CENTRO DI ARCHEOLOGIA CRETESE - UNIVERSITÀ DI CATANIA

STUDI DI ARCHEOLOGIA CRETESE

VII

JOSEPH W. SHAW

MINOAN ARCHITECTURE: MATERIALS AND TECHNIQUES

per seguir virtute e conoscenza

STUDI DI ARCHEOLOGIA CRETESE

Collana diretta da Vincenzo La Rosa

Undertaken with the assistance of the
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ALDO AUSILIO EDITORE IN PADOVA - BOTTEGA D'ERASMO

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INTRODUCTION

This book has been written with the aim of providing a guide, for students and professional archaeologists alike, to the building materials used by the Minoans and the techniques they used to prepare and set them into place. It often focuses on the finer buildings discovered, thus on the architectural style characterizing the Minoan «Palaces» and the houses of the affluent[1]. Usually it does not deal with room and building shape and their relative relationships, functions, or significance. To learn more about those concerns, the reader can consult a forthcoming book, *Architecture of Minoan Crete,* by John McEnroe. There also remains the still very stimulating book on most aspects of the subject, J. Walter Graham's *The Palaces of Crete,* published in a revised edition in 1987.

Research work in Minoan contexts has expanded since the 1970s, when an early version of this book was published, often under the auspices of one of the Foreign Schools of Archaeology (American, British, French, German, Italian, and Swedish in Crete). At the rich, great palatial sites of Knossos, Malia, Phaistos and Hagia Triadha, as well as elsewhere, further excavation work has taken place. Often, however, concerns for rectifying still incomplete documentation, and thus understanding, have taken priority, so limited soundings characterize some of the recently published investigations[2]. One result of such restudy has been to reveal a variety of phases within building complexes, also to add complexity to the once simple succession of First (or Old) through Second (or New) Palace Periods. There have also been evaluations of unpublished materials recovered from earlier excavations, as at Hagia Triadha[3], Phaistos[4] and Knossos[5]. At the same time there has been a substantive shift away from concentrating on recovering valuable objects, to using any and every means to gather information about the domestic economy of the people, whether poor or affluent, how they lived and what they consumed[6]. Material analyses of all kinds, for instance faunal[7], floral[8], or petrological for ceramic analysis[9], have expanded in variety and with meaningful results. At the same time those considering theoretical aspects of the situation have fruitfully questioned the very meaning of earlier interpretations of the «Palaces» as functioning entities[10]. The regional roles of the Palaces, especially that of Knossos, continue to be debated[11].

Broader consideration has also resulted in detailed archaeological, geological, and land use surveys of defined areas, for instance that focusing on the immediate Knossos area by Sinclair Hood (Hood and Smyth 1981), a wider one by L. Vance Watrous and group for the

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[1] Tombs, with the exception of the Temple Tomb at Knossos and the ossuary of Chrysolakkos, are occasionally referred to here but are generally considered beyond the scope of this study.

[2] For instance, at Knossos by Sinclair Hood (Catling 1974, p. 34), at Malia by Olivier Pelon (1980 [with R. Anderson and J.P. Olivier]; 1989, 1993, 1999), and at Phaistos and Hagia Triadha by Vincenzo La Rosa (1977, 2002, 2007).

[3] Militello 1998 (frescoes); D'Agata 1999 (figurines).

[4] Militello 2001 (frescoes).

[5] Macdonald and Knappett 2001 (pottery).

[6] J.W. and M.C. Shaw (eds.) 1996, passim.

[7] Reese 1995; Reese, Rose and Ruscillo 2000; G. Jones 1984.

[8] C.T. and J.M. Shay 1995, 2000; Bedwin 1992.

[9] E.g. P.M. Day and V. Kilikoglou 2001.

[10] Rehak and Younger 2001, pp. 393-394, for a review.

[11] Rehak and Younger 2001, pp. 420-422; Wiener 2007.

Mesara Plain around Phaistos and Hagia Triadha[12], that of the large Malia Plain by Sylvie Müller, Robert Laffineur and group[13], or that by Nikos and Marina Panagiotaki of the Pediada area[14], which includes the area of the new palatial site of Galatas. These not only furnish information about the dates, arrangement, and nature of ancient settlement but also promote consideration of relationships between larger and smaller settlements within broader areas. Archaeological survey has also had the effect of helping to identify, and therefore, to protect antiquities from encroaching modern construction.

Concurrent with this has been the digital revolution, the shift from the typewriter to the computer, which has revolutionized data collection by making it easier to obtain and more efficient. It has even brought about the creation of web sites, hopefully long-term, dedicated to preserving excavation archives and making them available for consultation internationally, as in the case of Kommos[15].

New excavation has also flourished. There has been a return to old but still productive sites, like Mochlos (by Jeffery Soles), Pseira (by Philip Betancourt), and Vronda (by the trio of Geraldine Gesell, Leslie Day, and the late William Coulson), which is leading gradually to their publication in more detail and usually with a broader spectrum of concern in mind than that of the original excavators. Many new sites have been opened up, especially by the Greek Antiquities Service, which is often at the foreground of investigation, for instance at the palatial sites of Archanes (by Iannis and Effie Sakellarakis), Galatas (by George Rethemiotakis) Monastiraki (by Athanasia Kanta), and Petras (by Metaxia Tsipopoulou). From early on foreign schools of archaeology have participated in similar new exploration, like Chania (by Eric and Birgitta Hallager), Kommos (by Joseph and Maria Shaw), Myrtos-Phournou Korifi (by Peter Warren), or Myrtos-Pyrgos (by Gerald Cadogan).

Interest in prehistoric Aegean cultures in general has increased not only in the usual established periodicals, but also in supplements focusing on special issues and interests, often the proceedings of symposia and congresses. Extensive, multi-volume publications dedicated to single sites have also become more common. New, often academic, publishers even focus on the more general area (e.g. Paul Astrom's *Studies in Mediterranean Archaeology*, Robert Laffineur's *Aegaeum*, or Phillip Betancourt's Institute for Aegean Prehistory *Press Series*).

As a measure of this fervent activity *Nestor*, the occasional bibliography source for Aegean topics begun by Emmet L. Bennet, Jr., averaged 50 pages long in the early nineteen seventies, then increased to about 90 in the eighties, and now it is at least 150 pages long, reflecting a three-fold increase in interest over about forty years – a phenomenon that can also be estimated from the relative interest in Bronze Age Aegean themes at some of today's archaeological congresses. The Institute for Aegean Prehistory, founded by Malcolm Wiener, has done much to encourage all aspects of research.

From the point of view of Minoan architecture, our theme here, I should first acknowledge our debt to early excavators in Crete who began to fill in the picture from what they saw and recorded in the field, namely the valuable reports by L. Pernier and L. Banti for Phaistos[16], by J. Hazzidakis for Tylissos[17], by J. Charbonneaux, C. Pareyn, and H. and M. van Effenterre for Malia[18], by S. Xanthoudides for Nirou Khani[19], and by F.

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[12] Watrous, Hadzi-Vallianou, and Blitzer 2005.

[13] Müller, Laffineur and Anslin 2003.

[14] N. Panagiotakis 2003.

[15] Cf. https://tspace.library.utoronto.ca/handle/1807/3004

[16] *Festòs* I, pp. 441-446; II, pp. 417-485, 588-592; see also Pernier 1902, cols. 77-86, and Fiandra 1961-1962.

[17] *Tylissos* (2), pp. 48-58

[18] J. Charbonneaux 1928, especially pp. 347-363; H. van Effenterre and C. Pareyn, «Étude du Site de Mallia», especially p. 27 in *Mallia, Nécropoles*, II.

[19] Xanthoudides 1922, pp. 9-11.

Halbherr for Hagia Triadha[20]. Extensive information about construction is scattered throughout Sir Arthur Evans's monumental four volumes of The Palace of Minos at Knossos. Together with Evans's work we should mention N. Heaton's analyses of plasters used at Knossos and elsewhere in Crete[21], still a standard work on the subject, as well as T. Fyfe's work on the architectural designs on painted plaster decoration[22].

Since the 1970s the expanding interest in Minoan sites and their nature, along with the very number of students and academics involved, has encouraged increasing focus and thus specialization. This has enriched Aegean scholarship generally, and Minoan architectural scholarship in particular. Concerning building materials, for instance, there have been studies about newly discovered quarries[23], the nature and varieties of Cretan gypsum[24], as well as proof that Cretan gypsum was exported to Thera[25] and even to the Mycenaean Mainland[26]. Wood types used in construction have also been further investigated[27]. The use of mud brick has been charted[28], although more information is needed concerning its use on upper floors. Examination of lime plaster has proceeded apace, focusing on preparation, use on site, as well as relative constituents [29]. Building tools have been discussed definitively[30]. Concerning buildings themselves, concept and procedure of building layout have been explored more than earlier[31], as has orientation[32]. Methodology of fitting buildings into their landscapes has been investigated[33], as has earthquake-resistant construction[34]. Concerning walls and their appearance, orthostate[35] and regional wall construction[36] have been looked into, as have the character of Minoan roofs and parapets[37], also the chronology and variety of bases used in Neopalatial doors and staircases[38]. Various aspects of palatial central courts, including their development, have also been investigated[39]. «Mason's marks», incised marks on building blocks on many sites, are being reinvestigated[40]. Fortunately more general examinations, such as the spread of Minoan Neopalatial style on Crete, have also begun to appear[41]. There has also been some investigation of the little that we can deduce about Minoan builders and the building trade[42]. A typology of Minoan Neopalatial houses has also been proposed[43]. A major, ongoing addition to our knowledge is the custom of including a discussion of materials and techniques along with reports dealing with architecture[44].

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[20] Halbherr 1903, cols. 8-14; Halbherr, Stefani and Banti 1980.

[21] Heaton 1911.

[22] Fyfe 1902.

[23] Soles 1983; Driessen 1984; Betancourt 1996, 2001; Papageorgakis, Mourtzas and Orfanoudaki 1992.

[24] Chlouveraki 2002.

[25] Einfalt 1978.

[26] Gale, Einfalt, Hubberten and Jones 1988.

[27] Marinatos 1974; Follieri and Coccolini 1979-1980; Asouti 2003.

[28] Guest-Papamanoli 1978.

[29] Cameron, Jones and Philippakis 1977; M.C. Shaw 1996, 2005; Militello 1998, 2001; R. Jones 1999, 2005.

[30] Evely in *Crafts* 1993, 2000.

[31] Graham, *P. of C.* pp. 222-29 and addendum 5. Preziosi 1983, Chapter 4.

[32] J.W. Shaw 1973c.

[33] Fotou 1990; Zois 1990; Mantzourani 2005.

[34] Driessen 1987.

[35] J.W. Shaw 1983.

[36] McEnroe 1990.

[37] J.W. Shaw 1977, 2004.

[38] J.W. Shaw 1999.

[39] Driessen 2007; Palyvou 2007.

[40] Hood 1987; Begg 2004a and b.

[41] Driessen 1989-1990.

[42] See Evely in *Crafts*, pp. 554-55 and Chapter 5, part B here.

[43] McEnroe 1982.

[44] For instance, as Warren did with EM II Myrtos (1972), MacGillivray and Sackett did with Palaikastro (Driessen 1984), Popham and Sackett with the Unexplored Mansion at Knossos (Smyth 1984), Poursat for EM II Malia (Schmid 1996), Y. and E. Sakellarakis for Archanes (1997), and Hatzaki in her re-study of the

Architectural materials and techniques of related Aegean areas have also been explored in recent monographs, adding to our general understanding and providing a basis for future comparative studies. Aspects of Mycenaean Mainland architecture have been dealt with by Michael Küpper[45] and Pascal Darcque[46]. As in the case of Minoan studies, numerous separate articles have also appeared. Gunnel Hult[47] has contributed an invaluable study of Late Cypriot building technique as well as how it compares with other Eastern Mediterranean architecture. Especially timely for an examination of Minoan architecture has been the recent publication of Clairy Palyvou's dissertation[48] on Theran architectural materials and techniques and, now, her overall study of that island's architecture[49], which was strongly influenced by Minoan prototypes. Eleftheria Tsakanika-Theohari's doctoral dissertation about the structural role of wood in Minoan palatial buildings[50] provides systematic analyses of the subject and also questions some past assumptions. Particularly important for my study here have been continued investigations at Malia, by Olivier Pelon, into the early stages of the Malia Palace, and by Jean-Claude Poursat, along with his able architect Martin Schmid, of Malia's MM II Quartier Mu.

Aegean architecture must still be placed within the broader cultural panorama of neighboring Egyptian, Syrian, and Hittite traditions. Hult's comparative treatment of Cypriot architecture probably comes closest to achieving that aim. Caillot's studies of Ugaritic architecture (1983, 1994) provide provocative similarities with Minoan Neopalatial techniques. There is also, however, G.R.H. Wright's recently published *Ancient Building Technology* 2: *Materials* (2005). Since it covers the architectural history of the Ancient Near East, its scope did not allow for detailed discussion, especially of adjacent cultures such as those in the Aegean; but the attempt made therein to place Aegean architectural methodology within a broader spectrum is valuable. Of interest is the comment there that the well-preserved and well-studied tradition of Aegean fine plastering «may provide some specimen sample of the missing history» elsewhere in the Eastern Mediterranean[51].

The original outline of the material in *MA:MAT* 1 has remained, but errors and inconsistencies brought to my attention have been corrected. Much has been updated by new discovery. A few appendixes have been dropped as now being superfluous. Substantial new investigations in some areas, for instance the quarrying of stone and construction above ground floor level, have led to expansion of those sections. Some illustrations have been omitted and others added. More attention has been given here to LM III architecture, which postdates general palace use. The largest addition is Chapter 5, the first part of which explores in a comparative way topics discussed in earlier chapters. The second part provides some thoughts about Minoan builders, while the third sketches out the diffusion of Minoan architectural form beyond Crete, where it reflected Cretan life style, technical innovation, and cultural grandeur in differing contexts.

Little Palace at Knossos (2005). Soles also included a section on building in his restudy of Gournia Palace architecture (1991), also House Tomb architecture (1992), as did McEnroe (with Betancourt and Davaras 2001) in his analysis of the Minoan buildings at Pseira.

45 Küpper 1996.

46 Darcque 2005.

47 Hult 1983.

48 Palyvou 1999b.

49 Palyvou 2005.

50 Tsakanika-Theohari 2006.

51 G. Wright 2005, p. 163.

CHAPTER ONE

STONE

A) Building Stone (*figs.* 1-19)

Minoan masons generally derived their building stone from local deposits. Until the end of the Early Minoan period, builders simply gathered up loose stones and earth lying near the building site, as for the EM II house at Vasiliki (*figs.* 1a-b, 64-66), where mud and fieldstones formed a strong base or krepidoma for the wood and mud brick construction of the upper story[52]. Similarly, at the EM II site of Myrtos-Phournou Korifi (*fig.* 77) flat limestone slabs and sometimes water-rounded stones were used for the walls. No cut stone seems to have been used at either site.

Even after the dramatic changes in architectural techniques, and higher ambitions of the builders were reflected in the rise of the First Palaces, readily available, uncut stone continued to be used for the majority of interior and exterior walls, whether in palace, townhouse, or country villa. Almost the entire LM I settlement at Pseira (*figs.* 1b, 78-80), an isolated fishing village sheltered in a cove on an islet northwest of Mochlos, for instance, was built of schist slabs and limestone boulders gathered from the hillsides[53]; this practice is perpetuated in modern construction in the Mochlos-Pseira area. The houses of the town of Gournia were similarly built[54].

Certainly the first major change in building technique is the introduction of cut stone blocks. Pendlebury sees this change as a by-product of a technological revolution: «The introduction of bronze instead of copper had a great effect on the architecture. From the very beginning of MM I, good ashlar masonry was being produced and attention was being paid to the outward appearance of buildings»[55]. Good examples of ashlar masonry[56], Pendlebury notwithstanding, are not common in the MM I period, partly because they were hidden by later over-building and renovating, partly because the introduction of cut stone must have been a gradual one. Even in later periods cut stone was limited to special walls, rubble having been generally used in other cases.

Almost invariably, the types of stone preferred for ashlar construction were poros limestone, sandstone, and gypsum, no doubt chosen because of their availability locally and their relative softness[57]. Such stones, moreover, could be cut fairly easily in different directions, for

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[52] For a discussion of Early Minoan architecture, see Branigan 1988, pp. 36-66. Pendlebury (*A. of C.*, p. 62: the «House on the Hilltop») and Branigan (1988, p. 210) believe that the building shown here in figs. 64-66 is of EM II date. Sinos (1970, pp. 1-24) proposed that the building was actually early Middle Minoan, but a careful study by Zois, who also excavated at Vasiliki, confirmed the EM II date (Zois 1992, p. 270; 1976, pp. 11, 26-28).

[53] McEnroe 2001, p. 30.

[54] *Gournia*, p. 21.

[55] *A. of C.*, p. 283. See also Pernier's similar thoughts on the matter in *Festòs* I, p. 441.

[56] For a description of this masonry see pp. 58-76.

[57] Information about the types of stone used was partially brought together by Graham in his brief but good account in *The Palaces of Crete*, pp. 143-145 and passim. More specific information can be found scat-

their homogeneous structure prevented them from splitting along natural lines of cleavage, as would happen, for instance, with schist. The geological name for such stones is «free stones»[58].

Supplies of limestone and gypsum were abundant in the Knossos and Phaistos regions, but apparently fewer in the east where sandstone from local quarries often served as a substitute, as at Malia and Zakro. The presence of an early orthostate course of hard limestone at Chrysolakkos at Malia suggests that such stone must have been employed occasionally on an extensive scale, though the difficulties of cutting and dressing it, when softer stone was available nearby, prevented its popular use.

Other types of stone were used as well, however. Varieties of harder limestone were cut for thresholds, bases, and paving slabs. Schist, which occurred naturally in the form of flat slabs, was occasionally used for the same purposes. Conglomerates, crystalline limestones of various colors, opheiolite, and marble also occur, especially in places where their decorative quality would be appreciated.

1. Limestone

Limestone is defined as a «bedded, sedimentary deposit, consisting chiefly of calcium carbonate which yields lime when burned ... and is the consolidated equivalent of limy mud, calcareous sand, or shell fragments. The suitability for the manufacture of lime is not an essential characteristic»[59]. The Minoans used various types of this stone for building. One of them is a soft, even-grained stone, called «póros» or «porólithos»[60], with a color ranging from yellowish white to light gray. This should be distinguished from another, very soft type of limestone called «koúskouras»[61], which at best can be used as a filling material in rubble walls. Most ashlar walls were built with blocks of poros limestone, and occur frequently at various sites such as Hagia Triadha, Phaistos, Archanes, Kommos, Galatas, Nirou Khani, and Knossos (*figs.* 1b, 85-126).

It is clear that finer grades of white or creamy-colored limestone were often preferred for paving, bases (*fig.* 11), and stylobate slabs, which were generally more exposed than wall

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tered throughout excavation reports. Especially helpful are relevant descriptions in the two volumes of the publication on Phaistos (*Festòs* I, pp. 441-446; II, pp. 418-419), as well as in reports on Malia (Charbonneaux 1928, p. 350) that include a study by C. Pareyn of the topography, geology, and building materials of the Malia region («Étude Géologique», Chapter II in *Mallia, Nécropoles* II, pp. 9-27). The failure of Evans to present information in an organized way in *The Palace of Minos* is alleviated somewhat by the Index Volume, which has helpful listings such as «limestone», «gypsum», etc. Dr. J.N. Papastamatiou of the National Technological School of Athens has been particularly helpful with the identification of stone samples for this study. He was responsible in the past for producing a series of excellent geological maps of Crete, done at a scale of 1:50,000. Maps of the areas of Chania, Hierapetra, Siteia, and Ziros, the last three most helpful for the present study were available. I am indebted as well to the French School of Archaeology for allowing me to examine special collections of stone from the Malia area. For general information on stone types, I have relied on Rosenfeld 1965 and *Geological Terms* (1976). For a short general survey of the geology of Crete, plus references to more technical treatments of the subject, see Warren 1969, p. 124, but especially Rackham and Moody 1996.

[58] Rosenfeld 1965, p. 186.

[59] *Dictionary of Geological Terms*, 1976.

[60] As *Tylissos* (2), p. 49; *Festòs* II, p. 418; Xanthoudides 1922, pp. 9-10 (Nirou Khani). The term «poros» should be used with caution and be further qualified, however, for it is also used in reference to sandstone. It was a general term commonly used in Classical times, as it is by archaeologists today (See Orlandos 1958, pp. 68-70; Caley and Richards, 1956, pp. 73-75). For a fine description of varieties of limestone used for stone vases in Crete, see Warren 1969, pp. 133-134.

[61] See for instance *P. of C.*, p. 145; *Tylissos* (2), p. 48; *Festòs* II, p. 418; *Knossos* II, pp. 143, 699.

blocks. At the Palace of Kato Zakro the doorjamb bases in Room xxix, and the stylobate slabs of the light-well in Room xxviii to the north (*figs.* 1b, 129) are of a more compact stone type (most likely limestone) than the sandstone used for the building blocks, and must have come from elsewhere. The same is true of the limestone paving slabs of the main court at Hagia Triadha (*figs.* 1b, 57d)[62], and the stylobate in Room 64 at Phaistos (*fig.* 56). It is thought that the slabs of whitish stone used in the courts and walkways in the Palace of Malia (*figs.* 1b, 4) may have come from some distance away, perhaps from Chersonesos to the west[63]. The central courts of the Palaces of Phaistos and Knossos and parts of the Central Court at Malia were paved with large slabs of this material. Sometimes the same stone was used in the form of irregular slabs, for pavements, usually near or in the western courts which were often criss-crossed decoratively by walkways of finely cut and closely joined squared slabs (*figs.* 2, 3, 6).

Another type of limestone, quite different from «póros», ranges from grayish to dark blue or even black in color, and is much harder. Two varieties of this stone were used by the Minoans. The first, which I have termed the «boulder» type, is sometimes used as a packing for rubble walls, and, sometimes, when the stones were very large, for exterior walls, as at the Palaces of Kato Zakro and Malia (*figs.* 75, 76). These walls can be described as Megalithic or «Cyclopean», the latter a term usually applied to Mycenaean fortification walls on the Mainland. Blocks of this stone were also hammered down to form column bases (as that in *fig.* 146). Locally, this stone is called «sidherópetra» (ironstone) because of its hardness and the somewhat metallic sound produced when it is rubbed[64], its more usual designation being «asbestólithos»[65], a term used by villagers as well since the stone, when burned in a kiln, makes excellent lime (ἄσβεστος) for building. Deposits of this stone are to be found near many sites in the north of Crete, but are fewer in the area of the Mesara Plain. Fragments of the stone can be seen either scattered in fields or in talus slopes at the base of neighboring hillsides of the same material, and no doubt the Minoan masons turned to these hillsides when they needed large quantities of blocks. The limestone beds here, originally horizontal, have often been tilted by geological upheavals. Sometimes the strata have fractured horizontally and vertically, as a result of weathering and splitting along their natural lines of cleavage (*figs.* 7, 8). On such slopes agile quarrymen, equipped with pry-bars, and perhaps with wooden wedges and hammers, could loosen boulders, sending them skidding and rolling down to the lower slopes where they could be hauled away. Unlike the quarrying of soft limestone, and perhaps gypsum, extraction of such rough blocks often leaves little obvious trace. An exception is the sidherópetra quarry at Choirómandres in the hills south of Zakros (*fig.* 9).

A second variety of this hard limestone occurs in layers, at times horizontal, but also vertical (as in *figs.* 7, 8) which sometimes fracture through weathering to produce large, relatively thin slabs. Also described as «asbestólithos» (literally, limestone) and «sidherópetra» by the locals, it bears the additional name of «titanólithos». Beds of such stone, which was apparently highly valued for its evenness and durability, especially during the Neopalatial period, are not common in Crete. The slabs were almost always used singly for jamb-bases or thresholds (*figs.* 55b, 57b, 57f) rather than set in courses. The only exception, where such slabs were laid in courses, is that of walls of Room lxiv in the new excavations to the south-

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[62] This is a Mycenaean pavement but, according to Platon, it is made up of slabs reused from the earlier Minoan court. See now Cucuzza 2001.

[63] *Mallia, Nécropoles* II, p. 27; Dimou, Schmid and Pelon 2000, p. 439. I was also told by villagers at Malia that this stone type can be found only in the region of Siteia to the east. See also van Effenterre 1963, p. 242, n. 3; and *Mallia, Centre Politique* I, p. 29.

