV and Building XI were covered with destruction debris. In the case of the passageway this was a clearly discernible, *c.* 20 cm thick ash layer; in the two buildings traces of fire were less obvious. Moreover, the destruction layer in Building XI was to a large extent disturbed by an extensive pit with several human skeletons and disarticulated human remains, which was dug into the remains of Building XI immediately after the Final Palatial catastrophe or very soon afterwards: Maran 2008, 60–65. This pit was sealed by the compact, well-trodden surface of the courtyard area with the ovens in LH IIIC Developed.

96 A Post-Palatial reuse of earlier, Palatial walls is witnessed in the case of Building XI, former Building VI in the western centre of the Lower Citadel and in parts of the Palatial megaron on the Upper Citadel, but is always accompanied by a change in layout; see Mühlenbruch 2013, 57–60, 73–77, 258–259.

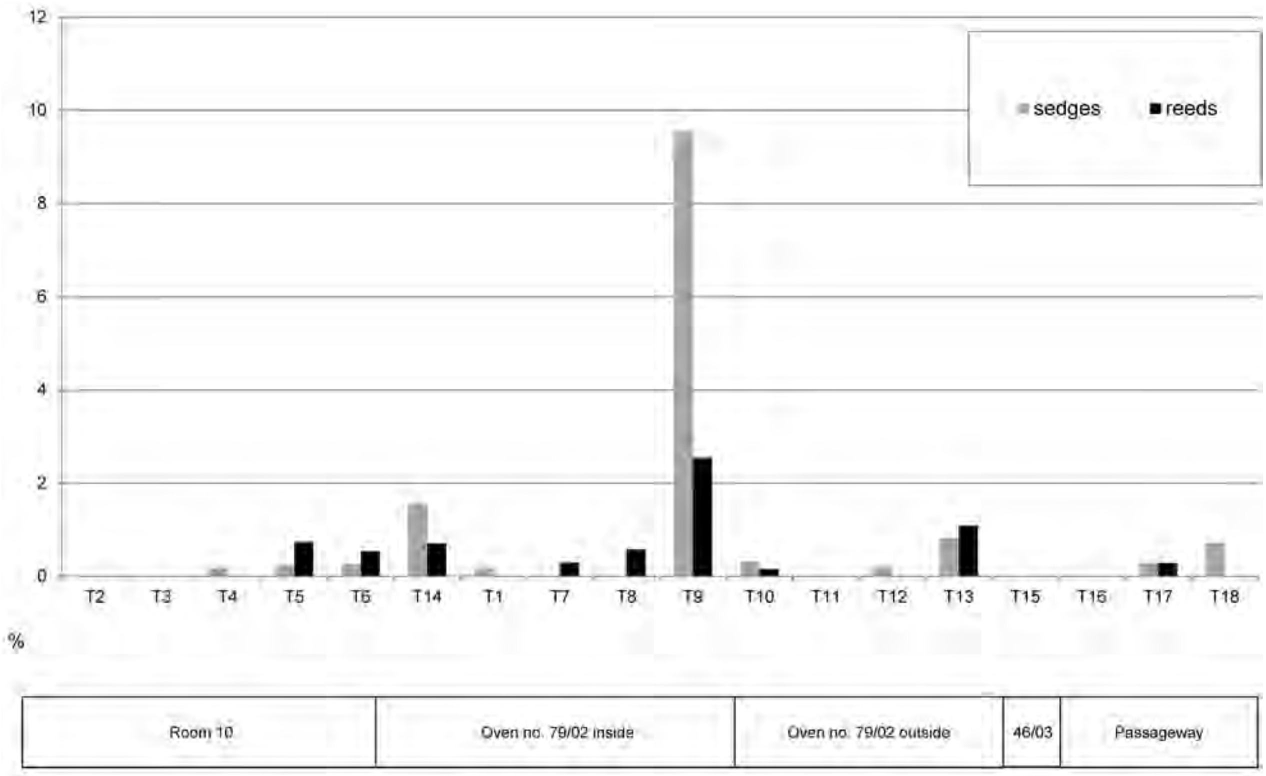


Fig. 24. Frequencies of phytoliths identified in the sediments that belong to riverine plants (reeds and sedges).

from the area outside the oven. We notice high frequency of husk phytoliths in sample T12.

Other plants identified were sedge and reed phytoliths (*Fig. 24*). They have been identified in almost all the samples but the sedges recovered from T9, i.e. from the interior of the oven, are very high (10%). These phytoliths belong most possibly to *Scirpus* sp. and they could indicate the presence of household material such as a basket or mat made of the flexible stems of this riverine plant. Nevertheless, the sample is a clay lump and preserves a large variety of plants including a large percentage of dicot leaf phytoliths (11%). The ash and clay lumps were sampled from the north wall of oven no. 79/02. This favours an interpretation of the phytoliths stemming from burnt organic material in the mudbricks rather than burning refuse of everyday activities in the oven. However, the ongoing analyses of the Tiryns ovens examined in this paper may add to this discussion.

The LH IIIC Developed courtyard features tentative evidence of a well-organized activity area perhaps even with re-established wide-ranging external contacts to Cyprus, if a clay ball with Cypro-Minoan signs is not a residual find but was originally deposited during this phase.[97] Within the last decade research has provided ample evidence that LH IIIC Tiryns witnessed not only the re-establishment of contacts with the wider Eastern Mediterranean region (albeit on a lesser scale than in the Palatial period) but also the construction of several large buildings such as Building T on the Upper Citadel and Megaron W in the Lower Town.[98] Therefore, it may not have been beyond the capacities of the Post-Palatial occupants of this area in the Lower Citadel North to procure such building material from the mountains of the Peloponnese instead of only recycling construction wood from the Palatial period. The space differs from other Post-Palatial activity areas because the concentrations of ovens are not a feature of any domestic space (single box-ovens inside rooms are also rare) so far discovered in Tiryns. The multiple ovens in the courtyard, therefore, indicate some quite intense or prolonged pyrotechnological activities beyond mere food production. Fireplaces in the Post-Palatial period are usually circular clay structures with an underlying sherd layer and a clay layer on

[97] For a discussion of the find spot and dating see Vetters 2011.
[98] E.g. Maran 2012a; 2012b, 158–160; Mühlenbruch 2013.

top. Such hearths/fireplaces are common features (often interpreted as places of cooking but they could have been used for other crafts as well), found inside and outside buildings and in some instances are rebuilt several times on the same spot or adjacent to one another.[99] The attestation of lead spills immediately next to oven no. 79/02 in the spatial analysis of the small finds excavated in the courtyard points to small-scale lead-working;[100] the archaeobotanical data complement this picture and suggest a more multifunctional use of the feature for metallurgical activities as well as food production.

Discussion

The results of the anthracological analysis from four different contexts at the Lower Citadel North in Tiryns allow us to provide tentative reconstructions of the natural vegetation in the vicinity of the site and its management during the latter part of the LH period along with suggestions for the possible provenance (and related use) of the burnt wood macro-remains in the different contexts at Tiryns. Kroll has interpreted the low density of charred plant remains as the result of regular cleaning activities of a highly organized settlement indicating how refuse was managed and organized within urban spaces.[101] In our case, an additional contributing factor has been the small number of samples *and* the impact of taphonomic factors because in the areas studied the plant remains are scarce possibly due to exposure to high-temperature fires: in all of the areas ashy layers were present, and charred plant remains were very fragmented and distorted. This effect is slightly mitigated in the case of olives because their stones are hard and more resilient to high temperatures.

Our results combined with previous studies from Tiryns show an assemblage rich in taxa, which represent different woodland habitats (*Table 3*) that, at present, have their parallels in the vegetation of the Peloponnese from the coast to the higher mountains. Based on the modern ecology of these taxa it is, therefore, possible to suggest a tentative distribution of the identified species both in the local environment around Tiryns as well as in the broader area of the Argolid and north-east Peloponnese during the LH period. To this end, the information from various pollen cores from this region, i.e. Lerna,[102] Koiladha,[103] Kleonai,[104] and the Kotihi lagoon in the north-western Peloponnese[105] is indispensable.

The taxon *Olea europaea* may include the wild oleaster and the cultivated variety, but a distinction between the two on the basis of wood anatomy is not possible. At present, the olive is indicative of the vegetation characterizing the thermomediterranean bioclimatic zone that includes the coastal areas of the Peloponnese.[106] The presence of the olive in all sampled contexts is in agreement with the location of the site in the coastal Argolid, where the prevalent environmental conditions would have favoured both the spontaneous growth of olive trees and shrubs and olive cultivation in orchards. *Prunus amygdalus* could have also been a cultivated tree but also an element of the natural vegetation growing, together with *P. spinosa*, various Fabaceae and the Maloideae, in open woodland under conditions of prolonged summer aridity.

Evergreen *Quercus* could have grown locally in the thermophilous vegetation but would have also formed part of the mesomediterranean woodland expanding towards the hinterland.[107] Deciduous *Quercus* and *Fraxinus* may also have grown in such formations in which Fabaceae and Maloideae could have constituted the understorey. Deciduous *Quercus* would have been the main constituent of supramediterraenan woodland expanding at mid-altitudes, as it does today in the Peloponnese.[108] *Abies* (*cephalonica*?) and *Pinus nigra*, the Mediterranean mountain conifers of the Peloponnese, would have formed forests on the mountains bordering the Argolid to the west, north, and south, similar to the present vegetation at these high altitudes.

The anthracological results reflect the importance of the olive in the local vegetation as a cultivated tree and/or growing in the wild. This is in agreement with Kroll's charcoal analysis in Tiryns where *Olea* was the most common taxon.[109] Moreover, all the pollen cores from the area show a remarkable increase of *Olea* for the Bronze Age compared to previous periods.[110] According to the Kotihi pollen diagram a similar situation occurred in the north-west Peloponnese.[111] The increase is interpreted as the result of combined factors: cultivation of the tree and proliferation in the wild in the maquis vegetation that, due to increased and more intense

[99] See Maran & Papadimitriou 2006, 116 figs. 62–63, 117; Maran 2008, 71 figs. 62–63, 78, 79 fig. 70 for examples of such Post-Palatial hearths.
[100] Brysbaert & Vetters 2015, 167–169 with fig. 5, 171 fig. 6.
[101] Kroll 1982, 467.

[102] Jahns 1993.
[103] Bottema 1990.
[104] Atherden *et al*. 1993.
[105] Lazarova *et al*. 2012.
[106] Dafis 2010, 57; Quézel & Barbéro 1985.
[107] Dafis 2010, 57; Quézel & Barbéro 1985.
[108] Dafis 2010, 57; Quézel & Barbéro 1985.
[109] Kroll 1982, 484.
[110] Atherden *et al*. 1993; Bottema 1990; Jahns 1993.
[111] Lazarova *et al*. 2012.

human activity during this period, replaced the previous deciduous and mixed woodland.[112] Evergreen oaks, Fabaceae, and Maloideae reflect the maquis vegetation that would have probably characterized the local uncultivated environments around Tiryns. According to Kroll's charcoal analysis the evergreen trees such as *Quercus ilex* type and *Phillyrea*, together with *Pinus*, could have grown on the steeper hill slopes.[113] In the pollen cores *Quercus ilex/coccifera*, *Juniperus*, *Pistacia*, *Phillyrea*, *Erica*, and Cistaceae indicate the expansion of maquis during the Bronze Age at the expense of the deciduous oak woodland that would have retreated to higher altitudes as a result of the intensive use of the plains for farming activities.[114] Nevertheless, the anthracological results indicate that species of the deciduous woodland such as deciduous oak and ash were valued for their wood and were probably procured for specific uses, such as construction timber and/or for the manufacture of wooden objects. This would be in agreement with Kroll's suggestion that deciduous riparian forests were still extant in the plain of the Inachos river and may have been the habitat of deciduous oak, ash, and *Ulmus/Celtis* identified in his samples.[115] Similarly, even species non-existent in the plain, such as the fir and black pine, would have been brought from higher altitudes where, according to the pollen record, they constituted the natural vegetation since the earlier part of the Holocene.[116]

The anthracological results from the Lower Citadel reflect the geographical breadth of basic activities of Tiryns' inhabitants, such as the procurement of fuel and timber, which would have ranged from the plains and the cultivated orchards to specific locations on the mountainous areas to the west at a considerable distance from the site (approx. 30 km in straight line).