[64] See also *P. of C.*, p. 145; Charbonneaux 1928, p. 350; *Mallia, Nécropoles* II, p. 27.

[65] Orlandos 1958, pp. 71-74.

west of the Central Court of Phaistos (*fig.* 81). These walls, the material for which may come from the neighborhood of the town of Peri nearby, are discussed here in the section on rubble masonry. Smaller slabs of this hard, dense, bluish-gray limestone were particularly popular at Knossos for pavements. In the Queen's Megaron, in the Residential Quarter at Knossos, Evans found a pavement of such slabs sandwiched between an early (lower) pavement of rough limestone and a later (upper) one of cut gypsum slabs (*fig.* 11). On the basis of this and of analogous situations elsewhere at Knossos, he came to the conclusion that what he called «Mosaikō» pavement was most typical of the Middle Minoan period at Knossos[66], although, as Graham objects, it also occurs in Hall 3a of the House of the Chancel Screen[67]. I have seen similar slabs still being used in Crete to pave basement floors and the exterior courts of houses. The pavements were also common outside of Knossos, and not just during the period of the First Palaces. They were used, for instance, in the court at Nirou Khani (*fig.* 10); and can be seen at Zakro in the light-well of Room xxviii (*fig.* 213), in Court lxiii in the East Wing, and as a border on each side of the whitish limestone slabs of the road leading up to the monumental Northeast Entrance. In the case of the light-well, the interstices between the slabs were sealed with white plaster, which was then painted red, a typical Minoan technique; in the court and the entranceway the only filling, apparently, was earth. In Neopalatial contexts in Central Crete, such slabs were often placed in the center of a room, and were set off by a border of gypsum slabs, as in Room 5 at Nirou Khani (*fig.* 12)[68].

Individual slabs of this same stone were often set at or slightly below floor level at Zakro (*fig.* 175), Malia (*fig.* 55b), and elsewhere, in order to provide firm support to vertical timbers reinforcing wall-ends or doorways, or supporting the timber framework of the second story. They served the same function as bases for free-standing pillars of mud and timber (*fig.* 175). Indeed, in Room xxviii at the Palace of Kato Zakro, only the base slabs of such a pillar were found, their original function being inferred from an analogous but better preserved pillar to the west.

Ancient sources for the larger slabs have not been located so far, more exploration being needed. In Eastern Crete, however, the most likely areas are in the vicinity of Milatos, east of Malia[69], at an area called «Ta Stena» a few miles southwest of the Palace of Malia (*fig.* 8), and at the tip of Cape Sidhero, north of Siteia[70]. It is evident, therefore, that the Minoans imported slabs of this stone when they could not obtain them locally. Those at Zakro (as in *fig.* 57f) were no doubt brought to the site by ship from some distance away. A variant of this stone type can be illustrated by the light grayish-blue blocks set as a krepidoma for the north and west sides of the ossuary of Chrysolakkos (*fig.* 198), as well as by two blocks used as orthostates in the northwestern corner of the Central Court at Malia[71].

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[66] *Knossos* I, fig. 155; Rosenfeld 1965, figs. 236, 245; also *A. of C.*, p. 154.

[67] *P. of C.*, p. 207, and note 32a. Evans (*Knossos* II, p. 395 and note 2) maintains a MM date. The stone used for such pavements at Knossos is sometimes called «amygdalōpetra» (or almond-stone) by both Evans (*Knossos* I, p. 211; II, p. 698; III, p. 266) and Pendlebury (*A. of C.*, pp. 130-131). Colin Macdonald (2005, pp. 98, 103) views it as typical of the earlier New Palace at Knossos.

[68] For a good description of pavements and paving materials, see *P. of C.*, pp. 206-209.

[69] Professor Platon provided me with this information.

[70] This last suggestion was made by Mr. Nikos Karantonis, who claims to have seen slabs of this type there. Dawkins seems to have the same opinion when he discusses the origin of certain thresholds found at Palaikastro (Bosanquet 1901-1902, pp. 311, 315). See also Driessen 1984, p. 143 and, for the Malia area, Dimou, Schmid and Pelon 2000. A slope where slabs were removed has been reported on Pseira by Betancourt (1996, 2001), where the stone is identified as metacarbonate, «a transitional limestone that combines the properties of phyllite and medium-gray limestone» (McEnroe 2001, p. 30).

[71] Charbonneaux 1928, p. 350, n. 1.

2. Gypsum

After poros limestone, gypsum is the most frequently used stone for cut blocks and slabs. Indeed, as a material it is in some ways superior to soft limestone. For instance, although poros limestone can be attractive, especially when its yellowish or brownish-white surface is struck by the sun, gypsum of a white or pinkish color, often beautifully veined (*fig.* 14), has a much more striking and elegant appearance. The lightness of its color, and the relative ease with which it could be cut by bronze saws into huge slabs as large as 1.96 m by 1.80 m[72] and only 0.025 m to 0.07 m thick, made it an ideal material for interior decoration in the form of dado courses, floors, thresholds, and benches (*fig.* 180). Moreover, in the open architecture in the residential areas it must have reflected sunlight brought in through the windows and light-wells and, at night, the light from lamps set on tables or stands.

The taste of the Minoans for color is well known, an instance of this in architecture being the use of gypsum slabs as a framework around paving slabs of darker stone (*fig.* 12). It is most likely that dado slabs of gypsum were often combined with materials of contrasting colors such as textile wall hangings, frescoes, cushions, rugs, or blankets spread out on the floor or laid upon benches built against the walls.

Gypsum is calcium sulphate, deposited in past millennia upon the drying up of salt lakes and inland seas[73]. It ranges in grade from a coarse, gray, and crystalline type now used for much of the reconstruction work on Minoan sites, to a very fine-grained material equal in quality to fine-grained alabaster. In Central Crete, extensive deposits of gypsum occur mainly in the Knossos and Phaistos areas[74]. As is also reflected by the architectural remains, these deposits become progressively fewer as one moves eastward until they practically disappear near the eastern coast.

The merits of gypsum as a building material were realized as early as those of cut poros limestone, as we can see from the remains of the early MM IB Palace at Phaistos, where gypsum slabs were employed for revetment and interior pavements[75]. In the Mesara Plain, at Hagia Triadha and Phaistos, gypsum was used more discriminately than in the Knossos region to the north. Although it was occasionally used here for the construction of low, single-block piers in basements and storerooms[76], it usually appears within important interior spaces, as pavements, treads of stairways, benches, thresholds, parapets, and doorjamb bases. It was particularly popular for dado slabs, 2 cm to 5 cm thick, set on edge and attached to the walls behind by thick layers of mud plaster (*fig.* 180)[77]. Only rarely was it used for column bases in the Mesara area, an example being the column bases in Room 25 at Phaistos. Outside the immediate Hagia Triadha/Phaistos ridge area, however, gypsum seems to have been used only occasionally. None was used at the Kommos settlement and port. Near the probable ancient way to Kommos from Phaistos, at Plákes, however, a handsomely appointed villa was constructed with neat poros ashlar masonry of small blocks and numerous gypsum doorjamb bases[78], possibly an indication of the relatively high social achievements and/or ambition of its inhabitants.

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[72] *Festòs* II, p. 418.

[73] Rosenfeld 1965, p. 116.

[74] For more information on gypsum sources, see also Warren 1964, p. 99, and 1969, p. 132. For an in-depth review of the sources and uses of gypsum in Crete, see Chlouveraki 2002, and 2006, Chapter 3. She also gives (2002, p. 292) a useful estimate of the cubic volume of gypsum used at four Minoan sites: Knossos: 408 m^3; Phaistos: 47 m^3; Hagia Triadha: 27 m^3; Nirou Khani: 4.8 m^3. Gypsum in elite Minoan structures in Neopalatial north-central Crete is discussed and charted in Adams 2006, pp. 9-12, and fig. 5.

[75] For the former see *Festòs* 1976-1988, II (Part 1), fig. 14.

[76] For example in Room 33 at Phaistos and the northern storeroom group at Hagia Triadha (*Festòs* II, p. 419).

[77] For this method of attachment, see *Guida*, p. 31; Xanthoudides 1922, p. 10 (Nirou Khani).

[78] Vallianou 1987, 1988, 1989, 1990 in preliminary reports.

At Knossos, gypsum performed a greater variety of functions. Monolithic pillars and blocks at the bottom of piers, carried up above in rubble and timber construction, were often of gypsum. The orthostate course along the West Façade at the Palace (*figs.* 92, 93), and the coursed ashlar masonry in the Southeast House, in the Pillar Crypt of the Royal Villa, in the basement of the South House (*fig.* 105), and elsewhere consisted of gypsum, although masonry of poros limestone still remains dominant. In the MM IIIB period column bases of gypsum seem to have been introduced at Knossos[79], while in the LM I period on the same site entire doorjambs (*fig.* 13) were made of this material[80]. The same stone was used for partitions, as in the Southeast House[81], and for the top slabs of certain balustrades of stairways, such as that of the Grand Staircase at Knossos (*figs.* 151C, 152). There the slabs have hollows within which Evans restored the bases of columns.

The high solubility of gypsum in water is clear when one visits many of the sites excavated early in the century and finds architectural members in gypsum which were left unprotected, now practically dissolved by rainwater. Because of this inherent weakness, gypsum was normally restricted to sheltered interior spaces. It was probably not often used for small-scale drainage channels, which were usually of poros limestone, sometimes of terracotta, and more rarely of plaster. Gypsum blocks were also used, however, in the construction of the great built drains in the east wing of the Knossos Palace[82]. Evans, and then Graham, however, have suggested that certain types of gypsum that were more resistant to water may have been recognized by the Minoans[83], as is implied by the presence of gypsum on the interior of the footbath in the Caravanserai[84] and within «Lustral Basins», where some scholars believe bathing actually took place[85].

Varieties of gypsum were available in the Knossos area, and those were selected by the masons for particular uses. Chlouveraki points out, for instance, that the «Domestic Quarter at Knossos represents a clear example of a designed interior decorative scheme, which makes use of four different varieties of gypsum»[86]. For the nearby Little Palace, Hatzaki notes that «the choice of either the white thin-grained or the grey thick-grained gypsum varieties is deliberate. Along the E. Sector the thin-grained variety features in all dados, paving slabs, and doorjambs. The same applies to the steps and gypsum pier blocks of ... Staircase 32 [and] balustrades. For the remaining parts of the building, the use of the grey thick-grained variety is almost universal»[87].

Elsewhere in the vicinity of Knossos, gypsum appears less frequently. Thus at Archanes to the southeast it was used only for a few piers at wall-ends and for bases in a pier-and-door partition just inside the magnificent entranceway of the building at Tourkogeitonia (*figs.* 123 a-c)[88]. At Tylissos it does not appear at all. At Amnisos, one of the two seaports of Knossos, only a few jamb-bases of gypsum are now visible within the villa excavated by Marinatos, and there was little used within the nearby houses excavated by Alexiou.

The villa of Nirou Khani, however, presents an interesting contrast in this respect, for although it is further to the east than Amnisos, its architect showed a taste for elegance in using gypsum slabs for doorjamb bases, flooring slabs, benches, and the treads of stairs, all

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[79] *Knossos* I, p. 211ff; *A. of C.*, p. 153.

[80] *A. of C.*, p. 188. See also Hatzaki 2005, p. 66.

[81] Evans 1902-1903, p. 13.

[82] Macdonald and Driessen 1988 and 1990, passim.

[83] *Knossos* III, p. 288; P. of C., p. 104. Chlouveraki (2006) discusses weathering of gypsum at length.

[84] *Knossos* II, p. 119, fig. 57.

[85] As in *P. of C.*, p. 104.

[86] Chlouveraki 2002, p. 29, fig. 4, Plan 2.

[87] Hatzaki 2005, p. 67. Apparently this thick-grained variety was eschewed by the builders of Phaistos and Hagia Triadha.

[88] *Archanes*, pp. 78-85.

used in a manner more reminiscent of the architecture of the Mesara Plain than that of Knossos. Noteworthy are the numerous benches of gypsum, a feature typical of the architecture of the Neopalatial period to the south, but less so at Knossos.

Further east in Crete, Neopalatial Myrtos-Pyrgos (*fig.* 211b and cover illustration) is the only site where gypsum was used extensively[89]. At Malia it is very rare[90], while at Gournia it hardly seems to have been used, even though gypsum quarries exist in the vicinity. Gypsum is similarly absent at Palaikastro[91]. At the Zakro Palace to the south, there are only three weathered gypsum blocks in the same area, one fallen, perhaps from an upper floor, in Room xxxv, another used as a corner pier in Room xxxvi, and the last as a rough doorjamb at the entrance to Room lx. Judging from the general scarcity of gypsum in the Zakro region, I suspect that these small blocks may have first been brought by ship, perhaps as ballast, and then left at Zakro when the ship was loading up with cargo.

3. Sandstone

Sandstone is called locally «ammoúdha»[92], and more rarely «ammoudhópetra» (literally, sandstone). It is most frequently used at Malia, Gournia and Zakro for blocks in façades and in interior walls (*figs.* 116-122). The stone itself (eolian sandstone) «originated from marine sand drifted and deposited by the wind along shores (sand dunes). It has been consolidated by means of calcareous material (mainly calcium carbonate) precipitated from aqueous solutions in the pores of the sand»[93]. The strength of the stone is determined by the size of the grains, the evenness of their distribution, and the strength of the gluing agent. At Malia the quality of the stone varies from a coarse variety, sometimes of a conglomerate (pebbly) type, to finer and more homogeneous types, the latter found at the nearby Point du Moulin to the northwest[94] and also further west along the shore.

In general, the material is quite friable, and when exposed to the weather the bond between gluing agent and sand grains is weakened and the stone tends to disintegrate. Moreover, since thin slabs or projections are likely to fracture or break off, little fine work can be executed in soft stone of this type, as it may be in poros limestone and gypsum. For these reasons, although sandstone was used for most of the ashlar walls at Malia, slabs of finer, stronger poros limestone, as well as slabs of a hard dark limestone, probably brought from some distance away, were used for paving (*figs.* 4-6). At the Palace at Zakro the same is true, although less stone was imported, partly because the local sandstone there is more compact due to its finer sand grains and stronger gluing agent.

4. Schist

Schist, also referred to as slate, is a metamorphic rock quite common in Crete, often recognized by its very shiny, micaceous texture (*figs.* 15, 17). It occurs in layers which can sometimes provide ready-made slabs for paving, for thresholds, or for column and pier bases. Since

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[89] For gypsum at Myrtos-Pyrgos, see Chlouveraki 2006, Chapter 7, pp. 288-293.

[90] It is not visible in the site, nor is it mentioned in the French study of stone types used in architecture (*Mallia, Nécropoles* II, p. 27).

[91] One small piece was reported in House A (Bosanquet 1901-1902, p. 306). Jan Driessen (personal communication) notes that a bench-like structure made of small gypsum pieces was found in Building 1.

[92] Charbonneaux 1928, p. 350; *Mallia, Nécropoles* II, p. 27; *P. of C.*, p. 145.

[93] Papageorgakis, Papadaki and Mourtzas 1992, pp. 21-22.

[94] *Festòs* II, p. 588, n. 241.

it tends to split easily into thin horizontal layers, it is not suitable for use in ashlar walls, although walls are occasionally made up entirely of schist slabs as at Palaikastro, Mochlos, and Pseira[95]. None is used in the walls at Zakro.

The most typical use of schist by the Minoans was for pavements. In the region of Knossos an attractive type of pavement was introduced, composed of thin, very micaceous flat slabs of a greenish-blue color, used in courts and occasionally in corridors. Although it rarely appears far from Knossos, it is used in a pavement northeast of Room 11 at Hagia Triadha. In this case, Pernier thought that the material was brought from some distance away[96]. Perhaps it originated in the area west of Hagia Galini, northwest of Phaistos, where I have seen entire cliffs of similar schist. At Malia similar slabs occur in the pavement to the left of the South Entrance and along the eastern wall there, as well as on the floors of Rooms vi, 1, and vi, 2. Charbonneaux records that this stone is given the local name of «pásparo» and can be found in natural strata some few kilometers away from the Palace[97].

Near Knossos pavements of this type were thought by Evans and Pendlebury to be characteristic of the MM IIIB - LM IA period[98]. Outside the Palace itself they form the treads of the interior stairs and the pavement of the upper terrace (partly restored) of the Temple Tomb[99]. Within the Palace many slabs found fallen within basements[100] were thought to belong to the pavements of upper floors[101]. Pavements of this type have been reported at Anemomylia (Katsamba)[102], near the coast, further east in exterior courts of the «Villa of the Lilies» at Amnisos, and at Nirou Khani (*fig.* 17) as well. To the south, beyond Archanes and Juktas, 13 slabs from a similar pavement appear in the southwest section of the villa at Vathypetro. According to Evans, in some instances such slabs were originally entirely covered by plaster[103]. It seems to me, however, that a material chosen for its appearance, as this clearly was, and brought from some distance away, would not be covered up except as a result of later repairs and/or renovation. Further indication that the slabs were not originally covered is provided by examples at sites elsewhere, where the interstices between the slabs are either empty or filled with plaster, sometimes painted red.

The quarrying of the stone, at least that which was used at Knossos, is thought to have taken place in the area at Rogdhia, west of Herakleion[104], the area where Evans and, later, Platon obtained material for the restoration of partially preserved pavements at Knossos (as *fig.* 15). It is probably not a coincidence that, with the exception of Hagia Triadha and

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[95] Jan Driessen informs me (personal correspondence) that there are schist dados in one of the rooms of the Palace at Petras.

[96] *Festòs* II, p. 588. n. 41.

[97] Charbonneaux 1928, p. 361.

[98] *Knossos* II, pp. 255, 683, 812; *A. of. C.*, p. 191.

[99] As *Knossos* IV, p. 992, fig. 950.

[100] *Knossos* II, p. 812.

[101] For instance in the Corridor of Processions (*Knossos* II, p. 684), the Later Propylon (*Knossos* II, p. 690, fig. 434), the Stepped Porch near the Throne Room (*Knossos* II, p. 812), and on the landings of the East Bastion (*Knossos* III, fig. 166). A similar stone, described by Seager as soft and slatey, may have been used for the flooring of the upper stories of LM I buildings at Pseira, where slabs were always found blocking the basement rooms (Seager 1910, p. 8). A different, harder green schist of a blue-green color was reported by Evans as built into the paving of the West Entrance to the Palace of Knossos (*fig.* 2) (*Knossos* II, p. 670). Two of nine schist slabs there are described as «bars» with dowel-holes in their sides (*Knossos* II, n. 2, fig. 427). One has been sawn (*Knossos* II, p. 671, fig. 426) and appears to be a base. Evans dubbed this stone «Spinalúnga», after the region near Hagios Nikolaos where it may have been quarried *Knossos* II, p. 670). Before it is accepted as a schist, however, it should be tested chemically, for it looks more like a close-grained limestone.

[102] *Knossos* II, p. 255.

[103] *Knossos* II, p. 670.

[104] *Knossos* IV, p. 992.

Vathypetro, most schist pavements appear at sites near these quarries. Hillsides with decomposed schist (*fig.* 16) also provided material for waterproofing roofs.

Another type of green schist, recrystallized and soft but less friable than that from Rogdhia, occurs in the region of Malia. This stone was used only sporadically on the ancient site, as for four column bases and a threshold in House E (*fig.* 197 [A]). In the Palace itself it was used for a series of column bases on the western side of the Central Court, for two slabs on either side of the eastern entrance to Room vi, 1, and for one unusual small base with three «saucer-shaped» holes to the north[105]. A series of rectangular pier bases along the eastern side of the Chrysolakkos ossuary (*fig.* 143) were also made of such schist. The source for this stone is unknown, although Pareyn believes that it may be in the vicinity of Malia[106]. I have seen thresholds of this stone at Mochlos, and a few cut pieces on the slopes of Pseira (*fig.* 57 c).

Micaceous purple-red schist also played a role in paving. At the Northwestern Entrance to the Palace of Malia it was quite clearly part of an intentionally colorful arrangement of red, gray, black, and cream-colored stone (*fig.* 6). Perhaps it is not by coincidence that a fine threshold slab, 1.74 m long by 1.15 m wide[107], at the South Entrance to the same Palace, is also of red schist. At Archanes it paved both upper and lower floors in the north wing of the palatial Tourkogeitonia building[108]. At Palaikastro it was used with effect along with green or bluish schist in both houses and roads. Both varieties probably came from near the Minoan town[109].

5. Conglomerate

Conglomerate, so extensively used in Mycenaean architecture in the Argolid[110], played only a small role in Minoan construction even though it was available in Crete. This sedimentary stone is made up of hard sea or river pebbles set in a natural cement matrix (*fig.* 18), so that in order to be shaped it must be sawn, hammered, or abraded. A chisel of bronze would be a poor instrument to work the coarse stone, and a hammer could only dress it roughly.

The only examples of dressed conglomerate of which I know are various bases for columns, mostly in the areas of Knossos and the Mesara[111]. At Malia the stone is rare[112], although once more, it was used for column bases (*fig.* 18)[113]. At the Palace of Kato Zakro, three huge, unworked slabs, somewhat triangular in shape, underlie the floor of the East Wing, in Room lxiii. One of these covers and protects a confluence of the drains there (*fig.*

[105] The last example is studied in Chapouthier 1928, pp. 316-323, fig, 14.

[106] *Mallia, Nécropoles* II, p. 27.

[107] *Guide*, p. 11; Dimou, Schmid, and Pelon 2000, p. 411, suggest nearby Selinari as a possible source.

[108] *Archanes* 1997, pp. 93-95.

[109] Driessen 1984, p. 143.

[110] J. Wright, 2006.

[111] Two (of three) in the stylobate of Room 1 at Vathypetro, two (of four) in the twin rooms facing northwest onto the main building complex of Hagia Triadha, one (of three) in the light-well of the Southeast House at Knossos, and four slabs, including one cut as a doorjamb, reused in a pavement at Knossos (*Knossos* II, p. 670, fig. 427). See also my separate discussion here of column bases, pp. 79-86.

[112] As *Mallia, Nécropoles* II, p. 27.

[113] One in the Court of the Magazines to the north, another in the ruins of the First Palace just north of the Residential Quarter, while another (*fig.* 18) is at the western entrance to House Za, east of the Palace (cf. *Mallia, Maisons* I, p. 73 and n. 6).

171)[114]. No doubt these slabs come from the nearby seashore, where they are still in the process of being formed by the gradual solidification of beach sand and gravel.

6. Other Stones

The remaining stone types that were cut, or simply dressed with a hammer, were probably selected as much for their appearance as for their working and wearing properties. These types consist of hard, veined limestone, opheiolite, phyllite, marble and still unidentified types of stone. They occur as curious oblong blocks (altars?) (*fig.* 57h) at Phaistos, and at Knossos as friezes and revetments, where they seem to be confined, curiously enough, to the West Wing.

A particularly beautiful variety of colored stones was sometimes used for column bases at Knossos, Myrtos-Pyrgos, Phaistos, and Hagia Triadha. At Knossos there are numerous bases of a type with orange and white veins (*fig.* 145), which Evans often describes as «breccia» (although it may simply be veined limestone or dolomite) and which he associates with the MM II phase of the Palace at Knossos[115]. The source of this stone was probably Kakon Oros[116], a rugged hill that overlooks the sea just east of Amnisos. A modern radar installation now prevents one from reaching the top of the hill, but one can pick up samples of the same type of stone along the lower part of the side road that leads up to the station from the modern highway. A similar stone can apparently be found at Viannos, as well as at Hagios Nikolaos[117]. At Phaistos a crystalline limestone, usually laced with white calcite veins, occurs in red, blue, and gray varieties. Examples of the red variety can be seen in Area iii (*figs.* 144 a, b) and in bases at Hagia Triadha east of Room 16 and north of Room 14. A similar stone, a phyllite, which is a metamorphic rock, slightly coarser grained than slate but finer than schist[118], is also used at Phaistos. Locally, such stones are called «porphyry» (πορφυρίτης). Of the blue variety, streaked with orange or whitish veins, there are examples in the enigmatic and beautifully cut and polished (σερπεντίνη) rectangular blocks, one of which (0.91 m by 0.60 m by 0.33 m) lies in the northern part of the Central Court (*fig.* 57h), another in Room 24[119]. Also at Phaistos, column bases of this stone were found in situ at the northern part of the Peristyle (Room 74). At Malia there is an example in Room xxi, 1 (*fig.* 138).