Based on the identification and uses of taxa attributed to the different contexts, the latter represent either the destruction of a building phase or the remains of fuel burned in thermal features. On the basis of the anthracological results we have already suggested that the combination of taxa from the local environment around Tiryns with others originating from non-local areas (e.g. the fir and the black pine) indicates the selection of specific taxa for specific purposes. In the case of Room 10 and the passageway we have opted to consider the taxa as representing the remains of building materials in relation to a thick ash deposit. Long and straight beams and poles would have been made from fir and black pine timbers while for other structural parts and features, timbers and plants commonly found in the surroundings would have been employed. If we may take this hypothesis a bit further, we could attribute the presence of dung in Room 10, as suggested by the phytolith analysis, to its use for the preparation of daub or plaster in order to cover the brushwood or other plant matter of an upper storey and/or ceiling. Such well-understood mixtures of daub would have helped in weatherproofing the walls and ceiling features and in controlling the humidity flow between the outside and inside of the building. As such, it would protect and preserve any organic material used in its construction from rotting in the most humid parts of the year, allow the building to breathe naturally between seasons, and improve the strength and stability of the plaster.[117]

The ashy sediment of Room 10, rich in dung, preserves phytolith remains that shed some light on the pastoral practices. The predominance of wild grass phytoliths most of which belong to the Chloridoids, i.e. plants related to the diet of grazers (cattle and sheep) and the low amounts of dicot leaf phytoliths that are mostly related to browsers (goats), suggests that the livestock kept in and around Tiryns belonged mainly to grazers (probably sheep) and maybe a few goats. The presence of Chloridoid short grasses points to free-ranging animals that have most probably been given supplementary feed with fodder as indicated by the high presence of straw. The presence of cereals (mainly wheat and some barley) in the sediment may indicate that cereals were also given as fodder to the animals and hence the cereal phytoliths have been brought into the room with the dung. There is no indication of any seed processing or storage in the southern part of the room, since stem phytoliths outnumber seed husk phytoliths.

With respect to the ovens the interpretation of the anthracological results, especially from oven no. 79/02, is more ambiguous. Qualitatively, the assemblage is similar to those from Room 10 and the passageway, i.e. the tentative construction timber debris. If we are to consider the taxa in this oven as fuel remains several questions arise: why is there a combination of non-local and local woods? Could they represent the remains of fuel deliberately selected for specific activities that required the use of certain species? Are the remains a reflection of the complicated superpositioning of structures in this area?

The use of the non-local taxa for fuel would imply deliberate choices and transportation since these would not have been readily available in the surroundings. However, the diversity of taxa in oven no. 79/02 does not support the idea of a selection of determined species for fuel and certainly many of the taxa would have been procured locally from

112 Jahns 1993.
113 Kroll 1982, 485.
114 Atherden *et al*. 1993; Jahns 1993.
115 Kroll 1982, 484–485.
116 Jahns 1993.

117 As demonstrated, for example, for Neolithic Israel: Goren & Goldberg 1991 (and references within); on purely functional uses of plasters to regulate relative humidity of living indoor spaces and to protect organic wood features from rotting, see Brysbaert 2008.

the natural vegetation or tree orchards. Resinous woods and hardwoods, trees and shrubs are all represented in the assemblage. It is, therefore, impossible to identify any specific use of this oven based on the wood species burnt in it. In fact, the calorific properties (calorific production measured in kcal or joules per kilogram of burnt wood) vary little from one species to another,[118] but depend mainly on the density and/or the chemical composition of their wood. However, the combustible properties fluctuate significantly in relation to the calibre, the rate of humidity (dry, seasoned, fresh, wet) and/or the physiological state of the wood (healthy wood v. dead or decayed wood).[119] Consequently, selection could have been determined by the availability of resources, the wood's moisture content and physiological state and its calibre. In the case of oven no. 79/02 many locally available taxa are present, and a wide range of calibres (although not possible to measure due to small fragments) to serve different purposes could have been at the disposal of the users either by choosing differently sized logs of a single species (e.g. olive branches and prunings) or by combining scrub vegetation (e.g. Fabaceae), tree branches, and bigger logs from cut-down trees (e.g. oaks). Other parameters such as the moisture content of the wood are difficult to evaluate, but in a settled community systematic firewood management and firewood storage was needed to meet the demands of a growing population, the development of technologies, and the increased energy needs.[120] We may, thus, suggest that seasoned wood was used in hearths, ovens, and kilns. In such a context and given the availability of other firewood resources the presence of the non-local taxa in the assemblage of oven no. 79/02 could be interpreted as the remains of carpentry used in the fire and/or recycling of decayed/unused timbers from previous buildings no longer in use.

From a phytolith perspective both ovens are not as prolific as the ashy sediment in Room 10. Regarding oven no. 79/02 we notice that no difference has been detected in the ash of the interior and the exterior of the oven suggesting that the ash outside the oven is a dump of the ash that was inside. Dung was likely involved in the construction of oven no. 79/02. In general, it seems that dung and ash were used as admixtures in the clay constructions. The purpose of this was to make the clay more stable and prevent cracking. The presence of dung in only one ash sample must reflect intrusive clay pieces enriched with dung. Since spherulites have not been recovered from the rest of the ash samples we conclude that dung was most probably not used as fuel for the ovens analysed. Taphonomic conditions could be responsible for poor preservation since spherulites suffer dissolution in highly acidic environments and can be decomposed to calcium oxide when exposed to temperatures higher than 600° C.[121] The environment, though, of the ashy sediments is not acidic but calcareous and the phytolith preservation does not point to such high temperatures.

On the other hand, leafy wood branches were the main component of the fuel material used in the ovens and especially in no. 46/03, since it preserved the larger volume of wood calcite. The fire in this oven must have been strong as indicated by the high percentage of molten phytoliths. The tinder used to start the fire was wild grasses as suggested by their high presence in almost all the samples. Cereal phytoliths have been identified in minor quantities in more than half of the samples and in all contexts. That means that apart from their use as staples they have entered the site either as by-products used as clay admixture and/or as fuel. Their presence as macroremains in oven no 79/02 could represent residues of cooking.

The ashy area in the passageway preserves exotic plants as has been suggested by phytoliths. Palm phytoliths identified only in this context suggest that this ashy layer is a different archaeological context. The part of the palm from which these phytoliths were produced of is uncertain. Previous research on *Palmae* phytoliths shows that *Palmae* species produce the same phytolith morphotype in all the organs.[122] Accordingly, it is not easy to recognize the part or parts of the tree used at Tiryns. It could have been the palm wood or else the leaves or fruits, or even all of them. It will be recalled that leaves of the palm tree are extensively used for roofing, matting, and basketry; the trunks can be used for beams in a building, the fibres of the bark for ropes, and the sugar-rich fruits (at least in the case of cultivated palms) for food.[123] It is not clear whether palms were part of the local vegetation or whether the material was somehow imported from other areas (Crete, North Africa, or the Near East).[124] However, a very quick survey demonstrated that iconographic evidence of the palm with date fruit was depicted on a Late Bronze Age (LBA) painted plaster fragment from Knossos, now on display at the Heraklion Museum.[125] Moreover, the palm tree was depicted on a MM IIIA amphora from the Loomweight Basement at Knossos[126] and Immerwahr mentioned several instances observed on Aegean Bronze

118 From 4000 to 4500 kcal/kg, Théry-Parisot 2001, 157.
119 Théry-Parisot 2001, 151–159 and references therein; Théry-Parisot *et al*. 2010, 144–145.
120 Asouti &Austin 2005; Théry-Parisot *et al*. 2010, 145–146.
121 Shahack-Gross 2011.
122 Piperno 2006; Vrydaghs *et al*. 2001.
123 Zohary & Hopf 1988.
124 Sarpaki 2001, 221 n. 255 reports Late Bronze Age charred wood remains from Crete, i.e. Palaikastro and Pseira.
125 Most recently Tsitsa 2013, 155.
126 Betancourt 1985, 104; Immerwahr 1990, 33 pl. 4 on MM II–IIIA depictions of palm trees on Kamares pottery.

Age painted plaster on which palm trees were depicted, ranging in date from LM IA (Akrotiri, West House, Nilotic Landscape and the palm tree with African from the Ravine),[127] to LM III (Ayia Triada sarcophagus).[128] Similar scenes were also recognized for the Greek mainland that have been dated to LH IIIB such as Mycenae's scene with Minoan Genii with donkey heads which, later on, could be joined with fragments depicting similar demons and palm trees, and a clay sealing with palm fronds depicted on it is known from outside the South-West Building at Pylos.[129] Finally, Rackham published a paper on the vegetation from Thera dating to before and after its volcanic eruption and palm trees feature among the plants listed.[130] The current palaeoenvironmental evidence provides no certain evidence for palm trees in the area of Tiryns in the Bronze Age. Nevertheless, the warm climate of the area would not be prohibitive for the growth of palm trees, especially on the coasts which would be within 2 km; the iconography and Rackham's study also indicate that the palm tree certainly was known in the Aegean, directly or indirectly, from the MM IIIA period onwards on Crete and, a little later perhaps, also on Thera. As no palm fruit macroremains and no palm wood charcoal are identified in the anthracological analysis of this context, maybe the plant identified in the phytolith assemblages could derive from a mat or a tray for foodstuffs etc., a basket, or any household container or domestic object made of palm leaves. This may also have been brought into Tiryns from a trip to Crete or to the Near East. An interpretation of the palm phytoliths as remains of a mat, tray, or other container or domestic object gains additional probability with regard to the find spot since fragments of the best preserved faience head-shaped rhyton were excavated in the immediate vicinity and slightly above the ash that contained the palm phytoliths.[131] One may assume that this vessel could have originally been placed on a mat, or in a tray or basket made of palm leaves. Previous studies provided evidence for the final embellishment of such faience vessels by gilding them in Room 78a,[132] but the original production place of the faience vessels is still obscure. The aperture in the mouth or snout of the figure vessel points to a manufacture according to Mycenaean predilections rather than an import from the Eastern Mediterranean. The whole assemblage, however, including an imported Canaanite amphora with Cypro-Minoan signs on the handles and a Hellado-Levantine chalice probably produced in the Argolid (but a vessel type mainly exported to the East), indicate an idiosyncratic collection of Cypriot/Near Eastern goods, Mycenaean products specifically geared towards export to the East, and potentially local emulations of Near Eastern or Cypriot vessels for luxurious consumption in a pan-Eastern Mediterranean élite context. The use of an imported container made from palm leaves would add yet another component to this assemblage.

Conclusions

All botanical species (except for Palmae) that we presented here as part of this very small assemblage from the new excavations in the Lower Citadel are no newcomers at the site of Tiryns because they have been known from the Lower Citadel, the Lower Town North-West[133] as well as from the Lower Town North-East,[134] but also from sites in the vicinity of Tiryns such as Midea[135] and Mycenae.[136] Samples derive from Palatial and Post-Palatial contexts in the Lower Citadel and Lower Town (with the latter only providing LH IIIC material), and a large number of sediment samples have been processed previously without much context-specific information available for them.

Therefore, the studied archaeobotanical data from our four different find spots in the Lower Citadel of Tiryns highlighted the value, first, of combining the analysis of the fruit/seed macroremains with anthracological and phytolith studies and, second, of integrating these results into the archaeological study of their contexts. As such, the multiple approach to the taxa present in these limited assemblages from the new excavations in the Lower Citadel contribute to the already known material from the site itself but also to that from sites nearby such as Midea and Mycenae. The results show assemblages rich in taxa, which represent different natural environments that, at present, have their parallels in the vegetation of the Peloponnese from the coast to the higher mountains. The anthracological study indicated, for example, that species of mountain conifer forests (black pine and fir) and the deciduous woodland (oak and ash) were desired and selected for their wood and likely procured as construction timber, sometimes transported over considerable distances, and/or for the manufacture of wooden objects. Placed in its broader context our study gave another glimpse of a long-term and ongoing process previously noted in pollen studies conducted in the region. Our study results fitted these well and showed that the fuel and timber selected and consumed at Tiryns came

127 Immerwahr 1990, 73, 188(9) with further references.
128 Immerwahr 1990, 102, 181.
129 Immerwahr 1990, 121; Kritseli-Providi 1982, pl. 1, figs. 2–3. Pylos: Blegen & Rawson 1966, 287.
130 Rackham 1978.
131 Cf. locus 1 in Kostoula & Maran 2012, 195–199.
132 Brysbaert & Vetters 2010.

133 Kroll 1982.
134 Pasternak 2006.
135 Margaritis *et al*. 2014.
136 Hillman 2011; Margaritis under study.

from the nearby plains and cultivated orchards, while other taxa were brought down by means of considerable human and other efforts from more distant locations.

Equally, the phytolith study of the dung material found in several contexts showed, for example, yet another way of how people creatively used and reused their nearby and more distant resources. Rather than employing dung as a fuel source for which it is best known, this plant-rich substance was likely used in admixtures to make daub and other clay-based features. As such, it functioned as waterproofing of walls and ceilings and by regulating the relative humidity of such surface covers, it prevented cracking and rotting of wooden beams in architectural features but also in oven constructions. The dung itself also offers rare glimpses of the goats and sheep that were part of the free-ranging livestock roaming around in and nearby Tiryns but which also received supplementary fodder to feed on.

Earlier research had already pointed out substantial evidence for the presence of non-local and exotic materials in various stages of production in LBA Tiryns.[137] Without sampling for archaeobotanical remains, and the subsequent implementation of an array of different analytical methods, the import of foreign food stuffs and organic products tends to become lost in the archaeological record. Although based on limited data, in this instance our study helps to visualize the acquisition, production, and consumption patterns of some of the most ubiquitous but least-visible and appreciated materials employed by past people in their everyday activities. Our current study added yet another instance of such prolific but otherwise archaeologically invisible material. The phytolith study highlighted the presence of palm, a species which would fit climatically in the Peloponnese but for which there is hitherto no such evidence. Probably arriving in the form of a woven mat or basket, the palm may have arrived from Crete or even further East, together with artefacts of East Aegean, Cypriot and/or Levantine origin, which were found concentrated in the northern sector of the Final Palatial Lower Citadel where such exotic materials indicated regular contacts between people from Tiryns with overseas.