Of the gray type streaked with white calcite veins, there are examples within Room 74 at Phaistos. These may have been brought in their rough, unshaped state from hillsides some 30 km to the northeast of Phaistos, along the main highway from Herakleion, where I have seen boulders of this stone that have rolled down from above[120]. A base of similar stone appears in the Northwest Portico at Knossos.

A soft green stone, referred to locally as «serpentine» (σερπεντίνη) but called by most local geologists «opheiolite» (οφίτης), was commonly used for bases in the First Palace at Phaistos, some of these bases, reused or not in situ, being visible in Rooms, 7, 63, and 64 (*fig.* 56)[121].

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[114] To the north, a single slab of conglomerate served as a step leading up to the veranda (Room xxiv) of the North Wing.

[115] *Knossos* I, pp. 211-212, figs. 156, 157; p. 370, fig. 268.

[116] *Knossos* I, p. 212. See also Warren 1969, pp. 127-128.

[117] *Knossos* IV, p. 234.

[118] Rosenfeld 1965, p. 103.

[119] As *Festòs* I, p. 442.

[120] Levi has also noticed these outcroppings on the hillside, and states that most of the colored stone types found at Phaistos can be found there (Levi 1957-1958, p. 325, n. 4).

[121] There is one example north of Room 13 at Hagia Triadha, and there were a few fragments of the same stone visible in the large court south of the main building complex there.

This stone has a greasy feeling to the touch (similar to steatite or soapstone) and can be quite friable. It is very similar to the stone of large outcroppings that I have seen in the hillsides along the road from Phaistos to Lebena (Leda), some distance southeast of Phaistos[122].

A wavy-grained stone, represented by one base in Room 1 at Hagia Triadha and a few fragments at Phaistos, is of opheiolite material mixed with limestone. Along with some of the other materials used for bases discussed above, this could be described as «marble», for «in architecture and statuary any limestone which takes a high polish is called marble. This also includes a large number of partly altered or unaltered compact crystalline limestones ... so compacted ... as to have physical properties similar to a true marble»[123]. Cipolin marble occurs at Malia in the form of certain column bases along the western and northern sides of the Central Court (*figs.* 132, 135)[124]. The excavators have not been able to locate the source of this stone, although they report that other bases, of a white limestone, may have been brought from Lasithi or Selini.

Evans reported a number of unusual stone types from Knossos, most of them intended to be used as architectural revetment or friezes. A number of finely cut close-grained limestone slabs, which had probably been used for a dado some half a meter high, were found in the area of the South Propylon[125]. At a later date Evans referred to these fragments as «mottled, highly polished marble»[126]. A number of rosette and half-rosette fragments, carved in stone, were found nearby[127]. A fragment of «Tryglyph Frieze» of a close-grained stone (*fig.* 19), dated by Evans to the MM III period, was found in the area of the Northwest Entrance[128]. Fragments of what Evans thought to be dado slabs, of «close-grained, greenish stone», were found here as well[129]. Theodore Fyfe, one of Evans's capable architects, made a special study of these fragments of architectural decoration which, as far as I know, occur only at Knossos in all of Crete, and there seem to be confined to the West Wing of the Palace. He separated the fragments according to stone types. He grouped together the rosette, slab, and various spiral fragments, and described the stone used as a «light greyish purple with a distinct granular texture, taking a perfect rubbing surface but not a polished one... . Without a chemical test it is difficult to say whether this is a limestone or sandstone»[130]. The triglyphs, which form the second group of fragments, are described by Fyfe as «bluish-grey, dense slatey stone ... apparently capable of taking a certain degree of polish»[131].

Finally, Evans reports that the imported Spartan basalt (*lapis Lacedaemonius*) found in the East Wing of the Palace (*fig.* 57g) may have been intended to be used as dado slabs[132], but there seems to be little evidence to prove his contention[133].

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[122] For a distribution map of similar stones in Crete, see Warren 1969, p. 129 («Chlorite or Chlorite Schist»).

[123] Rosenfeld 1965, p. 114. Perhaps for the same reason Pernier described these bases as «marble» (Pernier 1902, col. 78; *Festòs* II, p. 419). See also Warren 1969, pp. 134-135.

[124] *Mallia, Nécropoles* II, p. 27.

[125] *Knossos*, II, pp. 698-699, fig. 438.

[126] *Knossos* IV, p. 896.

[127] *Knossos* II, pp. 163-164, figs. 83, 84.

[128] *Knossos* II, pp. 591, 606, figs. 368, 370, 378; 379, and suppl. pl. xxii. Such friezes ranged from 19.5 to 45 cms. high.

[129] *Knossos* II, pp. 598-599, fig. 372.

[130] *Knossos* II, p. 606. Other fragments of a frieze of «purplish limestone» were found in a field at Knossos (Hood 1957, p. 21, figs. 18, 19).

[131] *Knossos* II, p. 606. For a catalogue and discussion of the Knossian fragments, as well as those from the Greek Mainland, see Moser v. Filseck 1986.

[132] *Knossos* III, p. 269. See also Warren 1969, pp. 132-133.

[133] See also Warren 1967, p. 199.

7. Polychrome Effects with Stone

As already mentioned here, some upper-class Minoans desired colorful interiors; their frescoes and wall hangings could be matched by stone dadoes along their walls (*fig.* 180) and by arrangements of stone paving slabs of differing colors on floors, in vestibules, light-wells and courts (e.g. *fig.* 6). Many of those feature rectangular white gypsum or limestone slab frameworks enclosing irregular dark blue or grayish ironstone slabs (*figs.* 2, 12). Combined with them, whether set next to an interior or exterior court, were often column bases of white, gray, green, gray-blue or other color stone, sometimes with veining of contrasting color obviously chosen for visual appeal[134].

The architects' desires to create such effects were often carried out in the so-called residential areas of the great palatial sites at Knossos, Phaistos, and Hagia Triadha. At palatial Archanes, purple and bluish-green schist paving enclosed by plaster borders of red and yellow featured in the first and second stories of the north wing[135]. At Palaikastro in Eastern Crete an innovative (but partially destroyed) decorative arrangement was found in Court A of Building 6. There a pattern of white limestone and red and green schist slabs, with column bases and pier-and-door partition bases of mottled green serpentine, along with randomly placed purple schist slabs set in a bright red painted plaster, show nuance in Minoan design[136]. At Myrtos-Pyrgos (*fig.* 211b and cover illustration), distinguished by architectural innovation, a stairway carried out in gypsum adjoins a light-well paved with purple limestone slabs with white plaster in their interstices. At the main entrance to that building from the south, two wooden columns on purple limestone bases were set on either side of an ashlar pillar in the veranda. Similar purple stone was used in the paving of the open court immediately to the south, where it was set in front of the veranda and on either side of a raised walkway of squared white limestone slabs, all stunning when seen looking south to the blue of the sea[137].

B) Quarrying and The Transportation of Stone (*figs.* 20-34)

Strictly speaking, the only stones extracted systematically from quarries by the Minoans were gypsum and poros limestone and sandstone. Other types of stone used in architecture, such as hard limestones and various schists and conglomerates, were most likely simply gathered up or pried loose from hillsides where they were known to be. In the case of some hard limestones, they may have been removed from the hillsides by means of mason's saws. The soft poros stones and gypsum, however, occurred in regular beds and could be methodically excavated with the help of tools made of hardened bronze, still a relatively soft metal. Such stones were the chief material used by the Minoan builders in wall construction of cut stone, which seems to have begun in the MM IB period and continued down through LM III.

1. Sandstone and Limestone Quarries

Usually a quarry, being simply a hole gouged in the rock, without any stratified manmade objects or habitation debris in it, defies dating. This is true of the majority of quarries in Crete, especially those located near large Greek, Roman or later buildings whose inhabi-

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[134] See also p. 80 here, and Rehak and Younger 2001, p. 399.

[135] *Archanes*, drawing 11 on p. 94.

[136] Driessen 1999; 1998, p. 249.

[137] Cadogan 1978.

tants could have exploited the nearest convenient stone supply. The sandstone quarry at Zakro is an exception, for it was undoubtedly used exclusively during the Minoan period. There is indeed hardly any possibility of post-Minoan intrusions here[138]. I searched the quarry carefully and found MM III sherds within the quarrying channels[139]. On the surface and in the immediate vicinity, there were no sherds later than Minoan. Moreover, to my knowledge, there are no nearby Greek or Roman buildings in which the blocks that were removed could have been used. The small (30 by 50 m), isolated quarry at Zakro, when first identified, helped the excavators to learn about Minoan quarrying techniques and consequently the identification of Minoan quarries elsewhere in Crete.

The site is known locally as «Pelekità» a name referring to the quarry cuttings which are still visible today (*figs.* 20-23). Here, a pocket of reddish-tan sandstone lies along the rough, forbidding shore at the base of towering seaside cliffs. These cliffs are composed of the hard gray limestone that is so characteristic of the entire Zakro region. The building blocks were removed from an area some 40 to 100 m inland. The ragged coastline is pierced conveniently by the sea at this point to form a tiny, deep and sheltered cove just wide enough for a small ship to dock there temporarily during relatively calm weather. Since the quarry is bordered by the cliffs on the west, and by extremely rough terrain on both north and south, it seems most likely that the blocks quarried here were taken away by ships. The ships, then, would have used this small cove for loading. Once freed from the rock, the blocks could be dragged and slid down the slope, perhaps with the help of rollers, and then laid in batches awaiting transportation to the building site.

At some points the sandstone in the quarry had already been eaten away by the sea and weather, and small caves were formed. The Minoans avoided the ruined parts but they removed much of the stone above and around them, leaving the caves capped by cornice-like steps (*fig.* 21). Aside from such anomalies, the quarry surface steps up regularly from the seaside in gigantic strides that follow the layers of sandstone that slope up from the sea. The steps are worn in many places by the weather, but some of the sloping trenches or quarrying-channels cut in the bedrock for the removal of blocks are still clear upon them (*fig.* 23). Within one of these channels were found the pottery fragments mentioned above, perhaps the remains of a plain water-jug used by the workmen and filled from a spring in the hillside far above[140].

There seems little doubt that the blocks removed were taken south to Zakro, perhaps half-an-hour away by boat (about three nautical miles) and about an hour and a half over a rough path by foot. Indeed, Platon originally thought that the poros sandstone blocks of the Palace must have been brought in by ship[141]. Aside from Zakro, the nearest known Minoan settlement easily accessible from here by sea is that at Karoumbes, a harbor settlement at

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[138] I would like in this connection to thank the former guard of the excavations, my good friend the late Nikos Karantonis, for bringing the quarry to my attention. My first visit there was in the fall of 1967. Professor Platon visited the quarry at a later date (1968) and his report, published after the above description and interpretation was written, confirms in general my own conclusions (see Platon 1968b, pp. 181-183, figs. 164a, and 164b). He also points out that the buildings in which cut sandstone blocks were used extensively at Zakro belong to the first and second phase of the Neopalatial Period (MM IIIB - LM 1 B), so that the period of time to which the use of the quarry is restricted is confirmed both by known architectural tradition and by the sherds found in and around the quarry. Hogarth also noted the quarry (Hogarth 1900-1901, p. 142).

[139] I thank Stylianos Alexiou for his identification of the sherds found.

[140] The workers could have lived in one of the numerous spacious caves along the side of the ravine which borders the quarry along the north, or may simply have «commuted» to work from their nearby settlement.

[141] Platon 1963b, p. 165.

least an hour away by boat. There seem to be no Minoan buildings constructed of sandstone at Karoumbes, however, and anyway, there is a fine source of still unquarried sandstone at the entrance of that harbor. It cannot be ascertained exactly where at Zakro the blocks were used, for there exist a number of buildings aside from the Palace itself which employ blocks of similar sandstone[142].

As it turns out, the quarrying technique used at Zakro is not a peculiarly Minoan one, but one used throughout the ancient Mediterranean world for a long period of time, no doubt because of its simplicity and practicality[143]. This is illustrated on the plan, *fig.* 23, where channels 7 cm to 11 cm wide were first cut down all around the four sides of the block. What tools were used for this process? On the one hand, the sandstone in the channels and the sides of the discarded block is so worn that tool marks are not preserved; on the other hand, clear traces of pick marks on similar stone in Minoan quarries elsewhere (e.g. *figs.* 26, 50 at 1) suggest that the same tool may have been used at Zakro. Moreover, there are occasional vertical marks, about 10 cm long and 0.5 cm wide, on the sheer rock scarp limiting the Zakro quarry on the south (*fig.* 23). If a saw or chisel had been used to make the channels, it would be difficult to explain the overlapping, slanting cut at A on the plan[144]. The most likely tool, therefore, remains a pick or mattock (such as those shown in *figs.* 36 (A, B), 37 (A, B), top, middle) mounted upon a long handle[145].

To judge from the way that the bottoms of the east-west trenches curve up, the quarrymen must have worked downhill and thus saved effort. Since, on the other hand, the north-south trenches stop evenly at the scarp sides, I imagine that these trenches were at least partially excavated by working out from the center. The shallowness of the trenches visible (20 cm to 40 cm) is probably the result of intentional over-cutting made when the overlying blocks were being removed. The uneven way in which one of the blocks is broken (at B on the plan) suggests that it may have been split off from below, perhaps by a pry-bar or a wooden wedge which otherwise has left no trace. The actual cutting operation was probably sped up a good deal by a generous soaking of the bedrock with sea water from the nearby shore. Of course, there is no archaeological evidence to show that this was done; but it is true that if rock of the limestone-sandstone variety is wet, it is much easier to cut, and it is likely that the Minoans realized this as well[146]. The method would also reduce wear on the bronze tools that they used.

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[142] It seems unlikely that they were used to face the western or southern sides of the Central Court of the Palace, for the widths of these façade blocks range from 58 to 70 cm, whereas those at the quarry range from 40 to 50 cm. The blocks in the «Light-well» (Room xxxvi) in the East Wing of the Palace average 35 to 41 cm in width, dimensions approximating those of the blocks removed from the quarry. The East Wing is so destroyed, however, that more exact comparison cannot be made.

[143] See, for example, Rosenfeld 1965, p. 203; Nicholson and Shaw 2000, pp. 5-7; Clarke and Engelbach 1930, pp. 12-22, especially fig. 12; R.J. Forbes 1963, VII, p. 168; Orlandos 1958, pp. 86-87.

[144] The length of the pick's handle would have been about 90 to 100 cm, to judge on the basis of the depth of the trenches visible (20 to 40 cm), plus the approximate thickness of the blocks already removed (30 to 40 cm), plus the distance between hand and stone lost during a slanting tool-stroke (about 30 cm), minus the distance from haft to blade.

[145] As noted above, this method of cutting narrow separating trenches was also used in Egypt. The tool marks visible within the trenches there «led to the supposition that picks must have been used although there are no known examples of copper picks in the archaeological record» (Rosenfeld 1965, p. 203). On the one hand, since the stone used for building in Egypt was usually much harder than that used in Minoan Crete, picks of soft metal could not be used there and chisels, mallets, and pounding stones were the only alternative. On the other hand, there is a possibility that bronze picks such as those found in Crete, of which Rosenfeld does not seem to be aware, could still be found in Middle Kingdom sites in Egypt.

[146] I have seen water used when marble was cut with a saw – here the water softened the stone, provided a

The constant stepping-up of levels in the quarry made it possible to remove blocks from the downhill side. It also enabled many workmen to cut a large number of blocks at the same time. The quarrymen removed blocks as they proceeded, and slid them down on top of the stone chips that must have accumulated as they worked. On the basis of the cuttings, the blocks must have been about 1.10 m long and 0.50 m wide when they were removed. Other blocks in the quarry measure 1.10 m by 0.47 m, 1.10 m by 0.46 m, 1.15 m by 0.47 m, and 1.40 m by 0.40 m, and one block, completely removed and lying abandoned on the upper slopes, is 1.40 m by 0.45 m by 0.30 m. The average length, therefore, was about 1.10 m, the width about 0.46 m. After being trimmed down for use on one edge (the front) and two ends, as well as the back corners, the block dimensions might have been reduced by fifteen percent. The thickness of the average block, to judge from the single complete block, and the depth of the «steps» cut in the quarry, must have been 0.30 m to 0.40 m.

Quarrying of large blocks by means of channeling, as in the Zakro quarry, has been observed elsewhere in Crete[147]. Of particular interest, for instance, is the quarry at Melamoúres first reported by Mourtzas in 1990 and discussed by Papageorghakis *et al.* in 1992[148]. It lies along a precipitous shoreline south of Kato Zakro, actually somewhat closer to the Palace than the Pelekità site just discussed, so it must be taken into consideration when considering the cubic volume of sandstone blocks removed for use at Kato Zakro, especially in the area of the Palace there.

Another quarry is a large group of small and medium-sized sandstone quarries at Ta Skarià (*fig.* 24), «the slipways», some distance north of Zakros and about half an hour by foot from the large Minoan site of Palaikastro, for which it furnished the sandstone blocks. As Driessen shows in his publication[149] (1984, and see our *fig.* 24 which shows a portion of one of the quarries), the same channel method of quarrying was used as at Pelekità, although Waelkens has suggested[150] that the chief tool at Ta Skarià may have been a point rather than a pick, judging from parallel traces, 2 cm to 3 cm apart, on the quarry faces[151].

One sandstone shoreline quarry was discovered in a precipitous seaside ravine along Crete's north coast near the Minoan peninsular site of Mochlos, and has been reported in detail by Soles[152]. He has connected this quarry with the Neopalatial Minoan ashlar buildings being excavated at Mochlos as well as with the renovation of the Palace at the town site of Gournia, some distance to the west[153]. He estimates that the sandstone used for the Gournia Palace may have totaled 100 m^3 [154]. The quarried blocks must have been taken there by sea, in the same manner as blocks from the Zakros quarries reached the Palace there.

All the quarries just described have in common similar techniques of extracting (the «channel» method) sandstone building blocks. They are also without significant later sites

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lubricant, and helped clean out the saw-cuts at the same time. I also found that water can be an invaluable aid in putting in survey markers which can take the form of hardened steel nails driven into bedrock. In some cases the nails would not penetrate dry bedrock, but would simply glance off the hard surface or chip it. If the same bedrock were soaked with water, however, the nails could be driven into it quite easily.

[147] For general works on ancient quarrying, including Minoan, see Waelkens 1992 and also, with a short description, Dworakowska 1975. More focused studies are referred to below.

[148] Papageorghakis, Mourtzas and Orfanoudaki 1992, p. 23, figs. 7-9; Papageorghakis, Papadakis and Mourtzas 1994 also provide a general survey of quarries in Eastern Crete.

[149] Driessen 1984. For Ta Skarià see also Blackman 2001, pp. 135-136, after L.H. Sackett and J.A. MacGillivray.

[150] Waelkens 1992, pp. 9-10 and fig. 20.

[151] See also Soles 1983, p. 45 and Papageorgakis, Mourtzas and Orfanoudaki 1992, p. 22.

[152] Soles 1983; see also Waelkens 1992, p. 9 and *MA:MAT* 1, p. 40, note 3.

[153] Soles 1983, p. 44; Pike and Soles 1998, p. 377.

[154] Soles 1983, p. 42.

nearby that built in sandstone. Two (Pelekità and Ta Skarià) have Minoan pottery associated with them[155]. Moreover, comparisons between stone at the sites and that in the quarries confirm the connection[156]. The quarries present in a graphic way how the Minoans exploited local sandstone deposits for ennobling their elite buildings. They were the first Aegeans to develop a systematic quarrying technology[157].

Some researchers have estimated the amount of stone removed from the individual quarries, sometimes using a «recovery coefficient» of 30 percent of the total amount of stone, that is what was left after the blocks had been formed and then trimmed to size. On this basis Pelekita and Melamoúres together produced some 1,260 m³ of blocks for Zakros[158]. The Mochlos quarry produced some 280 m³ [159] to 350 m³ [160]. By all estimates the Skariá quarry group produced the highest «recovery» mass, from 1,300 m³ [161] to 1,500 m³ [162]. Since only some 500 m³ can be accounted for at the Roussolakkos site, however, with some blocks used for building a local hamlet, Driessen suggests that some may have been sent down the coast to Zakros. Or, he wonders, perhaps an explanation for the discrepancy is that since a central building or Palace, common to large Minoan towns, has not yet been discovered at Roussolakkos, many of the missing cubic meters may some day be located within its confines[163], a compelling argument.

At Trypeti, some 450 m west of the old harbor works at Candia (Herakleion), «Flat rocks showed grooves about six inches wide dividing the limestone face into regular lines of square blocks»[164]. A similar method can be observed in the areas about 1.5 km west of Nirou Khani, at Hagioi Theódoroi, where a limestone promontory was quarried extensively sometime in the past[165]. Unreported, however, is a small quarry some 180 m offshore, on the islet, which has the typical arrangement of channels crossing at right angles. A good deal of Minoan pottery has washed into the quarry from the shallow earth fill that surrounds it.

A similar method of work can be observed at Phaistos, on the slope of the hill just to the southwest of the earliest Palace façade, where the hillside provided a convenient source of limestone. One block (*figs.* 25, 26), 1.22 m by 0.60 m by 0.30 m, lies abandoned within

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[155] Of some interest is that a few, presumably Minoan, signs have been found incised in Minoan quarries, perhaps strengthening the case that such signs («mason's marks», for which see p. 76), are actually marks placed by the masons involved in the quarrying. That from Ta Skarià is a «window» sign – but it is not represented on any Palaikastro blocks and is best known only at distant Knossos. A second from the Plakes site not far from Kommos is a simple Greek cross (Watrous, Hadzi-Vallianou and Blitzer 2004, p. 291 and pl. 10.2), which is paralleled by a similar mark on an orthostate block on the façade of Neopalatial Building T at Kommos (*Kommos* V, p. 89, no. 19). But the same sign is also made in the field by modern surveyors in the process of their work, so its presence at Plakes remains ambiguous. A third example has been reported from the shoreline sandstone quarries at Malia (Whitley 2005, p. 108, fig. 156, and see below), but is otherwise not known at the Malia site. Also, some ten signs have been reported from the Bronze Age quarries at Knossos, but the signs are engraved there on rock surfaces where there was apparently no intention of attempting to cut for building stone (Hood 2002, p. 101). More and better examples, therefore, are needed to connect quarries with «mason's marks».

[156] Papageorgakis, Mourtzas and Orfanoudaki 1992, p. 23.

[157] Waelkens 1992, p. 11.

[158] Papageorgakis, Mourtzas and Orfanoudaki 1992, p. 23.

[159] Waelkens 1992, p. 9.

[160] Soles 1983, p. 42.

[161] Driessen 1984, p. 149.

[162] Papageorgakis, Mourtzas and Orfanoudaki 1992, p. 22.

[163] Papageorgakis, Mourtzas and Orfanoudaki 1992, p. 22.

[164] *Knossos* II, p. 232. Another quarry, thought to be Minoan by Alexiou, appeared further west in the area of the harbor of Herakleion (*AD* 1968, p. 403, fig. 364 a).

[165] The remains of large buildings, the walls of which are built in Minoan «wedge» technique, run out into the sea from the shore. For good reason Marinatos thought these buildings to be Minoan (Marinatos 1925-1926, pp. 141-147).

the quarry[166]. Tool-marks on the side of the block (*fig.* 26) suggest that a pick may have been used by the quarrymen. Near Knossos itself, I have seen traces of quarrying operations of this type on the sides of a small ravine which during the rainy season feeds water into the Kairatos River. It is located just north of the modern road where it approaches the Venetian aqueduct south of the Palace.

The sandstone quarries in the Malia region deserve description[167]. They are not far from the Palace site, on the low series of rocky peninsulas that interrupt the superb, wide stretches of sandy beach along the shoreline (*figs.* 27-29)[168]. The quarry nearest to the Palace is about fifteen minutes' walk to the northwest. It lies across the small estuary that separates the main area of archaeological remains from the extensive plain of Malia to the west. The area in which the first quarry is located is called «Point du Moulin» by the French excavators, perhaps after a relatively modern mill establishment, now destroyed, which was once connected with the sea by means of a wide, deep ditch cut in the bedrock[169]. From the Point du Moulin and at intervals westward along the shore for a few kilometers, up to and beyond the small Church of Hagio Pnevma, can be seen traces of quarrying, the evidence usually being channels cut in the bedrock by a pick-like instrument such as that which may have been used at Zakro. Usually the blocks have been removed, although there are a few that still lie abandoned in the quarries.