For a better grasp of the human activities that took place in and around Tiryns in the LBA, Kroll's previous work is also insightful. On the one hand, Kroll suggested that deciduous riparian forests still existed in the plain of the Inachos river and could have been the habitat of deciduous oak, ash, and *Ulmus/Celtis*. Additionally, his work and further pollen studies indicated that fir and black pine made up the natural vegetation since the early Holocene. On the other hand, Kroll argued for an intensified agriculture in the Late Palatial period near or even beyond the carrying capacity of the land which, according to him, was linked to an intensive horticultural regime and a basically identical, but less intensive, agricultural regime in the Post-Palatial period, a point also made by Jahns' pollen studies.

In Tiryns, where it has been suggested that the local community may have grown in numbers from Palatial to Post-Palatial times, such human and ecological pressures may have resulted in more forest clearance. At the same time, such clearances would have also formed one of possibly several strategies of firewood management and fuel storage in order to cope with the growing population, the development of technologies, and the increased energy needs that accompanied these rapidly developing societal changes towards *c.* 1200 BC.

Ecological phenomena and human manipulation of these may constitute corollaries of economic and social organization in the Mycenaean world. In the Argolid, high levels of technological knowledge, networks for the management and exchange of natural resources, and labour specialization had developed[138] to such an extent that the conscious reuse and recycling of various materials (beyond recycling broken bronze tools and weapons), including timbers and plant-based items that no longer fulfilled their structural function in construction or utility as mat or container, had probably been much more common than evidenced by these limited archaeological and archaeobotanical data presented here. However, piecing together such evidence offers new vantage points for the reconstruction and interpretation of "invisible" human practices in the past.

MELISSA VETTERS
Fachbereich Altertumswissenschaften
Klassische und Frühägäische Archäologie
Universität Salzburg
Residenzplatz 1/II
A-5010 Salzburg,
melissa.vetters@sbg.ac.at

MARIA NTINOU
M.H. Wiener Laboratory for Archaeological Science
Souidias 54
GR-106 76 Athens
maria.ntinou@uv.es

EVI MARGARITIS
The Cyprus Institute
20 Konstantinou Kavafi St.
CY-2121 Aglantzia, Nicosia
e.margaritis@cyi.ac.cy

ANN BRYSBAERT
Faculteit Archeologie
Universiteit Leiden
Einsteinweg 2
NL-2333 CC Leiden
a.n.brysbaert@arch.leidenuniv.nl

GEORGIA TSARTSIDOU
Ephoreia of Palaeoanthropology, Speleology
Ardittou 34b
GR-116 36 Athens
gtsartsidou@ymail.com

[137] Rahmstorf 2008; Brysbaert & Vetters 2010; 2013; 2015; Kostoula & Maran 2012.

[138] See e.g. Brysbaert 2013b; 2015 on labour specialization and both human and natural resource management and organization in the context of monumental construction activities.

Bibliography

Albert, R.M. 2000. *Study of ash layers through phytolith analyses from the Middle Palaeolithic levels of Kebara and Tabun Caves*, Ph.D. thesis, University of Barcelona.

Albert, R.M. & S. Weiner 2001. 'Study of phytoliths in prehistoric ash layers using a quantitative approach', in *Phytoliths: Applications in earth sciences and human history*, eds. J.D. Meunier & F. Coline, Lisse, 251–266.

Asouti, E. & P. Austin 2005. 'Reconstructing woodland vegetation and its exploitation by past societies, based on the analysis and interpretation of wood-charcoal macroremains', *Environmental Archaeology* 10, 1–18.

Atherden M., J. Hall & J. Wright 1993. 'A pollen diagram from the north-east Peloponnese, Greece: Implications for vegetation history and archaeology', *The Holocene* 3:4, 351–356.

Badal, E. & M. Ntinou 2013. 'Wood-charcoal analysis from Neolithic Knossos: The local vegetation', in *The Neolithic settlement of Knossos in Crete: New evidence for the early occupation of Crete and the Aegean Islands* (Prehistory Monographs, 42), eds. N. Efstratiou, A. Karetsou & M. Ntinou, Philadelphia, 95–118.

Badal E., Y. Carrion, M. Macias & M. Ntinou 2012. *Wood and charcoal. Evidence for natural and human history* (= *Saguntum PLAV*, Extra 13).

Betancourt, P.P. 1985. *The history of Minoan pottery*, Princeton.

Blegen, C.W. & M. Rawson 1966. *The Palace of Nestor at Pylos in Western Messenia. Excavations conducted by the University of Cincinnati* 1. *The buildings and their contents*, Princeton.

Bohn, U., R. Neuhäusl with contributions by G. Gollub, C. Hettwer, Z. Neuhäuslova, T. Raus, H. Schlüter & H. Weber 2000/2003. *Map of the natural vegetation of Europe, scale 1:2,500,000*, Münster.

Bottema, S. 1990. 'Holocene environment of the Southern Argolid: A pollen core from Kiladha Bay', in *Excavations at Franchti Cave* 6, eds. T.J. Wilkinson & S.T. Duhon, Bloomington, Indiana, 117–138.

Bottema S. & A. Sarpaki 2003. 'Environmental change in Crete: A 9,000-year record of Holocene vegetation history and the effect of the Santorini eruption', *The Holocene* 13:5, 733–749.

Braadbaart, F., E. Marinova & A. Sarpaki 2016. 'Charred olive stones: Experimental and archaeological evidence for recognizing olive processing residues used as fuel', *Vegetation History and Archaeobotany*; DOI:10.1007/s00334-016-0562-2

Brun J.-P. 2003. *Le vin et l'huile dans la Méditerranée antique. Viticulture, oléiculture et procédés de fabrication*, Paris.

Brysbaert, A. 2008. *The power of technology in the Bronze Age Eastern Mediterranean. The case of the painted plaster* (Monographs in Mediterranean Archaeology, 12), London.

Brysbaert, A. 2013a. '"The chicken or the egg?" Interregional contacts viewed through a technological lens at Late Bronze Age Tiryns, Greece', *OJA* 32:3, 233–256.

Brysbaert, A. 2013b. 'Set in Stone? Socio-economic reflections on human and animal resources in monumental architecture of Late Bronze Age Tiryns in the Argos Plain, Greece', *Arctos* 47, 49–96.

Brysbaert, A. 2014. 'Talking shop: Multicraft workshop materials and architecture in prehistoric Tiryns, Greece', in *Material crossovers: Knowledge networks and the movement of technological knowledge between craft traditions*, eds. K. Rebay-Salisbury, A. Brysbaert & L. Foxhall, London, 37–61.

Brysbaert, A. 2015. 'Set in stone? Constructed symbolism viewed through an architectural energetics' lens at Bronze Age Tiryns, Greece', *Analecta Praehistorica Leidensia* 45, 91–105.

Brysbaert, A. & M. Vetters 2010. 'Practicing identity: A crafty ideal?' *Mediterranean Archaeology and Archaeometry* 10:2, 25–43.

Brysbaert, A. & M. Vetters 2013. 'A moving story about exotica: Objects' long-distance production chains and associated identities in Tiryns', *OpAthRom* 6, 175–210.

Brysbaert, A. & M. Vetters 2015. 'Mirroring the Mediterranean? Artisanal networking in 12th century BCE Tiryns', in *The Mediterranean mirror. Cultural contacts in the Mediterranean Sea between 1200 and 750 B.C. International post-doc and young researcher conference, Heidelberg, 6th–8th October 2012* (RGZM Tagungen, 20), eds. A. Babbi, F. Bubenheimer-Erhardt, B. Marín-Aguilera & S. Mühl, Mainz, 161–175.

Buchholz, H.-G. 2004. *Der Werkstoff Holz und seine Nutzung im ostmediterranen Altertum* (Beiheft zum Tagungsband Althellenische Technologie und Technik, Ohlstadt 2003, veranstaltet von dem Verein zur

Förderung der hellenischen Geschichte in Weilheim), Weilheim/Oberbayern.

Canti, M. 1999. 'The production and preservation of faecal spherulites: Animals, environment, and taphonomy', *JAS* 26, 251–258.

Cappers, R.T.J., R. Neef & R.M. Bekker 2009. *Digital atlas of economic plants*, Groningen.

Carrion, Y., M. Ntinou & E. Badal 2010. '*Olea europaea* L. in the north Mediterranean basin during the Pleniglacial and the Early-Middle Holocene', *Quaternary Science Reviews* 29, 952–968.

Chabal, L. 1997. *Forets et sociétés en Languedoc (Néolithique final Antiquité tardive). L'anthracologie, méthode et paléoécologie* (Documents d'Archéologie Française, 63), Paris.

Chabal, L., L. Fabre, J.-F. Terral & I. Théry-Parisot 1999. 'L'Anthracologie', in *La Botanique*, eds. C. Bourquin-Mignot, J.-É. Brochier, L. Chabal, S. Crozat, L. Fabre, F. Guibal, P. Marinval, H. Richard, J.-F. Terral & I. Rhéry, Paris, 43–104.

Colaianni, G., G. Fiorentino, E. Fouache, A. Pontrandolfo, A. Santoriello & F. Scelza 2012. 'Palaeovegetational reconstruction of the Krios Valley, northern Achaea (Greece): Archaeobotanical analysis conducted as part of the Aegialia Survey Project', *Revue d' archéométrie* 36, 127–137.

Dafis, S. 2010. *Τα δάση της Ελλάδας*, Thessaloniki.

Damblon, F., ed. 2013. *Proceedings of the Fourth International Meeting of Anthracology* (BAR-IS, 2486), Oxford.

Damm-Meinhardt, U. 2015. 'Building Complex A in the Lower Citadel: An outstanding mansion of the Palatial period', in *Mycenaeans up to date. The archaeology of the north-eastern Peloponnese. Current concepts and new directions* (ActaAth 4,°56), eds. A.-L. Schallin & I. Tournavitou, Stockholm, 117–130.

Damm-Meinhardt, U. & T. Mühlenbruch 2013. *Baubefunde und Stratigraphie der Unterburg und des nordwestlichen Stadtgebiets (Kampagnen 1976 bis 1983) Tafeln* (Tiryns, 17:3), Wiesbaden.

Davis, B., J. Maran & S. Wirghová 2014. 'A new Cypro-Minoan inscription from Tiryns: TIRY Avas 002', *Kadmos* 53:1–2, 91–109.

Domanski, M., J.A. Webb & J. Boland 1994. 'Mechanical properties of stone artefact materials and the effect of heat treatment', *Archaeometry* 36:2, 177–208.

Fiorentino, G. & D. Magri, eds. 2008. *Charcoals from the past: Cultural and palaeoenvironmental implications. Proceedings of the Third International Meeting of Anthracology, Cavallino – Lecce (Italy) June 28th–July 1st 2004* (BAR-IS, 1807), Oxford.

Flint-Hamilton, K.B. 1999. 'Legumes in ancient Greece and Rome: Food, medicine or poison?', *Hesperia* 68, 371–385.

Fuller, D.Q., C. Stevens & M. McClatchie 2014. 'Routine activities, tertiary refuse and labour organisation: Social inferences from everyday archaeobotany', in *Ancient plants and people. Contemporary trends in archaeobotany*, eds. M. Madella, C. Lancelotti & M. Savard, Tucson, 174–217.

Goren, Y. & P. Goldberg 1991. 'Petrographic thin sections and the development of Neolithic plaster production in northern Israel', *JFA* 18:1, 131–140.

Grossmann, P. & J. Schäfer 1971. 'Tiryns: Unterburg, Grabungen 1965', in *Tiryns* 5, Mainz, 41–75.

Hillman, G.C. 1981. 'Reconstructing crop husbandry practices from charred remains of crops', in *Farming practice in British prehistory*, ed. R. Mercer, Edinburgh, 123–162.

Hillman, G.C. 1984. 'Interpretation of archaeological plant remains: The application of ethnographic models from Turkey', in *Plants and ancient man. Studies in palaeoethnobotany. Proceedings of the Sixth Symposium of the International Work Group for Palaeoethnobotany, Groningen, 30 May–3 June 1983*, eds. W. van Zeist & W.A. Casparie, Rotterdam, 1–42.

Hillman, G.C. 2011. 'The grain from the Granary', in *Well Built Mycenae* 16/17. *The Post-Palatial levels*, ed. E.B. French with contributions by G. Hillman and S. Sherratt, Oxford, 748–781.

Immerwahr, S.A. 1990. *Aegean painting in the Bronze Age*, Pennsylvania.

Jahns, S. 1993. 'On the holocene vegetation history of the Argive Plain (Peloponnese, southern Greece)', *Vegetation History and Archaeobotany* 2, 187–203.

Jones, G.E.M. 1984. 'Interpretation of archaeological plant remains: The application of ethnographic models from Greece', in *Plants and ancient man. Studies in palaeoethnobotany. Proceedings of the Sixth Symposium of the International Work Group for Palaeoethnobotany, Groningen, 30 May–3 June 1983*, eds. W. van Zeist & W.A. Casparie, Rotterdam, 43–61.

Jones, G.E.M. 1992. 'Weed phytosociology and crop husbandry: Identifying a contrast between ancient and modern practice', *Review of Palaeobotany and Palynology* 73, 133–143.