As far as technique is concerned, the method of removal here is basically the same as that already described for Zakro, with the process being simplified for the builders by the fact that instead of having to cut into the sides of a cliff, here they were working on a flat, even if slightly irregular, surface. Moreover, whenever they were building in the immediate vicinity, instead of having to load the blocks into ships they could have used carts or sledges to transport them directly from the quarry to the building site. Sometimes the areas to be quarried were irregular, and as a result the channels were not cut parallel to each other, but at slight angles, so that the blocks removed must have been triangular and rhomboidal rather than rectangular in form (*figs.* 28, 29), as is usually the case.

In the past, certain circular holes visible in the bedrock of such shoreline areas where ancient quarrying has sometimes taken place (*figs.* 28, 29) were interpreted as the result of quarrying operations. For instance, at Hagio Pnevma, Evans reported «... borings ... about six inches deep and six to nine inches in width, and in some cases [they] retained part of the central core left by the large drill with which they had been worked out. They were arranged in regular rows – one sometimes intersecting another – and the native Cretans were well aware of the function that they had performed in the art of primitive quarrying. Into these would have been inserted the ends of wooden poles the expansion of which, due to saturation, broke the rock, the size of the blocks being further regulated by the same grooving process noted at Knossos»[170].

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[166] See also Fiandra 1961-1962, p. 116, pl. KE' 1, 2; Levi 1961-1962, p. 378.

[167] They are now being studied by a team surveying some twenty-five quarry sites along the seashore there (Müller, Laffineur and Anslijn 2003; Whitley 2005, pp. 107-08, after R. Laffineur and S. Müller). See also Guest-Papamanoli 1989.

[168] These have been noted in passing by Charbonneaux 1928, p. 350 and Pareyn (*Mallia, Nécropoles* II, p. 27).

[169] In the past this ditch, or channel, has been thought to have some connection with Minoan harbor works, but may possibly be no older than the mill itself. A skin diver interested in the history of port construction claims to have seen Minoan walls in connection with this channel (H. Frost, *Under the Mediterranean*, London, 1963, pp. 105-106, pl. X), but the only walls I saw here in 1969 use lime mortar as a binding for rubble, and therefore cannot be Minoan, for the Minoans did not use cement mortar for wall construction.

[170] *Knossos* II, p. 233, fig.131 b; see also p. 280; *Mallia, Écritures*, pp. 87-88, figs. 32-33; *P. of C.*, p. 145.

These curious holes are not arranged in any meaningful pattern and are completely natural in origin, perhaps being the result of erosion of this type of sandstone by wave action. That there is no regular pattern in this cratered landscape is best seen on the site itself, but one can still get a clear impression from photographs showing dozens of them occurring haphazardly in the bedrock. Nor does it seem possible that they were made by a frenetic workman using a circular drill, for although some of the holes are quite round and with vertical sides, many are too rough and irregular to have been made intentionally. For instance, that in *fig.* 30 a has a projection on one side which would have been removed during the process of drilling; it is also not completely circular and has a rim of harder stone (calcite?) which has not been removed by the process of erosion.

The holes occur outside of as well as within the limits of a particular quarry. Indeed, at Hagio Pnevma, where Evans made his observations, I have noticed that the holes extend some distance underwater out to where there are no traces of quarrying and the water is some 3 m deep. On high ground to the southwest, on the other hand, above the normal reach of the sea, the holes occur neither on the unquarried nor the quarried bedrock. When the holes do occur within quarries, they are at random intervals in relation to each other and have no connection with the channels which, as we have seen, indicate where blocks have been removed. Instead of occurring exclusively within the channels, which one would expect if they had been part of the quarrying operation, they appear elsewhere, as in *fig.* 28. It seems quite clear, therefore, that the holes are curious natural phenomena and the result of weathering in sandstone strata of this type[171]. A recent theory, which may well resolve the mystery of the circular holes, is that they are actually the negative molds of the trunks of trees which were growing in the sand when the sand was in the process of being consolidated into rock[172].

That these seaside quarries provided material for the Minoan Palace is quite clear. First of all, there is very little heavy building of later date in the immediate vicinity, although the blocks could have been removed from here for use in Roman buildings at nearby Chersonnesos. That the Minoans lived along the shore near the quarries, however, is clear, for Minoan pottery is plentiful in these areas. Moreover, the shoreline forms the only known local source for sandstone so frequently used for the Palace walls. That at least some of the blocks in the Palace were brought from the seashore is definitely proven by the presence in them of holes like those described above (*fig.* 30b).

Other quarries, those below ground, have also been found. Evans reported the presence of vast underground limestone quarries at Hagia Irini, also called the caves of Hazzidakis-Nivas [173], about two miles to the south of the Palace of Knossos[174]. Of the two great caverns there, only that to the west (*figs.* 31a-c) can be visited today, for the eastern cavern is locked, being used for storing explosives. The western quarry, however, is ample for a memorable visit. It is a great, cool, cathedral-like space created as the quarrymen followed a layer of fine limestone, with an average thickness of 3 to 5 m, into the side of the hill. At intervals immense square and rectangular piers have been left to support the ceiling (*fig.* 31b).

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[171] Waelkens concurs (1998, p. 8).

[172] Guest-Papamanoli 1989, n. 7, referencing an unpublished dissertation by R. Dalongeville, *Formes de corrosion et de construction organogène des littoraux actuels calcaires de Méditerranée,* 1986, p. 275.

[173] Faure 1964, pp. 166 n. 8, 227.

[174] The quarries can be reached by car if one passes through the small village southwest of the Venetian aqueduct. Visitors should go to these remarkable caverns in the morning, when the morning sun illuminates the caves from the east, and a flashlight becomes necessary only for exploring the innermost chambers. Todd Whitelaw informs me that outside the caverns the rock is extensively quarried, and on the opposite side of the ravine to the east quarrying has also taken place (personal communication).

Although the tools used here may have been the same as those used in the quarry of Zakro, the quarrying technique itself is quite different. Instead of removing the blocks in steps, as was done at Zakro, the quarrymen here removed them in vertical layers, so that the quarry had sheer faces when a series of blocks had been extracted. The same difference in technique between open and closed quarries has been observed in Egypt. In the latter case the area worked at one time was rarely extended inwards for more than the breadth of three blocks[175].

When Evans first visited these quarries, he saw some great «blocks half sawn out» and of «a Minoan character», and he concluded that the «laminations of the stone answer to those visible on many of the Palace blocks»[176]. I am not sure what Evans meant by «of a Minoan character», unless he was possibly referring to the shape or size of the blocks he saw. The only measurable block – this may be a block to which he was referring – is in a niche on the western wall; and it is half cut out by means of the channeling method which we have already described. The block is 2.50 m long, 0.66 m wide, and 0.42 m high, in dimensions quite similar to a large block I have measured from Knossos[177]. That he observed blocks that had been cut by a saw is debatable, for as far as I know saws were not used in the excavation of Minoan blocks of soft sandstone or limestone. The only tool used here may have been a mattock, or pick, the marks of which can still be measured in an area of soft earth near the aforementioned block (at *a* in *fig.* 31c). The tool marks are so clear that one can see that one end of the tool was pointed, while the other, flattened end, was 0.025 m wide.

In his excellent study of Minoan plaster, Heaton maintains that lime from this quarry furnished the base for much of the Knossian plaster decoration[178]. Whether the quarry is actually Minoan, however, remains unsure, for even though this is the only large quarry known near Knossos, the site of Knossos was used by Greeks and Romans as well[179].

Another underground quarry, not far from Phaistos and Hagia Triadha, is pointed out by the local inhabitants as the source of Minoan building stone. However, this quarry is at Ampelouzos, near the Roman city of Gortyn, and may have therefore served as a source of limestone for Roman engineers[180]. The caves are now closed due to a number of accidents caused by tampering with explosives stored there during and after World War II. In contrast to the quarries at Hagia Irini, where large open spaces supported by pillars are the rule, the quarry at Ampeloúzos is a series of labyrinthine passages, about 4 m broad and 2 to 3 m high, which follow the stratum of usable stone into the hillside[181].

At Phaistos Pernier reports a limestone quarry reused by the Romans at the lower part of the acropolis of Phaistos, above the church of Hagia Photini, where the «limestone appears in horizontal or oblique strata, which break off naturally into blocks or slabs, which reach a length of ... two meters. Many of the blocks of the second Palace, which seem roughly squared, exhibit the natural lines of fracture»[182]. This cliff side can still be seen, and

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[175] Clarke and Engelbach 1930, pp. 13-16.

[176] *Knossos* I, p. 533 (quotation), and fig. 388; II, p. 62.

[177] See the first one listed in n. 194 on p. 37.

[178] Heaton 1911, p. 700, and note, see also fig. 3; also *Knossos* I, p. 532, n. 3.

[179] It does seem unlikely, however, that the material for the impressive stone aqueduct of Venetian date came from the quarry at Hagia Irini. The blocks used in this structure are relatively small, while the large block mentioned above is at the rear of the cave, therefore being one of the last blocks to be quarried, and would hardly have been quarried so large if the builders had the intention of breaking it up later into smaller blocks.

[180] *Knossos* I, p. 533.

[181] Captain T.A. Spratt, *Travels and Researches in Crete*, London 1865, II, p. 45, Plan p. 49; see also Faure 1964, pp. 7, 9, 166 n. 9, 168, 205 n. 2.

[182] *Festòs* I, fig. 7; II, p. 418.

according to one of the guards of the nearby archaeological site, served as a quarry for the Germans during their occupation of Crete.

Elsewhere, there seems to have been quarrying at Amnisos which, according to Marinatos, may have been the source for blocks used at Sklavŏkambos[183]. At Archanes, where extensive building took place, especially during the LM I period, a major quarry still remains to be discovered. The only one with which I am acquainted is diminutive and was used for the extraction of a few limestone slabs (*figs.* 32a, b). The quarry is on the top of the hill at Phourni, a kilometer northwest of the modern town. Although the channeling method used to remove the slabs is reminiscent of Minoan technique, there is no proof that Minoans actually removed them. It is likely, however, that the Minoans used a similar method for procuring slabs used for pavements and the bases for doorjambs.

2. Gypsum Quarries

A few quarries for gypsum are known. In the Mesara, for example, a Minoan quarry was located southwest of the Palace of Phaistos. Unfortunately it is no longer visible, for it was covered up after its discovery in 1900[184]. It was from similar local outcroppings, such as that at nearby Gortyn, that the Italian excavators obtained materials for consolidating and reconstructing the ancient architectural remains[185]. The search in the area of Hagia Triadha led to the discovery of a quarry (*fig.* 33), here described by Levi: «The new feature in the restoration of the Palace was the discovery, after a long, costly, and difficult search, of the Minoan quarries of alabastrine gypsum, not far to the west of the Chapel of Hagia Triadha, quarries evidenced by the presence of enormous blocks detached from the hill. Near the bases of these blocks ancient sherds were found, among which are clearly some sherds of Kamares ware. The abandonment by the ancients of the blocks we found was due, in all probability, to their imperfection, since it has been possible to establish firmly that at Phaistos and Hagia Triadha, in contrast to Knossos, only perfectly compact material was used for the paving of floors and the revetment of walls, while veins were disregarded, or blocks abandoned, where the grain occurred in large crystals. Since, in the strata of rock, as indeed in individual blocks, compact zones and crystalline zones continually alternate, we were able to reutilize the still serviceable parts of the blocks abandoned by the ancients, installing by hand four temporary saws in their vicinity; while nevertheless in the immediate area the feverish search continued for richer veins of pure alabaster, untouched in the hillside. As we had spent a good part of the season discovering the quarries, and exploding numerous charges in the search for new veins, we succeeded in cutting only a limited number of slabs, all of beautiful material, however, white or veined, identical to that used in the Palace»[186].

This quarry, about fifteen minutes' walk along the road southwest of the site of Hagia Triadha, can still be visited, and along the way I have seen other outcroppings of gypsum, cut into by the bulldozer or grader that smoothed out the surface of the modern dirt road.

At Knossos, «Gypsádhes», a hill to the south of the Palace, probably furnished gypsum for the Minoans. There is little doubt that the material originally used in the Palace of Knossos came from here, and although the ancient quarry site is apparently not visible now, Evans reported the openings of large subterranean quarries in the hillside there[187]. It appears

[183] Marinatos 1939-1941, p. 72.

[184] *Festòs* II, p. 419.

[185] *Festòs* II, p. 588, n. 252; *P. of C.*, p. 144.

[186] Levi 1952, p. 321, and fig. 4. Translation from the Italian by Sara MacVane. See also Levi 1951, p. 340, and *Festòs* 1976-1988 II (Part 1), p. 3 and figs. 4-8.

[187] *Knossos* III, p. 192.

that quarries near Knossos were the sources for gypsum slabs used for floors of elite architecture outside of Crete, for instance at nearby contemporary Akrotiri on Thera[188] and, later, on the Mycenaean mainland[189].

There is little information about the technique used to extract gypsum blocks. The stone is so soft, however, that the systematic quarrying methods used for poros limestone may not have been necessary. Wedges were used by the Italians in their modern quarrying operations near Phaistos[190]. As is done now (*figs.* 58 a, b), slabs were probably sliced from blocks already removed. It is not known if small blocks used as pillar bases, for doorjambs, and the like were quarried separately or simply cut out from larger blocks[191].

3. Transportation

When building material was immediately at hand, its transportation presented no problem. At sites such as Myrtos-Phournou Korifi and Pseira, as we have already pointed out, the hillsides on which the towns were built furnished the slabs used for building the walls. Even in the case of the early orthostate façade at Phaistos, the excavators believe that the blocks were quarried from only a few dozen meters away[192]. Perhaps the only material usually brought from some distance at such sites was wood, which was sometimes used as a binder within walls and for jambs, lintels, and ceiling or roof structures. In the case of Pseira, if wood was not available on the island it must have been brought by boat from the mainland. Elsewhere, wood may have been brought by oxen and asses, among the first beasts of burden domesticated in Crete[193].

For some of the more elegant, better built structures of the First and Second Palace periods, however, wheeled vehicles such as carts and wagons were probably used. Perhaps even sledges and rollers aided during the process of removing blocks from the quarry and during the final stages of setting them in place at the building sites. It is difficult to imagine, for instance, that some of the huge blocks, that weighed tons, would have been transferred by other means[194]. Perhaps a wagon somewhat like that shown in a MM IA terracotta model

188 Einfalt 1978, p. 527; Palyvou 2005, pp. 111, 114, 126, 188 n. 47.

189 Gale, Einfalt, Hubberton and Jones 1988, passim; *Knossos* III, pp. 194-199; Mylonas 1966, pp. 62-64.

190 Levi 1951, p. 340.

191 For the quarrying of gypsum see also Chlouveraki 2006, Chapter 4.

192 Fiandra 1961-1962, p. 116. See also Levi and Carinci 1976-1988, Vol. I, figs. 4-10.

193 *Knossos* II, p. 157. For the Palaikastro model, its origins and implications, see Crouwel 1981, pp. 54-56. I am indebted to Joost Crouwel for his help in this matter. For the use of cattle for pulling, from an early period, see Isaakidou 2006, pp. 104-108.

194 Here are the dimensions of some of these blocks from various sites. Estimated weights are given for the poros limestone blocks:

Knossos: 2.40 × 0.71 × 0.59 m. Poros limestone block in a basement wall near South Propylon (*fig.* 82). Weight ca. 1,500 kg (3,300 lbs.). 2.21 × 1.05 × 0.55 m. Poros limestone block in wall west of Little Palace (*Knossos* II, p. 545, n. 1). Weight ca. 1,900 kg (4,200 lbs.).

Phaistos: 3.11 × 0.95 × 1.00 m. Orthostate block of poros limestone from early West Façade (*fig.* 88). Weight ca. 4,500 kg (9,850 lbs.). 2.07 × 1.03 × 0.64 m. Poros limestone block in Second Palace (*Festòs* II, p. 428). Weight ca. 2,025 kg (4,500 lbs.). 1.96 × 1.80 × (?) m. Gypsum revetment slab (*Festòs* II, p. 418).

Malia: 2.00 × 0.82 (max.) × 0.54 m. Hard grayish blue limestone krepidoma block at Chrysolakkos. 1.30 × 1.40 (max.) × 0.72 m. Malia, hard limestone corner block at entrance to «Agora» (*fig.* 196C).

Kommos: 3.44 × 0.94 × 0.35 m. poros limestone block Weight ca. 1,700 kg (3,736 lbs.). Also, 3.13 × 0.93 × ? (thickness not measurable). Poros limestone block. Both Kommos blocks belong to the long orthostate course of Neopalatial Building T (*Kommos* V, p. 21, note 78).

Other: 2.83 × 0.70 × 0.35 m. Kato Zakro, sandstone block in southeast corner of West Wing (*fig.* 122). 2.22 (max.) × 1.12 × ca. 0.25 m. Kato Zakro, hard bluish limestone threshold slab at Northeast Entrance. 2.20 × 0.67 × 0.67 m. Amnisos Villa, poros limestone block.

from Palaikastro (*fig.* 34), probably drawn by yoked oxen, carried these blocks[195]. For the process of loading, unloading, and positioning, wooden pry-bars, rollers, and ropes were probably used. There is no indication that any special cuttings in the blocks, such as the round holes drilled in certain blocks at Chrysolakkos (*fig.* 60 at 2), were intended to aid in the process, although this has been suggested by the French excavators[196]. The drilled holes here probably had another function, as I try to demonstrate in the section here on wooden clamps and dowels. At the same time that the large blocks were being brought, smaller gypsum and limestone slabs and blocks, column bases, wooden beams, perhaps even fieldstones and mud brick were making similar journeys from various parts of the countryside in carts or wagons drawn by oxen or asses[197] and at a later date perhaps by mules or even horses[198].

Since we do not know the actual distances traveled by individual blocks, we can only estimate from the quarry sites known, such as those at Knossos, Malia, Mochlos, Palaikastro, and Zakros, that a trip of a few kilometers was not unusual. Threshold blocks of hard limestone or polychrome column bases, however, may have traveled much greater distances. In the case of Zakro, to judge by the roughness of the terrain intervening between quarry and building site, the first stage of the trip was accomplished by boat or raft, and then the blocks were dragged or carted the remaining distance.

In a precipitous hill area south of Zakros, at Choirómandres, Tzedakis, Chryssoulaki and others have reported upland roads and quarries for *sideropetra* (*fig.* 9) from which blocks may have been transported to the building site by being tumbled along above thick walls, as well as delivery ramps, and occasional viaducts created over declivities that had to be crossed[199].

C) Tools for Building (*figs.* 35-63c)

With the development of Minoan civilization there grew up at least two experienced classes of craftsmen whose knowledge and skills could be extensively utilized (see also Chapter 5B here). Not least among the achievements of certain of these craftsmen was the manufacture of useful tools which helped develop better and more refined building techniques. Some of the metalworkers must indeed have been highly specialized, to judge from household metal equipment and other examples of metalwork found among the ruins of the destroyed palaces, houses, and tombs. These include large cauldrons, basins, weapons, and heavy or delicate metal tools. Molds for metal objects and ingots of raw copper add to our picture of the craft.

Many of the tools to be discussed[200] could have been used for cutting either wood or soft stone. Indeed, they must have accomplished many agricultural and household chores as well.

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[195] *Knossos* II, p. 156, fig. 78; IV, pp. 807-809.

[196] *Mallia, Nécropoles* I, p. 27.

[197] *Knossos* I, p. 224; II, p. 156; IV, pp. 807-809.

[198] *Knossos* II, pp. 156, 827. For an estimate of the time required to quarry stones for specific buildings, then transport the materials to the building site and build the structures, see McEnroe, *forthcoming*, Chapter 9.

[199] Tzedakis, Chryssoulaki, Voutzaki and Venieri 1989, p. 57, *figs.* 19, 27; 1990, fig. 1 on p. 45, note 7 on p. 46, pp. 48, 60. Also Chryssoulaki 1999 notes 21-22; I am indebted to her for her advice. Gerhard Plath, engineer-architect who has worked at the Choirómandres site, kindly informed me (personal correspondence) that the quarry for the guard-house there is about 180 meters away from it horizontally and some 32 meters above its level. For a similar transport ramp and remains of a viaduct reported near the Skariá quarries mentioned above, see Tzedakis, Chryssoulaki, Venieri and Avgouli 1989, p. 57, note 44.

[200] The first basic study of ancient tools used by the various Mediterranean peoples was written by Sir W.M. Flinders Petrie, *Tools and Weapons* (1917), who focused his attention on tools of various periods found in Egypt but included material from elsewhere as well. For Egyptian tools and the ways they were used, also consult Nicholson and Shaw 2000, pp. 355-356, and Clarke

In some situations, the exact variety of tools used and their specific uses remain vague. This ambiguity is partly due to the fact that the climate of Crete, unlike that of dry Egypt, does not encourage the preservation of organic remains: many Minoan tools were no doubt wooden or had wooden elements. We have also failed so far to carry out experiments with replicas of Minoan tools. Because of the uncertainty of some of their applications, tools which may have been used in building have been grouped below on the basis of type rather than specific function[201].

1. Double-Axes

The tool most commonly found in Minoan excavations is the double-axe, which was at first made of copper and later of bronze. It has two blades, with a single hole in the center designed to hold a wooden haft (*fig.* 35A). For the Minoans, the double-axe had two functions. One was purely ceremonial, as is clearly shown by numerous pictorial representations, as well as by the existence of axes cut and hammered from thin bronze sheets, which would be useless for practical purposes, and by miniature axes of various precious or rare materials. The other function was purely utilitarian, and the axe used then was of solid cast bronze. The latter type was used for woodcutting, and to judge from the humble contexts in which such axes are often found, often along with other tools, as well as by their worn, sometimes battered condition resulting from repeated use, they must have been a versatile, popular tool. Indeed, some are so abused and battered that they are often mistaken for hammers (*fig.* 35B shows an example)[202].

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and Engelbach 1930. Everyday scenes of manufacture and work commonly shown in Egyptian wall-paintings – but rare in Minoan – are quite helpful. See, for instance, the Tomb of Nebamun and Ipuky (no. 181) in Thebes, as illustrated in A. Mekhitarian, *Egyptian Painting*, Skira, 1964, p. 125. On the basis of these paintings, actual remains of tools, and worked stone and wood found, a reconstruction of Egyptian carpenters at work has been made by H.M. Herget, in *Everyday Life in Ancient Times* (Washington, *National Geographic Magazine*, 1951), p. 109.

Minoan bronze tools used for architecture, although numerous and well preserved, had never been studied as a group until *MA:MAT* 1 appeared in 1973, although Keith Branigan had discussed tools of the Early Minoan period in his short monograph, *Copper and Bronze Working in Early Bronze Age Crete* (1968), later extended in his *Aegean Metalwork of the Early and Middle Bronze Age* (1974). Many Minoan tools had also been assembled, along with others from elsewhere in the Mediterranean, in an admirable typological study of Aegean, Near Eastern, and Asian tools of the Bronze Age, by Jean Deshayes in his *Les Outils de bronze, de l'Indus au Danube (IV[e] au II[e] Millénaire)* I-II (1960). Another study, specifically of Cypriot tools, is that by Hector Catling, *Cypriot Bronzework in the Mycenaean World* (1964), which added information about metal-working in general and at the same time incorporated bronze objects reported from other areas of the Aegean. With the publication of Doniert Evely's first-volume of *Minoan Crafts: Tools and Techniques* in 1993, a detailed overview of all Minoan tools and crafts became available. My own debt to the above authors' efforts will be clear in the following pages which contain a brief, condensed study of those Minoan tools which were probably used by the builders. Thanks to the kindness of the excavator of Kato Zakro, the late Nikolas Platon, I have drawn for my own work on examples from among the great variety of tools found at the Palace there.

[201] For more information about the origin of various tools, methods of their manufacture, and comparison with tools found elsewhere, the reader is referred to the studies cited above and to the notes, also the List of Illustrations. For tools used by plasterers, see Chapter 4 on Lime and Clay Plaster.

[202] See also *Deshayes*, I, p. 255.