Kilian, K. 1981. 'Ausgrabungen in Tiryns 1978, 1979. Bericht zu den Grabungen', *AA* 1981, 149–194.

Kilian, K. 1984. 'Μυκηναϊκά εργαστήρια χαλκού στην Τίρυνθα', *Ανθρωπολογικά: Journal of Theory and Practice* 6, 55–57, 69–72.

Kilian, K. 1988. 'Ausgrabungen in Tiryns 1982/83. Bericht zu den Grabungen', *AA* 1988, 105–151.

Kostoula, M. & J. Maran 2012. 'A group of animal-headed faience vessels from Tiryns', in *All the wisdom of the East. Studies in Near Eastern archaeology and history in honor of Eliezer D. Oren* (Orbis Biblicus et Orientalis, 255), eds. G. Lehmann, Z. Talshir, M. Gruber & S. Ahituv, Fribourg, 193–234.

Kritseli-Providi, I. 1982. *Τοιχογραφίες του θρησκευτικού κέντρου των Μυκηνών*, Athens.

Kroll, H. 1982. 'Kulturpflanzen von Tiryns', *AA* 1982, 467–485.

Kroll, H. 1983. *Kastanas – die Pflanzenfunde* (Prähistorische Archäologie in Südosteuropa, 2), Berlin.

Kroll, H. 1984. 'Zum Ackerbau gegen Ende der mykenischen Epoche in der Argolis', *AA* 1984, 211–222.

Lazarova, M., A. Koutsios & N. Kontopoulos 2012. 'Holocene vegetation history of the Kotihi Lagoon (north-western Peloponnesus, Greece)', *Quaternary International* 261, 138–145.

MacGillivray, J.A., L.H. Sackett, J.M. Driessen & S. Hemingway 1992. 'Excavations at Palaikastro, 1991', *BSA* 87, 121–152.

Maran, J. 2008. 'Forschungen in der Unterburg von Tiryns 2000–2003', *AA* 2008:1, 35–111.

Maran, J. 2009. 'The crisis years? Reflections on signs of instability in the last decades of the Mycenaean palaces', *Scienze dell' antichità. Storia archeologia antropologia* 15, 241–262.

Maran, J. 2010. 'Tiryns', in *The Oxford handbook of the Bronze Age Aegean (ca. 3000–1000 BC)*, ed. E.H. Cline, Oxford, 722–734.

Maran, J. 2012a. 'Ceremonial feasting equipment, social space and interculturality in Post-Palatial Tiryns', in *Materiality and social practice. Transformative capacities of intercultural encounters. Papers of the conference, Heidelberg, 25–27 March 2010*, eds. J. Maran & P. Stockhammer, Oxford, 121–136.

Maran, J. 2012b. 'Architektonischer Raum und soziale Kommunikation auf der Oberburg von Tiryns', in *Orte der Herrschaft. Charakteristika von antiken Machtzentren* (Menschen – Kulturen – Traditionen; Forschungscluster 3/3: Politische Räume), eds. F. Arnold, A. Busch, R. Haensch & U. Wulf-Rheidt, Rahden/Westfalen, 149–162.

Maran, J. & A. Papadimitriou 2006. 'Forschungen im Stadtgebiet von Tiryns 1999–2002', *AA* 2006:1, 97–169.

Margaritis, E. 2013. 'Distinguishing exploitation, cultivation, production and domestication. The olive in the 3rd millennium Aegean', *Antiquity* 87, 746–757.

Margaritis, E. & M.K. Jones 2008. 'Crop-processing of *Olea europaea* L.: An experimental approach for the interpretation of archaeobotanical olive remains', *Vegetation History and Archaeobotany* 33, 381–392.

Margaritis, E., K. Demakopoulou & A.L. Schallin 2014. 'The archaeobotanical samples from Midea: Agricultural choices in the Mycenaean Argolid', in *Physis. L'environnement naturel et la relation homme-milieu dans le monde égéen protohistorique. Actes de la 14e Rencontre Égéenne Internationale, Paris, Institut National d'Histoire de l'Art, 11–14 décembre 2012* (Aegaeum, 37), eds. G. Touchais, R. Laffineur, F. Rougemont, H. Prokopiou & S. Andreou, Leuven & Liège, 271–276.

Moody J., O. Rackham & G. Rapp 1996. 'Environmental archaeology of prehistoric NW Crete', *JFA* 23, 273–297.

Mühlenbruch, T. 2013. *Baubefunde und Stratigraphie der Unterburg und des nordwestlichen Stadtgebiets (Kampagnen 1976 bis 1983). Die mykenische Nachpalastzeit (SH III C)* (Tiryns, 17:2), Wiesbaden.

Ntinou, M. 2011. 'Charcoal analysis at the Cave of the Cyclops, Youra, northern Sporades', in *The Cave of the Cyclops: Mesolithic and Neolithic networks in the northern Aegean, Greece* 2. *Bone tool industries, dietary resources and the palaeoenvironment, and archaeometrical studies* (Prehistory Monographs, 31), ed. A. Sampson, Philadelphia, 297–314.

Ntinou, M. & G. Stratouli 2012. 'Charcoal analysis at Drakaina Cave, Kephalonia, Ionian Islands, Greece. A case study of a specialized Late Neolithic and Chalcolithic site', in *Wood and charcoal. Evidence for natural and human history* (= *Saguntum PLAV,* Extra 13), eds. E. Badal, Y. Carrion, M. Macias & M. Ntinou, 43–52.

Ntinou, M. & G. Tsartsidou 2015. 'Domestic and ritual use of plants and fuels in the Neolithic cave of Alepotrypa, Peloponnese, Greece: The wood charcoal and phytolith evidence', in *Local to global significance of charcoal science. 6th International Anthracology Meeting, 30 August–5 September 2015, Freiburg, Germany. Abstract volume*, eds. T. Ludemann & O. Nelle, 97. https://www.anthraco.uni-freiburg.de/abstract/view

Pagnoux, C., L. Bouby, S. Ivorra, C. Petit, S.M. Valamoti, T. Pastor, S. Picq & J. F. Terral 2015. 'Inferring agrobiodiversity of *Vitis vinifera* L. (grapevine) in ancient Greece by comparative shape analysis of archaeological and modern seeds', *Vegetation History and Archaeobotany* 24, 75–84.

Pasternak, R. 2006. 'Bericht zu den archäobotanischen Funden aus Stadt-Nordost', *AA* 2006:1, 134–136.

Piperno, D. 2006. *Phytoliths: A comprehensive guide for archaeologists and paleoecologists*, Lanham, Maryland.

Polunin, O. 1980. *Flowers of Greece and the Balkans: A field guide*, Oxford.