Although the double-axe may not have originated in Crete[203], we may find it there as early as the EM II period[204]. It becomes more popular during Middle Minoan times, reaching its acme of use in LM I-II. Over two hundred double-axes from Crete are listed by Evely, along with a number of stone molds for their casting[205].

The simplest and most common type of double-axe has a slightly spreading profile above and below its rounded blades, with a circular hole in the center of the tool for the wooden shaft or handle (*fig.* 35A). It outnumbers all other varieties by at least two-to-one. Its length ranges from 10 cm to 24 cm, averaging about 16 cm to 20 cm, which makes it similar in size to many of the axes used for wood-cutting today. The advantages of the double-axe over an axe type with a single blade are clear, for it does not have to be sharpened as often and is perfectly balanced for swinging. No doubt woodmen and carpenters carried whetstones with them, such as those illustrated in *fig.* 48, from Phaistos. Whetstones of this type have been reported from a number of sites, such as Koumasa, Porti, Platanos[206], Tylissos[207], as well as from Gournia[208] and Kommos[209]. Many were pierced or notched and could be hung by a thong from one's neck. The haft of the axe must usually have been a length of hardwood sapling onto which the axe-head was set. This haft may have been soaked in water after it was fitted, so that the wood expanded and so ensured a tight fit. As in modern practice, perhaps small wooden wedges were driven into that part of the shaft that projected beyond the top of the axe-head. A number of axes have a long, horizontal groove on what is presumably the top edge of the axe, overlapping the haft hole on each side. This slot no doubt was intended for a wooden wedge or metal pin that would be driven into the haft once the axe-head had been set upon it, thus preventing the axe-head from slipping off or turning about the circular shaft[210]. In some cases the hole in the axe-head is oval rather than round, no doubt intended to keep the axe-head from turning about on the shaft, a device used also in modern axes. Occasionally the top of the axe-head was flat rather than up-curving[211].

2. Flat Adzes

Although a number of flat adzes are reported by Evely[212], they were apparently not in common use. Some curious tools from Eastern Crete, however, may well be adzes (*fig.* 35C). Of the type found there, there are two examples, one from Zakro, about 15 cm by 15 cm[213] and one from Palaikastro[214], 14.5 cm by 5.4 cm (*fig.* 35C) for the latter). They resemble a

[203] *Catling*, p. 89; Buchholz 1959, p. 21.

[204] Branigan 1974, p. 21; *Catling*, p. 89; *Crafts*, p. 54.

[205] *Crafts*, pp. 41-55, figs 20-21, pls. 14-15.

[206] S. Xanthoudides 1924, pl. XXIII, nos. 787-788; pl. XXXIX a, no. 1060; pl. XLIII, two (no number).

[207] *Tylissos* (1), p. 52, fig. 25, nos. 13, 15, 18; *Tylissos* (2), pl. XXVIIIj-o.

[208] *Gournia*, p. 32, pl. III, nos. 29-31. For Phaistos, see also Levi 1957-1958, p. 201, fig. 10. The range of measurements here is 8 cm to 22 cm. In those illustrated here (*fig.* 48), the first three (Excavation nos. 5012, 5012 B, 5008) are from Protopalatial fill west of the Theatral Area; the last (Excavation no. 5200) is from a deeper sounding and probably dates from the beginning of the Protopalatial period.

[209] Blitzer 1995; *Kommos* I (1) Type 5, pp. 441-447; Shaw 2006, in *Kommos* V, Chap. 5.4, Type 5, pp. 743-744.

[210] *Deshayes*, I, p. 256, Type Aa.

[211] Other axe types reported from Crete are the «Single» and «Trunnion» types (*Crafts*, pp. 53-61, figs. 23-25). Both have only one cutting blade mounted on a wooden shaft, and were no doubt useful for small jobs. Evely lists only 22 examples, which makes evident that the far more numerous double-axe, with 200 examples reported, was the preferred instrument.

[212] *Crafts*, pp. 72-75, figs. 31-32, pl. 17.

[213] Museum no. 2620. Note: all museum numbers given here refer to catalogue numbers in the Archaeological Museum of Herakleion.

[214] Museum no. 1130.

double-axe in dimension and shape, but are thin, being flat on one side and without a hole for a haft. It is possible that the one illustrated was used without a haft, in order for both blades to be functional.

3. Axe-Adzes

The axe-adze (*fig.* 37a, bottom), along with double-axes and chisels, no doubt shaped planks and beams. This tool has two very different cutting edges: one is like that of an axe, the other is a flat, horizontal blade intended for debarking, adzing, chopping, or even stone-cutting and digging. It has been suggested that such tools, of which a good number have been found outside of Crete, were especially suitable for mining[215]. Catling, however, thinks they are better suited to the needs of the carpenter[216]. Deshayes agrees with Catling, and refers to them as the «basic tool of the carpenter»[217]. Evely lists 10 examples from Crete[218]. In size they range from 14 cm to 19 cm long, so short that one suspects that they could have been used only for shaping the smaller wooden members in Minoan construction. Evely points out that the date range of the tool is often not clear, but that in any case it appears before the double-axe (below)[219].

4. Pick-Adzes and Double-Adzes

Among the larger bronze tools discovered in Crete are the pick-adzes (*figs.* 36A, B, 37a, top, middle) and the double-adzes (*figs.* 36C, 38a). The picks, which are quite similar to the modern mattock, are known from six examples, two from Hagia Triadha (*fig.* 37a, top, middle), one from Rogdhia Melevyziou[220], two from the Palace of Kato Zakro (*fig.* 36A, B)[221], and one from Itanos[222]. Those from Hagia Triadha probably date to the Late Palace period, and there is no doubt that those from Zakro belong to the Neopalatial period, when the Palace was destroyed. Of the first, two are 24.5 cm and 37.5 cm long, respectively, while the third is only 14.6 cm long, and had apparently been used as a hammer[223]. Those from Zakro are 14 cm and 16.5 cm long. In general, the tool type is characterized by a long, curving blade with a round socket at the center for the insertion of a wooden handle. As in modern mattocks, one blade is pointed, the other, intended for chopping and digging, is flat and sharpened.

The double-adze, on the other hand, has two flat, sharpened blades. Of the 17 examples from Crete listed by Evely[224], nine are dated to the MM III-LM IA period, the rest being of doubtful date. A worn example from Zakro, 12.5 cm long, is definitely of LM IB date (*fig.* 36C). Preserved lengths range from 12 to 39 cm. In *fig.* 38a can be seen three examples, the first almost new, the next two progressively more worn.

Deshayes believes that both of these types of tools were used primarily for agriculture[225], although I doubt that their function was so restricted. For instance, theoretically, either tool

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[215] Schaefer 1952, p. 44.

[216] *Catling*, p. 91.

[217] *Deshayes*, I, p. 289; see also Branigan 1968, p. 31.

[218] *Crafts*, pp. 67-71, figs. 29-30, pl. 17.

[219] *Crafts*, p. 71.

[220] These are *Deshayes'* nos. 2305-2307.

[221] The tool shown in *Knossos* II, fig. 392, no. 8, may actually be a pick and not a double-adze, as identified by Deshayes (*Deshayes*, II, no. 2088) and *Catling*, p. 90.

[222] *Crafts*, p. 71, no. 6, and (general) pp. 71-72, figs. 29-30, pl. 18.

[223] *Deshayes*, I, p. 292.

[224] *Crafts*, pp. 63-67, figs. 27-28, pl. 16.

[225] *Deshayes*, I, pp. 262, 293.

could have been employed in quarrying stone, for excavating the narrow, deep channels cut around blocks. Catling considers the double-adzes «more suitable for carpentry than stone masonry»[226] but fails to describe them as a tool for digging, which is what they are used for today in Crete. Perhaps the answer lies in an interpretation which allows for a number of possibilities. For instance, the tool in *fig.* 37a (A) could have been used for various types of work such as chopping and quarrying, but that in *fig.* 37a (B) seems too delicate to have been used to work stone. Similarly, the double-adzes could have served in many ways, the contrast between *fig.* 38a (A) and *figs.* 38a, b (C) showing how they were sometimes abused by their owners.

It is important in this respect to point out that definite traces of a pick are preserved on the scarps of the quarry at Hagia Irini, and I have seen similar tool marks on the rock sides of the chamber tombs in the hillside opposite the Palace of Knossos, on the east. I also suspect that picks left the tool marks visible in *figs.* 26, 50 (1), and 52. Traces of double-adzes (a chisel or the flat end of a pick could make similar marks) can probably be seen on certain blocks at Phaistos (*figs.* 63b, 63c), and unmistakable marks of the same tools were discovered on the walls of a Late Minoan chamber tomb (Tomb Z) excavated by Alexiou at Katsamba (*fig.* 53)[227]. Tools of the same shape, although naturally of steel, are used nowadays for digging house foundations in bedrock, in addition to agricultural applications. Since dynamite is now used to loosen poros limestone from the great hillside quarries that occasionally mar Greek landscapes, hand tools are restricted to quarrying stone blocks, which in turn have been largely replaced by concrete in modern construction.

5. Hammers

There might first seem to be a curious gap in our record when we come to hammers. No doubt the gap can be partially filled if we assume that wooden mallets, now lost, were used by carpenter and stone-cutter alike. Mallets would have been ideal for striking chisels, such as the ones shown in *fig.* 45A, B, which may account for the fact that the ends where the chisels would have been struck are not blunted and burred. Some cobbles, largely ignored until recently, also must have played important roles.

There is some evidence for metal hammers which could have been used to smooth the corners of blocks, to roughen smooth stone surfaces to provide a stable base for timber supports (*fig.* 55b), or to aid in dressing column bases of hard stone (*fig.* 146).

In his discussion of bronze hammers[228], Evely lists some 22 examples. Of those, however, only four, of which three are Neopalatial, were originally designed with a flat striking surface and therefore must be proper hammers. The first two are hammer-adzes from Knossos and Tourloti, respectively[229]. The other two examples (*figs.* 39a, b) have been misidentified by Deshayes as abused double-axes. The first (*fig.* 39aA) is 23 cm long, and is at its thickest about 8 cm wide. This is about the size of a modern sledgehammer, such as the one being used to break up stone in *fig.* 54. The ancient and modern hammers are quite similar in size, the latter being 22 cm long and 8 cm wide[230]. The comparison with the sledgehammer

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[226] *Catling*, p. 89.

[227] Stylianos Alexiou kindly furnished the photograph, which is also published in Alexiou 1967, p. 21, fig. 17. The tool used is called an «axinopelekys», literally, a pick-axe. For pick-marks in the *calcestruzzo* at Phaistos, in Room 28, see Levi 1952, p. 330.

[228] *Crafts*, pp. 97-105, figs. 42-46, pl. 22.

[229] *Crafts*, p. 101, fig. 44, nos. 11 and 12.

[230] The workman in *fig.* 54 is engaged in breaking up great chunks of poros limestone for use in a rubble wall which was being built for a parking facility at Knossos in 1969. The chunks of stone were brought from a neighboring quarry, from which they had been blasted by means of dynamite.

becomes even more appropriate when the weight of the ancient hammer, 7.24 kg (about 15.9 lbs.), is compared with that of the modern one, 7.00 kg (about 15.4 lbs.). Not only are the profiles of these two hammers completely different from that of a double-axe, but it is inconceivable that a double-axe could have weighed so much. The double-axe in *fig.* 35A, for example, weighs only 1.222 kg (about 2.69 lbs.)[231]. The second hammer (*fig.* 39a) (B) is smaller, being 15 cm long and 8 cm wide, and weighs 4.157 kg (about 9.2 lbs.). There is a good possibility that both of these hammers were used to break up stone, to judge from their roughened striking surfaces, which most likely would have been smoother had they been used in a smithy for metalwork[232].

A second group, seven hammers, were originally cast in different shapes that were modified through use from double-axes, of which one from Zakro is illustrated in our *fig.* 35B, or from double-adzes[233].

Perhaps the hammers most commonly used by carpenters and masons were erosion-rounded hard metamorphic and igneous stone cobbles that could be held comfortably in the palm of one's hand (*fig.* 40). These can often be collected easily from streambeds and shorelines. Few examples have been reported, however, these having been largely ignored because of their humble character. Hazzidakis's early work at Tylissos, published in 1934, remains a notable exception[234], followed up later, for example, by Warren's work at Myrtos-Phournou Korifi[235]. and by Popham's at Knossos[236]. It is often impossible to differentiate in the field between unused and used cobbles, the chief distinction being evidence for percussion (e.g. flaking, pecking, scoring, abrasion). Such hammers, or pounders, can be ubiquitous in house contexts, with evidence for wear being noticeable only after actual washing and inspection. At Minoan House X at Kommos, for instance, of the some 80 cobbles collected and labeled by the trench masters, only 27 were actually retained after washing and detailed examination, somewhat more than the number of bronze tools (19) recovered from the same building.

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[231] The worn double-axe in *fig.* 35 (middle) weighs only 0.832 kg (about 1.9 lb).

[232] On each side of the larger hammer, I have noticed a curious pattern roughly in the shape of a crown, in a light relief: . I am not sure if this pattern, which was certainly intentionally made, has a symbolic significance or is simply connected with the casting process of such a heavy tool. If the two curves at the top were not there, the relief would be similar to that of the second hammer from Hagia Triadha, and therefore just part of the reinforcement along the sides of the hammer. On the other hand, it does resemble a pattern discussed by Evans, which, however, had a curve at its bottom as well: . Evans thinks of this as a picture of a template, and connects it with decoration and with house building (Evans, *Cretan Pictographs*, London, 1895, p. 305). For more accessible drawings of the sign, see *A. of C.*, fig. 24 h and no. 19; *Knossos* II, fig. 113; *Mallia, Écritures*, pl. II, H 14 b, and p. 22).

[233] *Crafts*, no. 22.

[234] *Tylissos* (2), pl. XXVIII. There are also some stone hammers which were kept by the excavators partly because of their curious resemblance to animals (*fig.* 49B). One from Knossos was found along with a hoard of tools in a house on the northern border of the Palace, and was identified as a whetstone with a «tortoise-like head» (*Knossos* II, p. 629, fig. 392, no. 18). A large group comes from Gournia, where they are identified as hammers and sledgehammers. Among the examples from there are three small hammers, ranging 5 cm to 7 cm in size, and three larger ones, 15 cm to 23 cm (e.g. that in *fig.* 49B), and all apparently of hard limestone (*Gournia*, p. 32, pl. III, nos. 26-28, 37-39). Blitzer (1995) has catalogued similar objects as «differentially weathered pebbles» in *Kommos* I (1), her Type 16A; she notes (p. 475) that they may have served for suspension as weights for balances. See also *Crafts*, fig. 48, nos. 11-12 («Pestles»), and p. 217 for stone sledgehammers.

[235] Warren 1972a, pp. 233-234, fig. 102 and pl. 79a (a selection).

[236] *MUM*, Section 8 by Doniert Evely, especially pp. 224-225 and pl. 208. See also Evely's section on ground stone tools (*Crafts*, pp. 108-118, figs. 49-51, pls. 24-25.) For stone tools at Akrotiri on Thera, see Palyvou 2005, 114.

At Kommos Harriet Blitzer studied in detail the types of ground stone tools recovered[237], isolating some seven types that can be interpreted for our purposes here as possibly having been used by carpenters or masons. Her typology was developed after consideration of the size and shape of the cobble and the character of evidence for use. Our *fig.* 40 illustrates examples of pounders and a hand stone from three of those categories. Such tools could have been used to drive bronze chisels for either wood- or stone-working, or may themselves have shaped stones as suggested by the pecking marks on the column bases from the Kommos stoas or those on blocks at Malia (*figs.* 55a,b)[238]. Palyvou suggests also that cobbles may have been used for quarrying hard stone on Thera[239].

6. Saws

It was said in Classical Greek times that two mythical figures, Talos and Daedalos, invented the saw in Crete. The story goes that Talos first cut a stick in half with the jawbone of a serpent (or a fish's spine) and then copied it in metal. Daedalos, perhaps the greater inventor of the two, claimed a similar feat, which led to the quarrel in which he pushed Talos from the roof of the Temple of Athena[240]. The tale is made doubly intriguing by the fact that although pre-Minoan saws are known from the Ancient Near East, the Minoan saws are usually larger, better preserved, and more numerous than those found elsewhere.

At least 29 large bronze saws have been found at some six Minoan sites in Crete[241]. Very small saws, 5 cm to 14 cm long, are also reported[242], but they probably need not concern us here since they were used in the minor arts for making artifacts of stone, gold, and ivory[243]. Of the larger saws, at least 16 are securely dated within the MM III-LM I period[244] when they must have become fairly common both in palaces and large houses, although they were introduced as a type earlier.

All of the saws consisted of long, thin bronze sheets which, unlike many other tools discussed here, had been shaped by hammering rather than casting, because of their size and the extra strength furnished by the hammering process. Sometimes their top edge was smooth and straight while the lower, convex cutting side curved up and away from the sawyer. Some saws tend to be of the same width from one end to another, and others taper slightly toward one end. As should be expected from the various uses of saws now or then, a number of sizes must have been used, preserved lengths ranging from 0.17 m[245] to 1.70 m long, the size of the largest saw found in the Palace of Kato Zakro[246]. Thickness varies within the saw itself, but the range generally can be stated as 1 mm to 7 mm, at least for the saws in the large collection from Zakro. With a few exceptions, namely the thin saws that were used for cutting hard stone (*figs.* 42, 43), all other saws have teeth along the entire length of their cutting edges. The range of thicknesses of the toothed saws from Zakro is 3 mm to 7 mm.

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[237] Blitzer, in *Kommos* I (1), 1995.

[238] For Theran column bases dressed by stone tools, see Palyvou 2005, p. 130.

[239] Palyvou 2005, p. 113; see also McEnroe 2001, p. 34.

[240] Graves 1955, I, p. 312.

[241] These are listed by Evely as his types 3 through 5, also described in his *Crafts*, pp. 31-35.

[242] *Crafts*, chiefly Evely's saw types 1 and 2, listed and described in *Crafts* on pp. 26, 31, and 33-34.

[243] As *Deshayes*, I, p. 361; *Crafts*, pp. 33-34.

[244] *Deshayes*, II, nos. 2898 (four), 2899, and the ten LM IB examples found fallen on the floor of the West Wing of the Palace of Kato Zakro. Concerning saws, see also Wells (1974) and Evely (1993).

[245] *Crafts*, no. 42 on p. 31.

[246] The saw (*Crafts* no. 24, p. 31) is 0.21 m wide.

The teeth (*figs.* 44 A, B) are usually cut in a regular triangular form, probably with the use of a hammer and chisel while the bronze was still soft from heating, for files that might have cut or sharpened them are rare or unknown, although one has been reported from Gournia[247]. Certainly unusual among ancient cultures is that some Minoan toothed saws had an intentional «set» to the saw-teeth[248]. In similar modern cross-cut saws, designed to cut wood at right angles to the direction of the grain, the teeth are bent alternately from one side of the median line to the other, so that the saw-cut will be wider than the main part of the saw-blade and will not «bind» by being gripped along its sides by the wood that is being cut. In two saws from Zakros recently examined by the author, the teeth did not follow that pattern. Rather, every eighth or ninth saw-tooth was bent out alternatively to one side or the other while the remaining teeth were left straight[249]. The surprising weight[250] and the roughness of the large, heavy Minoan saws may also have alleviated the «binding» problem. Wooden wedges may have been used as well. However, since most of the cutting done with saws was probably against the grain[251], that is, at right angles to the timber's length, the carpenters or woodsmen may have simply placed the tree-trunk to be cut on top of a single log laid below it, as is done today, again partly in order to reduce binding. Much of the longitudinal cutting and splitting of wood must have been accomplished by the use of axes, adzes, and axe-adzes, with the help of wooden mallets and wedges[252].

There are usually small round holes in one end of the preserved saws. These were intended for the attachment of wooden handles, perhaps by means of metal rivets. Some of the collars for such wooden handles have been found (*fig.* 49 A). These are open pipe-like attachments of bronze, about 8 cm to 10 cm long, each pierced through the side by one or two holes for metal rivets or nails. Such handles were first identified at Knossos[253], where a pair was found along with a saw and other tools in the basement of the South House. There is also a pair, unidentified there, from Gournia[254] and a single similar pipe-like cap from Hagia Triadha[255]. From the position of the holes in the saw-blades, it appears that rather wide pieces of wood were attached on either side of the blade to form a frame. Remnants of the wooden handle can be seen on at least one saw from Zakro. One would think that bronze rivets, like the ones used for knives or swords, would have attached handles to saws. However, as far as I know, rivets have never been found associated with them. Most likely, a round wooden handle, either attached to or part of this wooden frame, was then strengthened by the pipe-like collars described above.

In some cases five or more holes were pierced through one end of the saw (*fig.* 41) and, as suspected by Deshayes in one instance[256], two or three of these were probably connected

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[247] *Gournia*, pl. IV, no. 7.

[248] For a good description of types of saw-teeth, see *Petrie*, p. 43. Wells (1974) thought that «the teeth of these saws are not raked in either direction», but also pointed out (pp. 6-7) that a saw from Knossos had an elementary form of setting. James Muhly also recognized a «set» in examples from Zakros (letter of June 10, 1975), perhaps in those mentioned in the text and the following note.

[249] Thanks to the kindness of excavator Eleftheris Platon and conservator Costas Nikakis, I had the opportunity in the summer of 2008 to check for «set» in two saws from the West Wing of the Zakros Palace. They are two medium-sized wood saws, Herakleion Museum nos. 2598 (from 1962) and 2572. The former was found folded in half, and was made and «set» more neatly than the second. For previous reporting about these two saws, see Evely 1993, p. 31.

[250] The longest saw from Zakro weighs 7.328 kg (or about 16.14 lbs.).

[251] As in *Catling*, pp. 93-94.

[252] If the Minoans did saw wood along its length («with the grain»), it is not unlikely that they adapted a technique used by the Egyptians: they may have lashed the uncut timber vertically to an upright post, and then sawed downward (for an example see A. Mekhitarian, *Egyptian Painting*, Geneva, 1964, p. 125).

[253] *Knossos* II, pp. 629, 630, fig. 393 b, c.

[254] *Gournia*, pl. IV, no. 66.

[255] Museum no. 1232; 8 cm long, 4.5 cm in diameter.

[256] *Deshayes*, I, p. 36; II, no. 2900; *Mallia, Maisons* II, p. 68.

with later repairs of the handles[257]. When only one handle is indicated by the rivet holes, the obvious implication is that there was only one man sawing at a time. In a few cases, however, holes pierced in both ends make it clear that the saw could be used by two men, one standing on either side of the log being cut[258].

7. Stone-cutting with Saws

Doubtless most of these large saws commonly cut wooden beams for timber framework, ceiling and roof structures. As Petrie describes them, such toothed saws were used for «scraping out a groove equally by pushing and pulling, like the tenon teeth of a modern cross-cut saw»[259]. To judge from saws discovered, large sizes were most common during the Neopalatial period, and with them were cut logs that reached a diameter of at least 0.60 m to 0.80 m[260].

It is not clear what types of stone were cut with saws and what kinds of saws were used in such cases. There is a good deal of unpublished evidence, for instance, that slabs of stone, especially hard stone, were cut with saws. However, contrary to what has been assumed in the past, there is no definite evidence to indicate that large, squared wall blocks were cut by this method; instead, they seem to have been chiseled smooth. After this chiseling process was completed, the final stage of smoothing was accomplished by grinding down the surfaces of the blocks, perhaps with another piece of stone. This is suggested by shallow, overlapping marks of abrasion on ashlar wall blocks (*fig.* 51).

It is probable then that the role saws played in the finishing of large blocks of soft limestone and sandstone has been overestimated in the past[261]. So far, many excavators have assumed that the large blocks of poros limestone or sandstone used for façades were cut by means of toothed or untoothed saws[262]. It is quite possible that saws could have done such work. If we assume that they did, then in the case of toothed saws one must also admit that the saw-teeth were worn down constantly and would have to be recut quite regularly by the bronze-smiths. However, the tool marks visible now on such blocks indicate that no mason's saws were used in the finishing process. If saws had been used on these blocks, then marks should have been parallel to each other, straight, and with definite ridges, especially on the very large blocks where a long saw (such as that being used for cutting gypsum slabs in *fig.* 58 a) would have been employed (as in *fig.* 57a).

At Phaistos, for instance, a block in a wall bordering the Central Court (*fig.* 62b), when struck obliquely by the sun, has a series of tool marks that is quite informative. Most of these marks arch out and down, like curving rays, from the upper left-hand corner of the block. The remainder of the marks, on the corners of the block (upper and lower left, upper right) go in different directions[263]. It seems to me that none of these marks could have been made by saws; the sides of the stone are relatively rough, the marks themselves are not straight.

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[257] The same is probably true of the saw shown here in *fig.* 41 from Zakro (Herakleion Museum no. 2600).

[258] As *Deshayes*, II, no. 2899. Four examples have been found at Zakro: Museum no. 2598 (1.04 m preserved), no. 2599 (1.39 m preserved), no. 2613 (1.55 m, total length), and no. 2674 (1.70 m, total length).

[259] *Petrie*, p. 43.

[260] Evans 1902-1903, p. 151.

[261] It can also be shown that saws were not used for quarrying these stones (see p. 35).

[262] As *Deshayes*, I, pp. 361-362 (gypsum and sandstone); *Knossos* II, p. 632 (implied when referring to toothed saws found at Knossos); Platon 1964c, Part II, p. 350, fig. 5 (toothed «mason's saws»); Orlandos 1958, pp. 59, 127 (gypsum, poros stone [limestone and sandstone]).

[263] These corners must have been cut separately, perhaps so that they wouldn't chip off, perhaps because «corner cutting» is easy, whether in stone- or woodworking.

Similar comments could be made about a pillar block from Knossos (*fig.* 62c). In the case of a wall block from Zakro (*fig.* 62d), the surface is not as smooth as one would expect if it had been cut by a saw and, moreover, the marks are at right angles to the stone's length. Surely, if a saw had been used, the block would have been cut in the simplest way, with the saw parallel to the length of the block, and the resulting marks in the block as we see it in situ would have been horizontal. A similar technique seems to have been used on the gypsum wall blocks in the basement of the South House at Knossos (*fig.* 105). I suggest, therefore, that all of these tool marks were made by another tool, probably a chisel of the types shown in *figs.* 46A or 46B[264]. The same chisel types cut the mortise hole and bedding for the beam on the top of the aforementioned block from Phaistos (*figs.* 62b, 221).

One would also suspect that if saws were used to cut wall blocks into which interior angles had to be carved, there would be indications of unintentional over-cutting in these angles, indicating where the saws had overshot their marks. All such interior angles that I have examined, however, are smooth and without a trace of saw-cutting.

From large, squared wall blocks of soft stone, we should now turn to consider whether other shapes or types of stone were cut by mason's saws. First, as far as gypsum slabs for revetment or flooring are concerned, it was generally assumed in the past that they were cut by means of bronze saws[265]. This is the method by which gypsum slabs used in restoration work at Knossos and Phaistos[266] were cut (*figs.* 58a, 58b), with the difference that the modern restorers used steel saws. During this work, water was used as a lubricant and cooling agent, which suggests by analogy that it was also used in ancient times. Nevertheless, as far as I know there is no published evidence in the form of actual saw-cuts, nor have I seen saw-cuts, on slabs on the sites themselves, to prove that this was the method used by the Minoans. Of course, one would not expect to find the tool-marks on the polished faces of the slabs, but rather on the backsides which did not show. Still, there seems to be no alternative to the saw to mass-produce such slabs in an economical way, especially when we consider that some were almost two meters square and only 5 cm to 15 cm thick. Moreover, as we will see, the Minoans did have a knowledge of stonecutting and did possess large, untoothed saws. We will have to make the assumption that these slabs were sawn in the accepted manner, therefore, and await confirmation from positive evidence found on the sites themselves.

The maximum size of the ancient mason's saws can be estimated as somewhat more than the width (the smallest measurement, aside from the thickness) of the largest slabs known. Slabs 1.80 m by 1.96 m[267] and 1.25 m by 2.10 m[268] are known. To judge from the measurements of the former, saws must occasionally have been more than two meters long, perhaps even 2.60 m, to allow the sawyers enough swing, or «throw», for their cutting motion.

For cutting and squaring smaller slabs of soft stone, such as those used in the walkways at Knossos, Malia (*figs.* 2-6) and elsewhere, it is also likely that saws were used. One might say the same about stylobate slabs used in many of the Minoan courts. While further substantiating evidence is desirable (and this should not rule out the possibility that chisels could have been used for the same job on the same or different sites), one positive example at Phaistos is nevertheless important. There a saw-cut (at arrow in *fig.* 56), 9.5 cm long and 6 mm wide at the top, is visible in a slab of the stylobate in Room 64. It is clear that the cut

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[264] Graham has also suggested that chisels made this type of mark (*P. of C.*, p. 154). See also the description here of chisels, p. 52. *Crafts* (p. 218, note 60) suggests, however, that the marks could have also been made by a point/punch rather than a chisel. Those in *figs.* 62f may have been made by a point/punch.

[265] See p. 46, n. 262.

[266] *Knossos* II, p. 632; *P. of C.*, p. 144, fig. 125.

[267] *Festòs* II, p. 418.

[268] In the Corridor behind the Queen's Hall at Knossos.

was made before either slab or column base was placed in position. For some unknown reason (I suspect that the slab was about to be cut in the normal way [shown in *fig.* 129]) the sawyers stopped short of cutting the entire slab[269].

Although slabs and blocks of soft stone by far outnumber those of harder stone, it is usually only on the latter that saw-cuts are most clearly visible (*figs.* 57a, 57g). This is partly due to the better preservation of harder stone, partly to the technique of cutting used. With this technique the saw, which has usually left straight and fine lines, was used to cut the sides of the slab down to a point, after which the remainder of the side would be broken off either by splitting it with a wedge from above or by means of a series of expert sharp blows struck from below with a hammer. Perhaps the cut was never completed because the lower part of the slab was often set below ground level and therefore not visible. On the other hand, the use of the saw on such attractive, hard (hence durable) slabs may originate in the quarrying process itself. Unlike softer stones such as poros limestone or sandstone, hard limestone cannot be worked easily with chisels or digging instruments of bronze such as picks. Instead, when struck with a tool it tends to fracture and split, often in unexpected directions. If, however, a mason saws a «guide line» at the point where he wants the finished slab to end, the break may very well be a clean one when the stone is struck, oftentimes repeatedly, with a hammer.

Another consideration is that such slabs were usually available only at some distance from the sites on which they were to be used. For instance, there is reason to believe that slabs at Kato Zakro were brought by ship from a substantial distance. It is reasonable to suppose, therefore, that large slabs might be given the finishing touches by the masons once they were removed from the hillsides and before they were placed on the boats. Thus their sides would be trimmed off in order to reduce the unusable stone mass, and at the same time this would increase the number of usable slabs that might be carried by ship at any one time. It would also increase, however, the risk of damage in transit.

Many thresholds, paving slabs, and stone bases of hard limestone of a gray or bluish color were squared in this manner. At Zakro good examples occur on the two pillar bases of the north entrance to the East Wing (*fig.* 57f) and on a threshold found in a house there. The threshold (detail in *fig.* 57a) dates at the latest to the LM IB period. The saw marks on it are almost exactly the same as those illustrated by Clarke on a piece of hard stone from Egypt[270]. Similar marks can be seen on the threshold of the entrance into the South Wing at Zakro[271]. The saw-cut on the Zakro pillar base in *fig.* 57f is 2 mm wide. Similar threshold slabs occur at Palaikastro, at the entrance to House N, and at an entrance to the second floor in House C at Tylissos (*fig.* 57b)[272]. In the latter site, the slab is 1.84 m long by 0.715 m wide, by about 0.30 m thick, the length of the slab in this case giving some indication of the minimum length of the saw used.

At Knossos we find saws being used at the beginning of the MM III period for cutting blocks of hard stone which were then carved and used as architectural friezes[273], as well as for preparing slabs of conglomerate and hard slabs of green schist, the latter found imbedded, probably reused, in the pavement of the West Entrance to the Palace of Knos-

[269] The part of the slab with the saw-cut has now split away from the main body of the slab due to weathering; there is no doubt, however, that they once were one.

[270] Clarke and Engelbach 1930, fig. 247.

[271] The threshold is 1.93 m by 0.68 m by about 0.15 m.

[272] The threshold lies on the top of the wall, at the entrance to a room of the upper floor, and above basement Room 11. This is not marked on the published plan.

[273] *Knossos* II, pp. 605-606; suppl. pl. XXII. Casson would attribute the finished cutting here to abrasion by emery flakes along ruled lines (Casson 1933, p. 29). I have not had the opportunity to inspect the cutting on these blocks.

sos (*fig.* 2)[274]. Saw marks can also be seen clearly on some pieces of speckled basalt (lapis Lacedaemonius) found in the area of the «Lapidary's Workshop» in the East Wing. In the illustration (*fig.* 57g), the cutting shown is 3.5 cm deep, 0.4 cm wide at its top, and about 0.2 cm wide at the bottom[275].

Other good examples of the cutting of hard stone occur at Hagia Triadha in the case of a small cruciform-shaped column base, facing onto the light-well of Room 2 (*fig.* 150), and also in the upper court there. Here the majority of paving slabs (*fig.* 57d) were cut along the sides in the manner already described for the threshold at Zakro. At Phaistos beautiful rectangular blocks (*fig.* 57h) of veined limestone were cut by saws as well, and were polished after having been cut.

At Chrysolakkos, the ossuary of the First Palace of Malia, certain blocks of the hard blue limestone krepidoma on the west and north sides of the ossuary were cut with a saw in a curious manner. The saw-cuts (*fig.* 60) appear a short distance from the ends of the blocks and are 1 mm to 2 mm wide, sometimes being so shallow that one is hard-put to explain their function, for they are so shallow, and the area between the saw-cut and the end of the block was clearly roughened by blows. One possibility is that we are dealing, in effect, with «drafted margins» cut into the ends of these Chrysolakkos blocks. Some of those blocks are now surely in reuse, lying on their sides but once set on edge, with the drafted margins restricted to the vertical, front ends of the blocks and not appearing either along their top or bottom edges. Perhaps the joints where the margins were cut were sealed with plaster, the effect being decorative as well as functional[276]. Also at Malia is an interesting example of a fragment of a slab of hard limestone, obviously left over from a sawing operation, in which the saw-cuts intersect (*fig.* 57e)[277].

A thin saw of bronze, with sand used as an abrasive and water or oil as lubricants, was probably used for cutting such hard stone. Emery, which was used in the process of cutting and polishing Minoan stone vases[278] and in the sawing of building blocks of hard limestone at the Palace of Tiryns[279], may have been used here as well. I do not believe that the saws used for this work had teeth[280], for the teeth would break off readily and, besides, the abra-

[274] *Knossos* II, pp. 671, 697, figs. 426-427.

[275] See also *Knossos* III, p. 268, fig. 181.

[276] See our *fig.* 60 (and, another example, Shaw 1973b pl. 97a, edge of block next to Block A). The use of formal drafted margins, in any case rare in Minoan architecture, has been explored most recently by Fiandra (1997) and Hood (2000). Fiandra identifies them on the Protopalatial orthostates of the Phaistos Palace (Fiandra 1997, *figs.* 8, 9, where the central, projecting surface of the block looks to me more unfinished than intentional [cf. Martin 1965, pl. xvii, 2, left]). Hood (2000) identifies one on a base block of hard limestone at Malia and on a rough poros block at Hagia Triadha re-used in the foundation of LM III Stoa EF (not Building ABCD, as in Hood 2000, *figs.* 1, 2). I am indebted to Pietro Militello for helping me locate the latter. For their more common use in Cyprus and further east in Syria, see Hult 1983 *passim* (for Crete, p. 48).

[277] Two blocks of similar stone, along the northeastern edge of the Central Court at Malia, were cut on their ends further down than the Chrysolakkos blocks, the remainder of the ends having been chipped off, probably with a hammer.

[278] Warren 1969, p. 160. For emery from Minoan Kommos, see Blitzer 1995, p. 447, Type 5, in *Kommos* I (1).

[279] *Petrie*, p. 45.

[280] There have been two main theories in the past about the typology of saws used for cutting stone. Orlandos thinks that all such saws were toothless and that the cutting was accomplished with the help of lubricant and abrasive (Orlandos 1955, p. 47), but he admits the discovery of a Minoan toothed saw which could also have been used for the cutting of stone (Orlandos 1955, II, p. 127). Deshayes suggests that sand and emery may have been used with either toothed or untoothed saws (*Deshayes*, I, p. 361), although it seems to me that water alone would be enough to ease the process of cutting soft poros limestone and sandstone. When discussing the cutting of hard stone at Mycenae, Wace was inclined to believe that the saws used were untoothed (A.J.B. Wace, *Mycenae*, Princeton 1949, pp. 52, 138).

sive used is the material which does the actual cutting in such operations. The clear saw-marks on a cracked threshold fragment from Zakro (*fig.* 57a) may indicate the addition at intervals of either lubricant or abrasive, or both. The straight lines of the saw-cuts, here and elsewhere, suggest that the cutting edge of the saw was straight, rather than curved as is the case with some of the larger wood saws[281].

Fortunately, a number of thin, toothless saws of bronze have been found in Crete, two at Hagia Triadha (one of these is illustrated in *fig.* 42) and two at the Palace of Kato Zakro (one is illustrated in *fig.* 43)[282]. Of the former, one has been published and well illustrated by Deshayes[283], while the other, curiously enough, is not listed by him at all[284].

To determine the thickness of the saws used to cut hard stone, one can measure the widths of the unfinished saw-cuts, which range from 1 mm to 2 mm at the bottom, becoming wider at the top. Obviously it is the former measurements which represent the maximum thickness of the saws used, for the upper part of the saw-cut, worn on its side by the action of the saw-blade and the abrasive sand or powder used, naturally widened out as work progressed, as can be seen clearly in a block of lapis Lacedaemonius from Knossos (*fig.* 57g).

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[281] Casson (1933, pp. 220-221) states: «It is important to make an attempt to ascertain the shape of the prehistoric saws, since the shape probably remained constant even into the Iron Age in classical times. Schliemann suggested that the saw 'had the form of a common knife which a single worker grasped by the handle'. It is certain that the modern stone-saw, that requires two men to work it, was not employed in prehistoric times, for almost all sawn surfaces are slightly curved, showing that they could not possibly have been done with the modern type of saw, which cuts dead straight. I am inclined to suggest that the saw there used was a gently curved or semi-lunar blade of metal fastened into a strong wooden back which could be held by one man with one or two hands».

A few comments and corrections should be made here. First, as far as Mycenaean saws are concerned, I think that Casson's suggestion about semi-lunar shaped saws is a good one, as long as he confines himself to sites in the Argolid. Indeed, in the Argolid where there was a tradition of using hard conglomerate for architecture, a special variety of tools may have developed, as explained in detail in Küpper 1996, pp. 14-25 and, in review, J. Wright 2006, pp. 33-34. But to the north, in Boeotia, there is a number of long saw-cuts in the thresholds of the Mycenaean site of Gla, and these saw-cuts could only have been made by straight saws. His statement, however, does not apply at all to Minoan remains, for the Minoan saw-cuts and the bottom edges of the saws preserved (*figs.* 42, 43 [partly preserved]) are straight. As to his statement about two-handled mason's saws, if we discount the known toothed saws with two handles from Crete, which could have cut stone, we must also consider the very length of some of the stones cut by untoothed saws in Crete. For instance, a threshold block from Tylissos (*fig.* 57b) is 1.84 m long, and would require a saw at least 2.50 m long to be cut as we see it now. Surely a saw of this size could not have been used by one man: I think, therefore, that we have to postulate two-handled saws without teeth, while the actual saws have yet to be discovered.

[282] *Crafts*, Type 5, pp. 33 (five catalogued examples) and 35.

[283] *Deshayes*, I, p. 360; II, no. 2904, pls. XLVIII, 8; LXII, 12; Herakleion Museum no. 1531; *Crafts* no. 49 (from a tomb). Length 0.515 m, 0.065 m wide, 0.007 m thick.

[284] Herakleion Museum no. 702; *Crafts* no. 46. Length preserved 0.50 m, 0.125 m wide, 0.001 m to 0.002 m thick. This saw, recorded in the catalogue of the museum in 1902, must be the toothless saw reported by F. Halbherr (in Halbherr 1902, p. 443, and in Halbherr 1903, col. 68). See now Wells 1974, p. 3, also the caption for fig. 3 on the same page. A toothed saw 1.44 m long was found at the same time with holes for handles at either end, a feature unique until the discovery of similar saws at the Palace of Kato Zakro. This toothed saw is probably Deshayes' no. 2899 (MM III-LM IA) and that illustrated by Orlandos (Orlandos, 1955, fig. 20 [length given as 1.44 m]) (*figs.* 44A, B). The two toothless saws from Zakro were found in the West Wing of the Palace in 1963. The maximum preserved length of the first is 0.57 m, and its width is 0.128 m, and its thickness 0.001 m to 0.003 m, with four worn holes which must have served for attachment of a handle on one end. The second, bent (*fig.* 43), is 0.875 m long, 0.12 m wide, and 0.001 m average thickness.

All of the four toothless saws mentioned fit into this width size category, while none of the toothed saws do, which helps to demonstrate that untoothed saws cut the harder stone types.

8. Drills

If we are to judge from the few drills preserved, the use of this tool in Minoan timber construction must have been limited. Chisels probably did most of the cutting for mortises. There are only 14 sure bronze drills for wood from Crete reported by Evely[285]. All of these are dated to the Late Minoan period. Two of the small drills, which indeed may have also served as chisels (*figs.* 36D, 36E) were found in the Palace of Kato Zakro[286]. Aside from a short, worn drill from Phaistos[287], the best three examples are from Gournia, 27.5 cm, 18.5 cm, and 7.5 cm long, respectively, of which the medium-sized one is illustrated here (*fig.* 46D). The two examples from Zakro are 11 cm and 23 cm long. Apparently the shaft of the drill was often square in section, and was worked by continual turning, with or without hafts, probably mostly to excavate holes for wooden dowels. At Palaikastro a drill was found[288] with a curious hollow shaft with a pointed tip. A number of pebbles with a hollow in one side, «against which the butt end of the drills may have been played» were found next to them[289].

Hollow circular drills were used for the penetration of hard stone, not simply for building blocks but also for relief work[290] and the hollowing out of stone vessels[291]. In the case of building blocks, drills excavated mortises for wooden dowels and perhaps occasionally for door pivots as well. There is a number of such mortises at Malia (*figs.* 59, 197A, B, 199). The diameter of the holes varies from 1.5 cm to 6.4 cm, their depth from 2 cm to 5 cm. The drill itself was probably not of bronze, but a section of reed or bamboo swiftly rotated by means of a cord, with a simple abrasive such as sand or emery and a lubricating agent such as water or oil used for the actual cutting of the stone[292]. In Crete, Warren has shown that emery, probably imported from Naxos or Samos, was used for similar drilling in stone vases[293].

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[285] *Crafts*, pp. 77-85, figs. 33-36, pl. 19.

[286] Platon 1964c, Part II, p. 350. They were found in the West Wing of the Palace, and are of LM IB date.

[287] *Deshayes*, II, no. 186.

[288] *Crafts*, p. 78, no. 1.

[289] Dawkins 1923, p. 119, pl. 25q. For similar stones from Kommos see Blitzer 1995, Type 6, pp. 448-451 in *Kommos* I (1).

[290] An excellent description of the use of the tubular drill in Greece during the Bronze Age (it was not used during the later, Classical period) is to be found in S. Casson's analysis in *The Technique of Early Greek Sculpture*, Oxford, 1933, p. 24, 34, 209-215. Here he is concerned with its use in Minoan and Mycenaean sculpture, especially in the friezes of hard stone and the carving of the Lion Gate at Mycenae. For tubular drill bits see Beven 2007, pp. 50-51 and *Crafts*, p. 84.

[291] For their use in making stone vessels, see Warren 1969, p. 160.

[292] See Orlandos 1955, p. 129; *Mallia, Nécropoles*, II, p. 27; *Deshayes*, I, pp. 395-396. For comparable practice in Egypt, see *Petrie*, pp. 44-45; R.J. Forbes, *Studies in Ancient Technology*, VII, p. 173; Rosenfeld 1965, pp. 164-165. Casson (Casson 1933, pp. 212, 214) believes that the drill was of metal, rather than reed. Indeed, metal would probably be superior, for the small bits of emery used would gradually become imbedded in the drill edge and make it a very effective cutting instrument. The uniformity of the diameter of the drill holes at Mycenae makes this quite likely. In Minoan architecture, judging from the range of hole sizes in the orthostates at Chrysolakkos, reeds may have been used. These reeds could have been disposed of as they were worn down, which accounts for the variety in the diameters of the holes. However, Warren thinks that large metal drills, 10-15 cm in diameter, may have been used in the manufacture of Minoan stone vases (Warren 1969, p. 161), and so perhaps both techniques were in use at the time. For a detailed discussion of the possible processes involved in making a unique, large stone vase found at Akrotiri on Thera, see Warren 1978.

[293] Warren is the first to show conclusively that emery was used by the Minoans in the drilling process (Warren 1969 pp. 160, 162, 190). See also Casson 1933, pp. 195-197, 235-236 and *passim*.

9. Chisels

Many bronze chisels have been found on Minoan sites throughout Crete, surely an indication of their usefulness. There are a number of types[294], the most characteristic being flat in section, with the cutting blade being considerably wider than the butt-end, which sometimes shows signs of having been battered by a hammer (*figs.* 45A, B). Of these typically and uniquely Minoan chisels, the earliest known is of EM date, from Pyrgos, while many of the examples of a more developed form[295] are restricted to the Late Minoan period. Although many (as *figs.* 45A, B) were probably not set into wooden handles, being hit directly by hammers or mallets, others which show no traces of hammering (as *fig.* 45C) may have been set into a handle or simply worked by hand. Variations of the same type are known.

The chisels just described may have been used chiefly on wood, for mortising, smoothing and joining[296]. The broad blade of the most common type must have made it particularly useful for planing down rough surfaces, the butt perhaps being hit by mallets of which there is now unfortunately no trace (such blades could have been sharpened by whetstones such as those in *fig.* 48). There is no reason, however, why the same chisel might not have been used on soft stone as well, for the tool marks one can see on certain blocks (*figs.* 63a, 63c) are often 1 cm to 3 cm wide, which indicates the use of a broad cutting blade such as that of a chisel or of a double-adze. Such marks are especially evident at Phaistos, in the area of the Western Magazines of the Second Palace, on the wall blocks (*figs.* 63b, 63c)[297], as well as the krepidoma course (*fig.* 63a)[298]. Chisels or points[299] probably also left the tool marks visible on orthostate blocks of both the southern and the northern section of the First Palace of Phaistos (*figs.* 62e, 86, 88)[300]. These marks form horizontal ridges when the direction of cutting changes. This distinct technique also appears on a reused block built into an early wall to the south (*fig.* 62f). Two large but stray examples with similar ridges were found at Kommos[301]. Such marks may simply be the result of an early method used to create a relatively even surface on the blocks, and were perhaps produced by working in stages. On the other hand, in the case of the orthostate blocks, the pattern formed by the marks, which in some cases continues in a line from one block to another, probably had a decorative function as well. Pernier believed that the tool marks were left by double-axes or saws[302], but this seems quite unlikely[303].

Three of the sturdiest chisels found on Crete can be seen in *fig.* 46 (A, B, C). At some points they are square in section. The first two resemble modern «cold chisels» used today for metal work. It is possible that chisels such as these cut the teeth for

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[294] *Crafts* (pp. 2-19, figs. 1-7, pls. 1-7) carefully describes some six types with subtypes, almost as many (177 plus) as double-axes (over 200, in *Crafts*, p. 49).

[295] *Crafts* Types 3a iii and 3b. All of the chisels in *figs.* 45 and 46 are probably of Neopalatial date.

[296] *Crafts*, p. 14 notes that associating Type 3 chisel with woodworking gains some support from a Type 3 chisel being found in the Northwest House at Knossos along with three double-axes, five double-adzes, and a whetstone.

[297] Compare the strokes of the mason visible in *fig.* 63b with the drawing illustrating the 'mason's stroke' in Casson 1933, p. 238.

[298] Cf. *P. of C.*, p. 154, fig. 120.

[299] For this category, difficult to define chronologically, see *Crafts*, pp. 86-96.

[300] For a variety of chisel marks on gypsum blocks see Chlouveraki 2006, figs. 4.13-4.40.