Quézel, P. & M. Barbéro 1985. *Carte de la végétation potentielle de la région méditerranéenne; feuille n.1: Méditerranée orientale*, Paris.

Rackham, O. 1978. 'The flora and vegetation of Thera before and after the Great Eruption', in *Thera and the Aegean world* 1. *Papers presented at the Second International Scientific Congress, Santorini*, eds. C. Doumas & H.C. Puchelt, London, 755–764.

Rahmstorf, L. 2008. *Kleinfunde aus Tiryns aus Terrakotta, Stein, Bein und Glas/Fayence vornehmlich aus der Spätbronzezeit, Forschungen und Berichte* (Tiryns, 16), Wiesbaden.

Rahmstorf, L. 2015. 'Workshop activities and pyrotechnology at Mycenaean Tiryns', in *Mycenaeans up to date. The archaeology of the north-eastern Peloponnese. Current concepts and new directions* (ActaAth-4°, 56), eds. A.-L. Schallin & I. Tournavitou, Stockholm, 143–149.

Sarpaki, A. 2001. 'Condiments, perfume and dye plants in Linear B: A look at the textual and archaeobotanical evidence', in *Manufacture and measurement. Counting, measuring and recording craft items in early Aegean societies* (Meletemata, 33), ed. A. Michailidou, Athens, 195–265.

Schachl, R. 2006. 'Die archäobotanischen Reste', in *Aigeira* 1. *Die mykenische Akropolis*, Fasc 3. *Vormykenische Keramik, Kleinfunde, archäozoologische und archäobotanische Hinterlassenschaften, naturwissenschaftliche Datierungen* (DenkschrWien, 342; Veröffentlichungen der Mykenischen Kommission, 24), eds. E. Alram-Stern & S. Deger-Jalkotzy, Wien, 189–201.

Schliemann, H. 1886. *Tiryns. Der prähistorische Palast der Könige von Tiryns*, Leipzig.

Schweingruber, F.H. 1990. *Anatomie Europäischer Hölzer. Anatomy of European woods*, Bern & Stuttgart.

Shahack-Gross, R. 2011. 'Herbivorous livestock dung: Formation, taphonomy, methods for identification and archaeological significance', *JAS* 38, 205–218.

Stevens, C.J. 2003. 'An investigation of agricultural consumption and production models for prehistoric and Roman Britain', *Environmental Archaeology* 8, 61–67.

Théry-Parisot, I. 2001. *L'économie des combustibles au Paléolithique* (CEPAM, Dossiers de documentation archéologique, 20), Paris.

Théry-Parisot, I., L. Chabal & J. Chrzavzez 2010. 'Anthracology and taphonomy, from wood gathering to charcoal analysis. A review of the taphonomic processes modifying charcoal assemblages in archaeological contexts', *Palaeogeography, Palaeoclimatology, Palaeoecology* 291, 142–153.

Thiébault, S. ed., 2002. *Charcoal analysis: Methodological approaches, palaeoecological results and wood uses. Proceedings of the Second International Meeting of Anthracology, Paris, September 2000* (BAR-IS, 1063), Oxford.

Tsartsidou, G., S. Lev-Yadun, R.M. Albert, M.A. Rosen, N. Efstratiou & S. Weiner 2007. 'The phytolith archaeological record: Strengths and weaknesses evaluated based on a quantitative modern reference collection from Greece', *JAS* 34, 1262–1275.

Tsartsidou, G., S. Lev-Yadun, N. Efstratiou & S. Weiner 2008. 'Ethnoarchaeological study of phytolith assemblages from an agro-pastoral village in northern Greece (Sarakini): Development and application of a Phytolith Difference Index', *JAS* 35, 600–613.

Tsartsidou, G., S. Lev-Yadun, N. Efstratiou & S. Weiner 2009. 'Use of space in a Neolithic village in Greece (Makri): Phytolith analysis and comparison of phytolith assemblages from an ethnographic setting in the same area', *JAS* 36, 2342–2352.

Tsitsa, E. 2013. 'From Minoan artists to Swiss restorers through the prism of conservators', in *Paintbrushes. Wall-painting and vase-painting of the 2nd millennium BC in dialogue. Summaries*, ed. A. Vlachopoulos, Athens, 152–155.

Valamoti, S.M. 2004. *Plants and people in Late Neolithic and Early Bronze Age northern Greece. An archaeobotanical investigation* (BAR-IS, 1258), Oxford.

van der Veen, M. 2007. 'Formation processes of desiccated and carbonized plant remains – the identification of routine practice', *JAS* 34, 968–990.

Verdelis, N. 1964. 'Ανασκαφή Τίρυνθος', *ArchDelt* 19, Chron., 108–118.

Vernet, J.-L., ed. 1992. *Actes du Colloque "Les charbons de bois, les anciens écosystèmes et le rôle de l'Homme"* (Bulletin de la Société botanique de France, 139, Actualités botaniques, 2/3/4), Montpellier.

Vetters, M. 2011. 'A clay ball with a Cypro-Minoan inscription from Tiryns', *AA* 2011:2, 1–49.

Vrydaghs, L., H. Doutrelepont, H. Beeckman & E. Haerinck 2001. 'Identification of a morphotype association of Phoenix Dactylifera L. lignified tissues origin at Ed-Dur (1st AD) Umm Al-Qaiwain (U.A.E.)', in *Phytoliths: Applications in earth sciences and human history*, eds. J.-D. Meunier & F. Colin, Lisse, 239–250.

Weiberg, E., I. Unkel, K. Kouli, K. Holmgren, P. Avramidis, A. Bonnier, F. Dibble, M. Finne, A. Izdebski, C. Katrantsiotis, S.R. Stocker, M. Andwinge, K. Baika, M. Boyd & C. Heymann 2015. 'The socio-environmental history of the Peloponnese during the Holocene: Towards an integrated understanding of the past', *Quaternary Science Reviews*. http://dx.doi.org/10.1016/j.quascirev.2015.10.042.

Wilkinson, K.N. & C. Stevens 2003. *Environmental archaeology. Approaches, techniques and applications*, Stroud.

Willerding, U. 1973. 'Bronzezeitliche Pflanzenreste aus Iria und Synoro', in *Tiryns* 6, Mainz, 221–240.

Zangger, E., M.E. Timpson, S.B. Yazvenko, F. Kuhnke & J. Knauss 1997. 'The Pylos Regional Archaeological Project, Part II: Landscape evolution and site preservation', *Hesperia* 68:4, 548–641.

Zohary, D. & M. Hopf 1988. *Domestication of plants in the Old World: The origin and spread of cultivated plants in West Asia, Europe and the Nile Valley*, Oxford.

Zohary, D., M. Hopf & E. Weiss 2012[4]. *Domestication of plants in the Old World*, Oxford.