[301] *Kommos* V, p. 89, nos. 17 and 18 and pl. 1.135 and 1.139b.

[302] *Festòs* I, p. 184, fig. 77.

[303] A «hands-on» comparison between Minoan tool marks and those made by similar tools on similar stone would be both welcome and useful.

saws[304]. These chisels could also have been used to cut wood or soft stone – for instance, for cutting mortise holes. The third chisel (*fig.* 46C) may have accomplished similar tasks; to judge from the shape of its sharply tapered butt-end, it was probably set into a wooden handle that was struck by a heavy wooden mallet, a bronze hammer, or a hand stone.

10. Rasps

Rasps for careful finishing of framing or furniture wood were also used. That in *fig.* 47, recently discovered in an LM I context at Mochlos, may be unique at this point in the Minoan archaeological record. Its rounded working end (the other end is broken off) has projecting teeth; two sides of its shaft are quite rough, as if intended for use as a wood file[305].

To summarize, most of the tools discussed here were used for cutting wood. Double-axes, various types of adzes, saws, drills, chisels, points, stone cobbles, and an occasional rasp must have been the basic tools of the carpenter, whether he worked independently or in association with the masons building or repairing palaces and other major buildings. With these tools he cut down, butchered and debarked trees, then split and sawed them into usable sections, then joined and finished the beams and boards produced. To join the wood, he must have employed a variety of techniques, such as mortise-and-tenon joints, doweling, and perhaps even binding, although we have no direct evidence to infer such devices. Nails were used at a minimum, although a few Minoan nails and molds for them have been reported from some sites[306]. As we have seen many of the tools used for cutting stone have left their respective marks (*figs.* 50-63c).

There are, however, a number of lacunae in our archaeological record because certain tools, such as the wooden mallet, cannot have survived. Other items such as strings used for laying out wall lines, plumb bobs to assure verticality[307], ropes for hauling the logs and setting logs and blocks in place, and wooden wedges are also unknown. Devices for linear measurement[308],

[304] In this respect the teeth of the saw from Zakro in *fig.* 41 are interesting. Those toward the ends of the saw are regular, like the teeth in the saw from Hagia Triadha (*fig.* 44), having been formed by chisel blows made from above when the blade was laid flat. Toward the saw's center, on the other hand, the teeth are very coarse and wider than the blade itself, and must have been formed when the saw-blade was set on edge and struck from above by a chisel. It seems likely that the coarser teeth were made when the original, fine teeth had been worn down through use, perhaps having cut poros limestone blocks used in building. This theory of the repair of the saw is supported by the number of holes made for attachment of the handle: there are six holes on one end, whereas two or three are normal.

[305] Cf. Soles and Davaras 1996 pp. 195-196, from House C3.

[306] See *Gournia*, p. 32, pl. III, nos. 54, 62, 67 B; pl. IV, nos. 25-26; *Festòs* II, p. 373, fig. 239, also our Appendix A. A number of small nails (MM III-LM IIIB) were found at Kommos (*Kommos* I [1], p. 513, and *Kommos* V, pp. 53, 69, 80, 719-720). Unusually large nails as long as 15 cms have been reported from LM II contexts in the Unexplored Mansion at Knossos (see Catling in *UM*, p. 205, pl. 196, h, i, j); those could have performed an architectural function. Evely (*Crafts*, p. 534), comments about Minoan nails, «Even after their introduction, metal nails are never that common – much must have continued as before».

[307] van Effenterre (1980, Vol. I, p. 108-109, pl. 149, 151) made some provisional identifications. One, perhaps of a plumb bob (HM 22.162, 4.1 cm high) is tear-shaped, of terracotta. It is pierced toward the top, and has a partial piercing in its bottom. The other candidate (van Effenterre 1980, pl. 149) is a small thin, tapering piece of conglomerate broken off toward the top where it was pierced for suspension. Usually, however, similarly shaped items of hard stone have been classed as whetstones, as suggested in *Kommos I*, pp. 442, 444, no. GS 252 in pls. 8.17 and 8.91.

[308] As far as Minoan units of measurement are concerned, we have no direct, irrefutable evidence. No instruments (such as our rulers or yard sticks) or standards have apparently survived. Instead, we have to

wooden or metal angles, or levels[309] have been recognized so far. To fill the mason's toolbox we have a variety of tools, many identical with those used by the carpenter. He also had saws, picks, perhaps worn double-axes or double-adzes, chisels, and whetstones. In some cases he must have had heavy hammers of bronze such as those discovered at Hagia Triadha.

Tools which he also must have used, but which have not survived, include bamboo bow-drills along with abrasives, and a cup or jug of water or oil to serve as a lubricant. We are missing as well his wooden angles and mallets, ropes and strings (like those known to have been used for fresco work) for lifting blocks and laying out lines, wedges, plumb bobs and rollers, as well as pry bars. No doubt both mason and carpenter also had simple abrasive stones for smoothing wood and stone surfaces.

D) Masonry (*figs.* 64-128)

1. Foundations

Foundations[310] were usually built of coarse rubble. Occasionally roughly coursed blocks, in some cases reused from earlier structures on the same site, were used in massive footings of important walls. As early as the EM II period at Vasiliki, we see how the Minoans were careful to provide buildings constructed on a slope with a stepped krepidoma or plinth (*fig.* 65). The most impressive krepidomas and foundations, however, exist in the Palace of Knossos and to some extent in that of Phaistos as well. At the former site, for instance, the thick walls of the mysterious structure, called the «Keep», in the North Wing of the Palace,

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base conclusions on other material remains discovered by archaeologists. A first step is the examination of the dimensions of the buildings (the wings, courts, rooms, etc.) where general dimensions would be most readily recovered. Naturally, there are inherent problems (e. g. at which side of a wall to begin measuring) and pitfalls (oversimplification or, its opposite, the deducing of complex architectural relationships that may not have been in the minds of the architects), but this is part of any study of a people for whom a strong literary tradition does not exist. D. Preziosi and J.W. Graham examined the problem from various points of view and have come to quite different conclusions. The first decided that the Minoans used any one of four hypothetical modular units in their planning and that, if the particular module used for any one building can be established, then a complex grid which must originally have formed the basis of the architect's plan can, in some cases, be superposed on the archaeologist's state plan (Preziosi 1967, p. 193; 1968, p. 171; also 1970). The other, J.W. Graham, maintained that the Minoans used one unit of measurement (or «foot»), equivalent to 30.36 m, and he proceeded to show how this foot, originally deduced from sections of the Palace of Phaistos, was used by builders at other Minoan sites as well (*P. of C.*, pp. 222-229; 1960a, pp. 335-341).

I am of the opinion that Graham's approach is the more reasonable one and that his conclusion is therefore more likely to be correct. For one thing, it has the virtue of simplicity and can apply to a variety of buildings with a traditionally Minoan form. One factor strongly in the favor of Graham's proposal is that his published theory, made clear before the Palace of Kato Zakro was discovered, seems to apply to that Palace as well (Graham 1967; *P. of C.*, pp. xi-xii). Additional proposals concerning Minoan units of measurement have been made by Cherry (1983) and, in connection with Kommos, by Bianco 2003. Also, Schmid (1984) proposed the use of a harmonious module is Malia's Quartier Mu. See also Shaw *forthcoming b*.

[309] The Minoans demonstrate expertise in leveling. Driessen notes for Palaikastro, for instance, that the *sideropetra* krepidoma of Building 1 there is so level that the builders must have used special devices (personal communication). At huge Building T at Kommos, the gradually sloping krepidoma level of the north ashlar façade wall, over sixty meters long, was calculated carefully so as to match the grade of the bordering road, which carried run-off rainwater to the sea. The krepidoma level, moreover, matches the slope of the same building some fifty meters to the south (*Kommos* V, p. 21 and note 75).

[310] See also *P. of C.*, pp. 149-150. For aspects of terminology, see Zois 1990.

go down some seven meters into the deep fill upon which the Palace was constructed[311]. These deep walls, dated by Evans to the earliest phases of the Palace, are somewhat later than the finely laid foundations of limestone blocks along the northwestern borders of the Palace (*fig.* 71)[312]. The foundations for the columns of the Stepped Portico to the south of the Palace (*fig.* 156)[313] are no less impressive. Here stacks of huge limestone slabs stood some four meters high below ancient ground level, with the bottom slab of each set within a special cutting in the bedrock.

Especially conscious of the natural landscape they lived within, the Minoans became adept in creating terraced areas for the setting in of descending levels of interconnected architectural spaces[314]. A particularly fine example of adaptation of building to terrain is provided by the southern wall of House C at Tylissos, which was built on a well-constructed krepidoma that reached down to bedrock (*fig.* 115)[315]. Apparently, preparatory to building, the Minoans had leveled the bedrock and created a series of terraces serving as platforms for the houses. They also made special provision for pillar foundations, as can be seen in a sounding made in a court of House A[316].

At Phaistos, where the Palace was built on a rocky slope that descended precipitously from the northeast to the southwest, the builders of the Second Palace created a giant platform to the southwest. It consisted of thick walls, somewhat thicker than the walls set upon them, of rough blocks that went down 2.00 m to 3.40 m in specially dug trenches (*fig.* 111)[317]. They also made sure that there were stable bases for many of the inner rooms in this area, with the walls descending as far as 2.70 m below floor level[318]. Column bases[319] and stylobates (*fig.* 153)[320] also received wide and deep foundations of large stones. This method of construction, which characterizes both foundations and upper walls of the Late Palace of Phaistos, formed such a contrast with the mud, rubble, and wood make-up of the walls of the First Palace of Phaistos that Pernier believed it to be a basic contrast in the building techniques used for First and Second Palace structures[321].

A similar concern for stability is shown at Hagia Triadha (*fig.* 112), where a heavy wall that bordered the main building area to the north was carried down at least two meters. The wall consisted of six courses of limestone blocks of which the interstices were carefully chinked with small stones and then plastered over. On the other hand, there is surprisingly ample evidence that in some cases very little effort was made to build deep and strong foun-

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[311] *Knossos* I, p. 136, figs. 100, 101. The possibility remains that the walls were the sides of a reservoir (Lawrence 1957, p. 298, n. 2; Dunbabin 1942, pp. 84-85). Branigan has suggested that the «Keep» served as a granary (Branigan 1992, p. 163).

[312] *Knossos* I, p. 149, fig. 109. Work at the Northwest Terrace by Hood dated the wall in our *fig.* 71 to EM III (Catling 1974, p. 34), which would make it an earliest example of shaped blocks, but not yet ashlar, in Minoan architecture. MacGillivray cites MM IA and IB as possibilities suggested by others (MacGillivray 1994, pp. 49-51). The wall retains an early building platform that can be compared with another at Kommos upon which Protopalatial Building AA was set (*Kommos* V, pp. 1-17 and 846-847).

[313] *Knossos* II, pp. 144-145, figs. 74, 75.

[314] For building plans related to terrain, see especially Fotou 1990; Mantzourani, Vavouranakis, and Kanellopoulos 2005. For building on the slopes at Pseira, see McEnroe 2001, pp. 35-36.

[315] *Tylissos* (2), p. 48.

[316] *Tylissos* (2), pl. III, 2.

[317] *Festòs* II, p. 427, fig. 271. See also *Guida*, fig. 54. To some extent these walls must have been constructed on sloping ground, and were built in order to create a level platform for the southwestern wing of the Second Palace at Phaistos.

[318] *Festòs* II, p. 427.

[319] See also *Festòs* II, p. 288, fig. 181; Levi 1957-1958, p. 324, fig. 168.

[320] Levi 1957-1958, figs. 177 (p. 329), 184 (p. 334), 185 (p. 335).

[321] *Festòs* II, p. 433.

dations for very important structures. Sometimes this was due simply to the convenient level of the bedrock as, for instance, in the wall of the veranda (Room xxxiv) at the Palace of Kato Zakro (*fig.* 140), set on bedrock which at this point almost coincides with the original level of the Central Court. The wall bordering the north side of the Central Court at Phaistos was also set on bedrock[322].

It would seem that at Malia, both at Chrysolakkos and along the West Façade of the Palace, no attempt seems to have been made to extend the walls down to bedrock which, in the case of the latter, was only some 0.60 m below ground level[323]. Occasionally, however, walls of earlier structures at Malia were used as the bases for later walls[324]. At Phaistos, in contrast to later structures mentioned above, the walls of the First Palace were simply set on a base of slabs and rubble, in Room x for instance for a maximum of 0.40 m to 1.20 m[325].

2. Rubble Walls

Minoan rubble walls are composed of rough, uncut stones, normally bonded together with earth, mud, or clay, and sometimes reinforced with timber. Sometimes they include shaped stones from earlier structures. Many such walls were plastered over with mud and/or lime plaster on one or both sides and, in fancier establishments, were sometimes shielded at the bottom by a dado of gypsum slabs. These last are two typical Minoan methods of concealing mediocre wall construction. During all Minoan periods rubble is the typical material for foundation, basement, and interior walls. Sometimes, as at Phaistos, rubble was probably used, instead of the usual mud brick, in the walls of the upper stories.

Such simple construction naturally does not lend itself easily to a typological study[326]. However, I have arranged such walls in rough categories based on the size and arrangement of stones, that is, according to their present rather than final appearance since, once plastered, many of them could not have differed greatly from one another.

One of the most common techniques used to lay a rubble wall was simply to gather up fieldstones from nearby and pack them, one on top of the other, with mud mortar filling the interstices. In the EM II house at Vasiliki (*figs.* 64-66) mud and stone walls, approximately 0.65 m thick, were reinforced by numerous small, round timbers that ran horizontally along the face of the wall and sometimes transversely through the wall at various heights[327]. A very thick layer of mud plaster, overlaid by fine lime plaster painted a dark red, helped consolidate the wall and protect it from moisture. A somewhat similar technique was used at Gournia as, for instance, in House Ac of MM III date (*fig.* 67)[328]. Here one can see that as stones were being set, each stone was pushed down into the mud that had covered the stone below it.

The same technique can be seen in walls at Malia. An interesting technique of construction is that of the thick walls of Area I, 1, 2, 3, of the Palace of Malia, which I have not noticed being used anywhere else (*figs.* 68, 69)[329]. Here the wall, about 0.70 m thick, was

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[322] *Festòs* II, p. 427.

[323] Charbonneaux 1928, pp. 348-349, fig. 1.

[324] Charbonneaux 1928, p. 350.

[325] *Festòs* I, p. 446; II, p. 425. The West Façade at Knossos, which helped support a structure at least two stories high, provides another example of shallow wall footings.

[326] For the regional variations in plans and materials, especially in house architecture, see McEnroe 1990.

[327] Seager 1904-1905, p. 209.

[328] See also *Gournia*, p. 22, Plan fig. 8.

[329] Charbonneaux believed that some of these walls belong to the First Palace at Malia (Charbonneaux 1928, p. 357). Daux calls some of them «prépalatiale» (Daux 1966, p. 1011; see also pp. 1008-1011, and fig. 2). Pelon considers them to be of EM II date (Pelon, Anderson and Olivier p. 41), incorporated later into the Palace construction.

built up in stages: first fairly large stones were laid in mud and carried up to the height of 0.90 m, without using an exterior form such as those usually used in pisé architecture[330]. Next, the top of this section was leveled off with more mud, mixed with small stones and pebbles, and an extra-thick layer of mud was added onto that. The wall section was allowed to dry before further building, as is shown by the failure of the mud at the bottom of the next wall layer to coalesce with it (no. 2 in *fig.* 69). At least three such superposed layers were constructed in this way; how much further it was carried up, and whether mud brick construction replaced rubble on a second story level, is unknown[331].

Walls in which some effort was made to lay the stones in rough courses, separated by mud and mortar, can be seen elsewhere, and seem to be confined to the Middle Minoan period, although this may be merely a coincidence. For instance, in the MM IA Pillar Basement at the southeast corner of the Palace of Knossos (*fig.* 70), roughly oblong blocks of poros limestone were laid down on thin layers of mud[332]. An even more regular arrangement of small, roughly-cut stones laid in thin, brick-like, almost isodomic, courses, can be seen in the EM III foundations at the north side of the Palace of Knossos (*fig.* 71)[333]. A similar coursing, but with smaller, more rounded stones, was used in the walls of rooms of the MM IB Palace of Phaistos (*fig.* 72). One can see in *fig.* 73 what is in effect a cross-section of a wall over two meters thick at Phaistos, made fortuitously when an early trial trench was dug by Pernier[334]. Most of the base of this wall is composed of large boulders upon which the remainder of the wall was built. The outside face of this wall, if I am right, was once part of the exterior façade of the First Palace, being formed of a single line of orthostates surmounted by compactly packed rubble.

A variation of this method of coursing can be observed in the walls of the Middle Minoan ossuary excavated on the hill of Phourni near Archanes (*fig.* 74). Here the walls are composed of large, roughly shaped blocks of soft poros limestone, obtained from the same hillside into which the ossuary was built. The interstices between stones are packed with mud and small chips of stone, the latter readily available since the stones were dressed on the same spot. The visual effect is rather pleasing and may well have been intentionally so.

Roughly coursed walls, often composed of large boulders of hard gray or bluish limestone, sometimes partially hammer-dressed, have been described as «megalithic» or «Cyclopean», although the latter term is more appropriately applied to the distinct masonry of fortified Mycenaean citadels. On the other hand, at Petras in eastern Crete, an apparent Minoan fortification wall flanking the eastern side of the site might well fit into a landscape somewhere in the Argolid[335]. Huge stones are also employed in ordinary Minoan building, although on a less grandiose scale. Sometimes, for example, large stones are used for building the exterior walls of palaces and houses. At the Palace of Kato Zakro large boulders of hard limestone make up the southern and western façades of the Palace (*fig.* 75). Here first

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[330] This type of construction is occasionally referred to as «pisé architecture». I avoid the term here, however, since it usually implies the use of a wooden form into which the mud and rubble are set, the form being removed when the wall has dried. There is no indication that this technique was used at Malia.

[331] A similar technique of layering material, then allowing it to dry, then re-layering and finally, plastering, referred to as «cob wall» method (an English cottage architectural term), has been identified in two walls of Building 5 at Palaikastro (personal correspondence from Jan Driessen, 11/12/06). van Effenterre recognized a similar technique at the Malia Palace (1980, pp. 117-119).

[332] See also *Knossos* I, fig. 106.

[333] *Knossos* I, fig. 109, pp. 148-149.

[334] The area above the southern section of the First Palace later became Pernier's excavation dump.

[335] Tsipopoulou 1999b, pp. 183-185, pl. xxviii b, xxxiii-xxxiv.

a krepidoma was built, then the wall itself, set back about 0.20 m. Some of the edges of the blocks are roughly hammer-dressed, as are those in *fig.* 75, the western wall of Room xii[336]. As usual, the exterior joints, at least along the lower courses where moisture would first penetrate, were plastered. On the interior, mud and rubble were built up against the back of the blocks and then plastered over, giving a total wall width of about 0.70 m. In such cases, mud was used only as a filler and not as a mortar, for the blocks rest directly on top of one another. A similar method of building can be seen in the exterior wall of House B at Zakro, which borders a stepped descending pathway that leads south to the Palace. Here, however, a greater attempt was made to select roughly rectangular blocks and to lay them in courses.

Similar megalithic walls of LM I date appear also at Gournia[337]. A fine example of a corner flanking a doorway opening into Room v, 1 at Malia (*fig.* 76) is of uncertain date[338]. The joints of this wall are filled with clay and small stone chips, while the coarse back face was filled out with rubble and then plastered over. Elsewhere at Malia, especially along the outside borders of the South and East Wings, equally large blocks form the krepidoma or first course of the walls. At Knossos, Phaistos, and Hagia Triadha, megalithic walls of this type are minimal, probably simply because locally quarried, soft poros limestone was so easy to build with and so readily available.

Other walls are simply composed of slabs of limestone or schist, which were laid one above the other in an overlapping fashion. Such stones could be removed from local outcroppings that were stratified in such a way that it was easy to break off and pry loose slabs along the natural lines of cleavage. Walls of this type can be seen at Palaikastro, Myrtos-Phournou Korifi (*fig.* 77), but especially in the LM I town of Pseira (*figs.* 78-80). Here most lower walls, stairways, and buttresses were made up essentially of slabs. Important wall corners and a retaining wall on the east (*fig.* 80) were reinforced by means of larger blocks, roughly shaped. Very little earth, and probably no mud, was used in this «dry-walling». Unlike the thick slabs in early walls in Room lxiv of the First Palace of Phaistos (*fig.* 81), those at Pseira are not of uniform size. The former, however, are quite uniform and were laid like bricks, one above another, with a very thin layer of mud mortar in between.

Finally, I should mention the walls which, although made up partially of rubble and mud, contain a large proportion of reused blocks of poros-limestone or sandstone (*figs.* 82, 102). Such walls usually occur at large palace sites which have gone through a series of rebuildings, and where material from earlier structures was utilized in foundation or interior wall construction. A fine example of a wall making use of reused material can be seen in the north wall of the Lobby of the Stone Seat, in the West Wing of the Palace of Knossos, where the wall is made up of fragments of re-used gypsum slabs from burnt pavements or dadoes (*fig.* 83)[339]. Concerning these and other walls described here, there is little indication that Minoans used the type of wooden scaffolding that is anchored temporarily into the wall being built alongside it. One of the few convincing examples is in Neopalatial Building T at Kommos, where there are shallow gaps in the wall structure every so often, about a meter above floor level (*fig.* 84)[340].

[336] The topmost block in *fig.* 75 was found fallen in front of the façade, and was replaced by the excavators.

[337] *Gournia*, p. 21.

[338] Charbonneaux 1928, p. 349, n. 2; pp. 350-351.

[339] Panagiotaki 1999, p. 248; Macdonald 2002, p. 41.

[340] For the possible use of scaffolding in LM III Building P at Kommos, see also *Kommos* V, pp. 78-80.

3. Ashlar Walls

Orthostates

In terms of Minoan architecture, orthostates are large cut blocks with a smooth, rectangular exterior face and often an irregular back face, usually set upright on one of their longer sides upon a low, projecting krepidoma or plinth. Orthostates were introduced in the First Palace period, to which most of the known examples probably belong. They appear to have been used exclusively for important façades. The orthostate course with its krepidoma may have been devised as a time-consuming but practical (and attractive) substitute for a weak rubble socle of fieldstones. Naturally this new, expensive method of building could only be adopted in important structures. In Classical Greek architecture orthostates were retained for their aesthetic appeal[341], even after mud brick and rubble were replaced by cut blocks. Only recently, with the recognition of Neopalatial Minoan examples, has it been discovered that the same seems to have happened earlier in Crete[342].

The best known examples of orthostates are those of the magnificent West Façades of the Palaces of Phaistos and Knossos. The first belongs to the Protopalatial Palace. The Italian excavators believe that portions of this façade were constructed during two different periods. That to the south (*figs.* 85-87), excavated by Doro Levi, is dated to the MM IB period, and that to the north (*figs.* 88-91), excavated by Pernier, to the MM IIA period[343]. Both sections of each of these façades are aligned, although they are on different levels of a hillside which descends to the magnificent Mesara Plain far below. Both wall blocks and krepidomas are composed of locally quarried poros limestone. The orthostates line only the exterior faces of the thick walls, the backs of which are made up of rubble which has been plastered over.

This early orthostate façade constitutes one of the best preserved examples of monumental stone architecture. Its two sections differ basically in two ways. The proportions of the blocks differ in each, the average height of the blocks in the northern section being 1.00 m, while those in the southern section are 0.65 m. Furthermore, those to the north are generally longer and thicker. The other basic contrast is that, as seen in plan, the northern section consists of a monumental façade with setbacks at intervals[344] and with the opening for an entranceway at its southern limit marked by a monumental propylon. The two openings through the façade further north (opening into Rooms viii and x on the plan), were probably not originally part of the design[345].

The southern section of the façade, however, which appears most clearly in its original form when one «thinks away» later structures built over its northern part, is basically of the pylon type. That is, it consists of two massive, projecting wings on either side of a monumental entranceway. Exactly where this entranceway would have led at its furthest extent is unknown, for excavation east of Room lxiv has been blocked by massive construction belonging to the later Palace. It is not impossible, however, that the corridor actually served at one time as the major lower (or southwestern) entrance to the Palace.

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[341] Lawrence 1957, p. 100.

[342] The West Façade at Knossos, discussed below, may be a late example. The orthostate façades at Galatas and Kommos are definitely Neopalatial.

[343] Levi 1964, p. 14; Fiandra 1961-1962, p. 125. For an extended description of the southern area, see *Festòs* 1976-1988, II (Part 1), pp. 29-349.

[344] For a discussion of these setbacks, see Graham 1960b, pp. 329-333; also *P. of C.*, pp. 162-179.

[345] As *Festòs* I, p. 195; II, p. 572, figs. 305, 306. Most likely they were formed at the time of the addition of the temporary «shrines» (Rooms v, vi, vii) on the outside of the façade by the removal of two blocks and the rubble backing of the wall behind them. This is suggested by the lack of uniformity in the size of the passages as well as by the absence of reveals for doorjambs on the blocks flanking the passages.

As far as technique of stonecutting is concerned, the northern and southern sections are quite similar[346]. The treatment of the outer surfaces of the blocks, for instance, is the same, for on many of them one can see in both sections the same distinct zones of horizontal and vertical tool marks, about 9 cm apart (*figs.* 62e, 86, 88). The blocks were also set next to one another in similar ways. Thus, where the wall projected slightly, one of the rear corners of the projecting block would be cut away and the block adjacent to it would fill that space (*figs.* 87 at B, C, E); 90, at 1; 91 (IA and IB). All of the vertical joints, as well as the horizontal joint along the top of the krepidoma were sealed with lime plaster. Also, the ends of most of the blocks seem to have been cut almost at right angles with their faces, unlike the wedge-shaped blocks of the later façade, so that in some instances they join practically all the way to the back.

Another similarity in the construction of the two walls is the presence of numerous square cuttings on their upper surfaces, no doubt mortises intended to receive wooden dowels that retained horizontal and perhaps vertical timbers. It was believed, however, that the dowels might have been used to support a series of slabs set on edge along the top of the wall[347]. The same opinion was expressed by architect Fiandra when she discussed the original use of various slabs of limestone which are now built into the northern and southern walls of Room lxiv (*fig.* 81)[348]. There is, however, hardly any evidence to support such a theory. First, there are no corresponding mortises cut in the slabs themselves. Secondly, no slabs were found in situ on top of the orthostate blocks or else fallen in front or in back of the façade[349]. Moreover, there seem to be no instances of joining of superposed blocks by means of wooden dowels in Minoan architecture, and the presence of mortises for dowels normally suggests the attachment of a wooden beam above, such as that which I have restored in the section, in *figs.* 87 and 90. The purpose of this beam could have been two-fold: 1) primarily, to serve as a footing for vertical beams mortised into it[350], and 2) to help bind together the separate blocks of

[346] Fiandra, however, considers the technique to be different (Fiandra 1961-1962, p. 116). See also Fiandra 1997, pp. 52-56.

[347] Levi 1957-1958, p. 218; also 1964, p. 51.

[348] Fiandra 1961-1962, p. 119, Pl. AA', 3. In a later publication (Fiandra 1997, p. 56), the same author mentions the dowel holes as «square holes ... which serve to connect the blocks vertically to the overlying part of the wall», but does not specify further.

[349] An arrangement somewhat similar to that first proposed by Levi and Fiandra was suggested by R. Naumann for certain orthostate courses in Asia Minor. He restores upright boards on top of both edges of the orthostate blocks, with horizontal beams supporting the boards from the interior. These horizontal beams are fastened to the tops of the blocks by means of dowels (Naumann 1955, pp. 107-110, figs. 94-98). Once more, however, there is no direct evidence for boards, or slabs for that matter, set on edge. Naumann puts the boards there in the first place because the distance from the edge of the blocks to the dowel holes is about 19 to 24 cm, a distance too great to be covered by a single timber, considering the fact that timber used elsewhere in the area is usually smaller. In the case of the façade at Phaistos, the dowel mortises are set back 7 to 20 cm from the edge of the orthostates, thus requiring timbers 15 to 30 cm in width. First, there is no question that the Minoans had timbers of this size and larger. That such timbers were sometimes laid horizontally can be clearly demonstrated by the beddings, 25 to 35 cm wide, along the edge of window sills (as *figs.* 212 a, 220). There is no question that the timber in such cases took up all or almost all of the width of the bedding, and that slabs or boards set on edge were not used, for no one would design a window the front of which would be partially blocked. The closest that one can come to relating slabs set on edge to orthostates in Minoan architecture is probably the slabs, now no longer visible on the site, which were used to face the high krepidoma at Chrysolakkos (*Mallia, Nécropoles*, I, pl. xxxix, 1). It seems clear, therefore, that the slabs at Phaistos, certainly reused in their present position in Room lxiv, must have come from elsewhere in the First Palace.

[350] There is no trace, however, of such timbers; but if there was no wooden frame set vertically on the orthostates, then one must re-examine the purpose of the horizontal beams which certainly were there. Were they only to bind together the wall blocks? If so, the masons «over-designed», for when the timbers were no longer there the walls remained quite intact rather than splay-

the orthostate wall. In contrast to Levi's later opinion, Pernier came to the conclusion that along the northern section of the façade which he excavated a series of horizontal beams was held in place by dowels[351].

Pernier also believed that in the northern section the wall above the orthostates was composed of mud brick[352], since some mud bricks were actually found near the wall[353]. If, however, mud brick had been used here, it would constitute a radical departure from the mud and rubble construction since proven to have been used for the upper parts of many contemporary walls of the southern section of the First Palace. Indeed, at no time in the history of the palace site was mud brick favored for construction work of any magnitude[354].

The best indication of the type of wall that rose above the orthostate course occurs in the southern section (*figs.* 73, 85). Here masses of ancient wall material were found collapsed in front of the façade[355], and while Levi stated at first that there is no guarantee that the original construction was rubble[356], later he came to the conclusion that the superstructure was «built of stones bedded in earth»[357].

While the presence of the horizontal beams on the Phaistos orthostate course is sure, its function remains to be investigated further. If we assume, as we should, that the beams were attached with a specific purpose in mind (which we must since their positioning, as shown by the dowel holes, is usual and predictable), then one can first suggest that the beams were intended to keep the blocks from shifting out of alignment. However, lines of orthostates of which the original upper wall has disappeared (e.g. Chrysolakkos at Malia, the West Façade at Knossos, the western wall of the first Phaistos Palace) have remained straight, in place, without being joined together, for over a century since their excavation, a time during which Crete has suffered from numerous earthquake tremors. That the beams's primary purpose was to keep blocks from shifting, therefore, seems doubtful. The most likely alternative is that the beams formed the lower part of a stabilizing framework of vertical and horizontal timbers. The first were keyed into the beams set on the wall. The second would probably have been set at window, ceiling and roof levels, all vanished with time.

A similar, but much simpler arrangement existed at the time in Crete in the early west façade of Building A of MM II Quartier Mu. There a single line of ashlars, laid end-to-end, formed the outside face of the wall[358]. The wall was, according to Malia architect Martin

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ing or bending out, even during and after the upper walls' collapse and, later, even now, after a century of exposure. Or, perhaps, the timber was intended to keep the wall set partly upon it from shifting, but if this was the chief aim then there should have been a parallel line of timber along the back face of the wall, or transverse timbers anchoring the orthostates. More likely, there was a timber framework (vertical and longitudinal timbers) designed to prevent the wall from leaning out, as might happen during an earthquake (for the effect, see Monaco and Tortorici 2004, *passim*).

[351] *Festòs* I, pp. 184, 441-444. It seems to me that the only possible evidence for a course of stone set above the orthostates of this early façade may be found on the northernmost section excavated by Pernier, where a low block is set upon the orthostate wall at a point where the top of the wall meets the sloping bedrock of the hillside (*fig.* 89). I believe, however, that this block, instead of implying an entire course of stone blocks, may have been intentionally laid here in order to prevent the dissolution of an upper wall of soluble material, at least part of which would have been cut away by runoff rainwater that passes by the top of the orthostate course at this point.

[352] *Guida*, p. 46; *Festòs* I, p. 443.

[353] *Festòs* I, p. 228.

[354] See pp. 127-131 and Levi, «Festòs», *Enc. dell'A.*, III, p. 630: «non furono usati per grossi muri».

[355] As shown in Levi 1957-1958, figs. 35 (p. 219), 103 (p. 267); *Festòs* 1976-1988, II (Part 1), fig. 15.

[356] Levi 1957-1958, p. 218.

[357] Levi 1964, p. 5; *Festòs* 1976-1988, II (Part 1), pp. 32-35, figs. 19-22 for this façade.

[358] Poursat and Schmid 1992, p. 32.

Schmid[359], not carried up in stone but, rather, in mud brick, and all the wall was plastered over. Thus the stone base course functioned as a socle surmounted by wall materials.

More like the proposed Phaistos façade, with its timber framework, were the walls in the MM III East Wing at Knossos (figs. 181, 182a, b) or the north façade of much later LM III Building P at Kommos[360], where the wall material was also at least partly encased within wooden frameworks. At Knossos the frameworks were often covered over by dados (if on the interior) and/or by thick clay and lime plaster.

At Knossos orthostates once more seem to be confined to façades dating to the Middle Minoan period. In the Palace area the best preserved and most monumental Minoan orthostates border the West Court (*figs.* 92, 93). The wall is made up of thick gypsum blocks set on edge upon a krepidoma of slabs of poros limestone. According to Evans, the wall was originally built during the MM IB period and then underwent a series of alterations during MM III[361]. As in the façade of the First Palace of Phaistos, which most likely predates the West Façade at Knossos, the ends of the blocks seem to have been set into the corresponding cuttings of adjacent blocks (*fig.* 93 at C). In contrast, however, to the somewhat squared ends of the blocks from Phaistos, those at Knossos assume an oblique or irregular line, the shape of the block conforming more to the wedge-shaped blocks typical of later periods (as in *fig.* 122). Another interesting and unique feature is that at Knossos both exterior and interior faces of the wall were lined with orthostate blocks, each face being joined to the other by transverse wooden clamps that spanned an interior filled with rubble. Only one dowel hole, and that quite eroded by the weather, is now visible in the top of the partly restored façade, and it is perhaps on the basis of such evidence that Evans restored a horizontal timber at this level (*fig.* 92).

The material of the superstructure here is problematic. Even though the excavators found no ashlar masonry blocks either on or fallen alongside that wall, Evans restored such blocks (in concrete) (*fig.* 92), concluding that «what may have been originally preserved of the later Palace in the way of fine limestone masonry ... which undoubtedly rose in solid masses on the borders of the great Courts on either side» had been removed by ancient stone

[359] Personal correspondence. He also notes that there are no dowel holes cut into the tops of the blocks, so there is no evidence at this point that a wooden beam was placed horizontally above the ashlars, which might be termed «low» orthostates, given their size and positioning. According to Schmid there was no evidence for blocks fallen from upper courses.

[360] *Kommos* V, pl. 1.78A-1.78D.

[361] *Knossos* I, pp. 127-128, 131, 209, figs. 95, 96; II, p. 665: Evans 1900-1901, pp. 3-4, fig. 1; 1904-1905, p. 24. Platon, on the other hand, believed that the West Façade was first built at the beginning of the Neopalatial era, in the beginning of MM III (Platon 1968a, pp. 49-52). Macdonald (2005, p. 44; Macdonald and Knappett 2007, p. 175) recently expressed a preference for a Protopalatial date. In favor of a later date might be the use of wooden tie-beams set into dovetail clamp cuttings on the back of the Knossos orthostate blocks, a methodology also used at unpublished Neopalatial Galatas. A Neopalatial date (MM IIIB/LM IA) for the West Façade is also suggested by sherds in the sounding made at the eastern end of Magazine 12 (Momigliano 1992, p. 170) and, perhaps, by sherds from below slabs of the West Court immediately west of the façade with orthostates (Momigliano 1992, pp. 174-175). For a later date, see also Catling 1974 (after Hood), p. 34 (MM III) and Schoep 2004, p. 248.

Evans discovered what he thought were clear remains of an east-west passageway running under the West Façade and dating to the earlier stages of the First Palace (*Knossos* II, p. 662, figs. 423-425; IV, figs. 30, 34). He believed that this passage way was covered by a later extension of the early orthostate wall. However, judging from the portions of the façade not obscured by modern restoration, there is no indication of a patch having been made in the wall. Instead, the general technique of construction and joining appears to be uniform all along the wall line, from the Portico of the West Entrance (the southern terminus of the orthostates) to as far as Storeroom 11 which, curiously enough, has orthostate blocks in line along the southern robbers, Greek, Roman, and Venetian, while the gypsum blocks «were eschewed by later depredators»[362]. As it appears today, part of the façade consists simply of the single orthostate course with nothing on top but the earth and rubble which was found above it[363].

However, if Evans's restoration is correct, one would think that fallen blocks would have appeared in the area somewhere, despite the forays of stone robbers. Since no such blocks were found, I believe that there were probably no cut blocks used and that, instead, the upper wall was composed of small stones set in mud, similar to the orthostate wall at Phaistos. The remains now visible on top of the wall at Knossos may actually be remnants of the very wall that here rose so high above the West Court. The rubble above the walls near Magazines 7 and 8 is probably part of this superstructure, with some of the small stones apparently still in situ[364].

No other orthostate elsewhere in the Palace was topped by cut blocks, to judge from the evidence. For example, still in the West Wing but bordering the Central Court is an extensive orthostate wall with one side faced by cut blocks. This wall is only partly visible, for part of it is now covered by modern restoration, and another part was covered over in ancient times when it was incorporated into a later façade which extended further to the east[365]. A unique feature of this wall, visible at the northwestern corner of the Central Court, is the curved corner formed of gypsum blocks (*fig.* 94)[366]. This feature is otherwise unknown in Minoan architecture. On the exterior face of the wall the excavators found traces of red wash[367].

Within the East Wing of the same Palace appears a single gypsum block set on a gypsum plinth, thought by Evans to belong to an early orthostate line[368]. Other orthostate blocks can be seen built into the later walls of the North Wing. These were probably removed from their original positions late in the Middle Minoan period. In the South Wing, which remains largely unpublished, orthostates functioned as retaining walls which were built up against the sloping sides of the partly natural, partly man-made prominence upon which the Palace was constructed[369].

Outside the Palace proper, gypsum orthostates occur at the Little Palace, where they are set on a poros limestone plinth. Evans attributed them to an earlier Minoan frontage[370] which

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side of the room. It seems likely, therefore, that most of the wall, particularly the southern section with which we are concerned, belongs to one building period, probably that of MM III. For this area, including the possible earlier façade, see Momigliano 1992.

[362] *Knossos* II, p. 349.

[363] See also photographs of the same façade before and after restoration work: before, *Knossos* I, figs. 95, 96, Suppl. pl. I; IV, fig. 914; after, *Knossos* IV, fig. 36.

[364] Banti also excludes the possibility of a stone superstructure here by suggesting brick and timber (the brick being more common at Knossos than Phaistos) as possible materials (*Guida*, p. 40; «Knossos», in *Enc. dell'A.*, II [1959], p. 729). Matz suggests rubble packed with clay or mud brick (F. Matz, *Crete and Early Greece*, London 1962, p. 80). In a little-known sketch-restoration illustrating types of wall decoration Theodore Fyfe, Evans's invaluable architect, did not show coursed masonry but, instead, a series of horizontal and vertical posts enclosing a vertical paneling pattern topped by a window (Fyfe 1902, pp. 114-115, fig. 25 left).

[365] *Knossos* II, p. 798, figs. 521, 523, 525, 526; III, p. 4; IV, 903 and n. 1, figs. 877, 878.

[366] *Knossos* I, p. 140, fig. 102; II, p. 798, figs. 521, 525; IV, p. 903, figs. 877, 878; Evans 1903-1904, p. 26.

[367] *Knossos* IV, note on fig. 877. This corner was used by Evans as evidence to support his theory of «Insulae», which were separated building units that may have formed the plan of the original First Palace of Knossos (as *Knossos*, IV, p. 903, n. 1). For criticism of this theory see *P. of C.*, p. 230. See also Lawrence's discussion of the curved corner (1957, p. 298).

[368] *Knossos* I, p. 364, fig. 264; III, p. 234.

[369] *Knossos* I, fig.154. There are two blocks on top of one of these orthostate walls of the South Wing, but by themselves they cannot be called evidence for a second course of masonry, since they are irregularly placed and are of different materials (limestone and gypsum), the mixture being a rare occurrence in any Minoan wall.

[370] *Knossos* II, pp. 514-515, figs. 316, 328. Hatzaki dates the earlier Little Palace façade to MM IIIA or earlier, followed by later orthostate construction during the Neopalatial Period (2005, pp. 197-199, Pl. 7a).

«demonstrates the survival of an earlier Middle Minoan tradition». At Malia the only true orthostates are probably those along the eastern and southern façades of the ossuary at Chrysolakkos (*fig.* 96). These are poorly preserved blocks of hard limestone set on edge on a krepidoma of rough blocks laid on their sides. Mortises for dowels suggest that, as at Phaistos and Knossos, horizontal wooden beams, forming a base for a superstructure of rubble and/or mud brick, were laid upon these blocks[371]. It is also likely that some of the blocks used in the northern and western krepidomas here were intended originally to be used as orthostates. There is no doubt that the exterior walls belong to the First Palace period[372] and as such remain part of the Protopalatial architectural tradition.

In the so-called «Agora» northwest of the Malia Palace, a number of thin, white limestone slabs, called «asprôpetra» locally[373], faced the enclosure wall on the interior of the great MM IB court there. The slabs average 15 cm to 25 cm thick, with a maximum length of 1.80 m and a maximum preserved height of 0.98 m[374]. Despite their being called orthostates by the French excavators[375], they can perhaps be described more correctly as an early form of dado slab because of their thinness.

Within the Malia Palace itself, it is difficult to point out wall blocks which can be called «orthostates» in the sense of the term used here. The walls of the West Façade at Malia, for instance, appear to have been at least two courses high in places (*fig.* 118). Actually, the most likely candidates for orthostates at Malia are two blocks of hard, bluish limestone, perhaps reused from an earlier structure, now facing a wall in the northwestern corner of the Central Court[376].

Up until a short time ago, it appeared that the Minoan tradition of orthostate construction on important façades stopped at the end of the Protopalatial period[377]. Recent excavation has shown that this was hardly the case, for Neopalatial orthostate façades have been discovered at Galatas Palace in the Pediadha, east of Knossos, and another at the palatial court-centered building at Kommos, the harbor town of Phaistos and Hagia Triadha on the Libyan Sea. The orthostate façade at Galatas[378] occupies the northern width of the Central Court. The wall is set, as usual, on a single, projecting plinth, with finely cut blocks. In plan, one sees only a line of blocks making up most of the wall's width, as at Phaistos, and, like all the major examples discussed thus far, dowel holes cut into the tops of the blocks demonstrate that a horizontal beam stabilized the upper wall structure.

The Galatas wall is canonic: a single course set on a projecting plinth. The wall was lined with blocks only on the exterior face, with a timber frame with most likely rubble filling above that point. The Kommos wall, the longest monumental Minoan ashlar wall known at this point, lines the northern and eastern exterior of palatial building T[379]. The wall (*fig.* 95) rests on the usual projecting plinth; the interior face is made up of smaller, only roughly squared blocks. The exterior is unusually high (1.40 m above the plinth, versus 1.15 for the Knossos West Façade and ca. 1.00 m for the Phaistian north-western façade). Uniquely, the Kommos wall is usually composed of two courses of blocks, the lower one (0.94 m) much higher than the upper one (0.46 m). The lower course, moreover, is made up of slabs, averaging 0.35 m

[371] For a detailed discussion of the evidence, see pp. 114-126.

[372] *Guide*, pp. 76-78. MM IB-II (Soles 1992, p. 168).

[373] van Effenterre 1963, p. 242; Daux 1963, p. 876.

[374] van Effenterre 1963, p. 243. Also, *Mallia, Centre Politique*, I, pp. 24, 28-31, and pls. xxxi, xxxii.

[375] *Guide*, p. 53.

[376] See also Charbonneaux 1928, p. 350, n. 1.

[377] They did not feature, for instance, at certain major Neopalatial palatial structures such as the second Palace at Phaistos, the Palace of Kato Zakros, or the small Palace at Petras.

[378] For Galatas see Rethemiotakis 1999.

[379] For T and the wall concerned, see Shaw 1983, also *Kommos* V (2006), pp. 20-22, pls. 1.41-1.44, Foldout B and (for plans only) *Kommos* IV (2000), Foldouts A-C.

thick, while the upper one, ca. 0.60 m thick, was probably intended to help retain the lower one with its very weight. Occasionally a single thin slab takes up the entire height of the wall, also without precedent[380]. Upon the ashlar wall base, which averaged the same height as width (1.40 m), were, presumably, set rough blocks, perhaps faced with plaster, like the composition of the interior wall face: masses of them were found collapsed behind the façade[381].

The Kommos wall is intriguing. Historically it must have been intended to impress visitors arriving by sea – how else can one explain its monumentality in the context of a relatively small harbor town? Architecturally, its single/double course combination is without precedent, and its huge, thin slabs set on edge represent a new concept in Minoan orthostate construction[382]. One can compare it with other examples cited here, but it is more difficult to explain the stylistic differences between the supposedly contemporary examples at Galatas and Kommos, both built at the beginning of the Neopalatial period[383].

Coursed Ashlar Masonry

Coursed ashlar masonry was introduced during the period of the First Palaces, although it seems not to have been common until the MM III period when the early versions of the Second Palaces began to be constructed. In all cases the stone used for such walls was sandstone, limestone, or gypsum.

Techniques of Building

Instead of being guided by elaborate structural and aesthetic principles like those that can characterize Classical architectural design, the Minoan mason simply aimed at producing a reasonably attractive, sturdy masonry with a minimum of material and effort. As a result, once the technique of cutting and laying the blocks was established in the First Palace period, the appearance of some of the walls seems to have remained basically unchanged. Details of construction of such walls, therefore, will be discussed here with only occasional reference to chronological distinctions.

The typical plan of such walls is illustrated here by examples from Zakro (*fig.* 122), Hagia Triadha (*fig.* 212a) and Archanes (*fig.* 123b). In each case, cut blocks were placed only along the exterior wall face, the face intended to be seen and usually the one that was exposed to weathering. Only the front, visible side of each block was smoothed and provided with straight edges, so that adjacent blocks touched only along the outer vertical edges. The back sides of each block were normally broken off or chiseled obliquely so as to form a roughly triangular or wedge-like shape. The upper and lower surfaces of the blocks were treated in a similar manner, with only the borders along the outer edges being smoothed, the rest being left rough and sometimes even cut in at a slant. Cutting the stone in this manner must have simplified the joining of the blocks on the façade[384].

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380 As in *Kommos* V, pl. 1.42-1.44.

381 There is no trace along the top of the orthostate course of the usual square mortises which stabilized a timber framework, as in other examples described here.

382 By being set on edge, the slabs come closer to the term «orthostate» as applied to Classical Greek construction. In order to compare Minoan orthostate construction with similar walls in the Ancient Near East, one should consult Hult's valuable review of the subject (1983, pp. 66-70). For intriguing early Mycenaean orthostates suggesting Minoan influence at Pylos, on the Greek Mainland, see Nelson 2001, pp. 117-125; Wright 2006 p. 14, and our chapter 5 here.

383 The unusual height of the Kommos façade probably determined its two-coursed arrangement. The occasional full height of some orthostate slabs and the length of others, however, indicate the architectural ambition that brought about the construction in the first place.

384 See also *Festòs* I, fig. 238; *Gournia*, p. 23; *Knossos* I, p. 401; II. p. 406, n. 4; Marinatos 1950, pp. 245-246

The gaps formed between the blocks in the interior of the wall were filled out with rubble, and the short distance remaining between the back face of the widest block and the inner face of the wall was filled out with mud plaster. The wall illustrated from Zakro is on the average 0.72 m thick, a few centimeters greater than the widest block used. At Zakro, usually the interior face was plastered over. Elsewhere in Crete, the plaster was sometimes replaced along the lower part of the wall by a dado of gypsum slabs (*fig.* 180).

No doubt some of the blocks were partly trimmed in the quarries to simplify transportation, but the final sizing probably took place where the walls were being built (as in *fig.* 54). Surprisingly, perhaps, the expected layers of chips are not usually reported by excavators[385], although they have been referred to in connection with early excavation work at Palaikastro, and with the Minoan Unexplored Mansion at Knossos[386]. Perhaps there was an admirable custom of cleaning up, as apparently at Myrtos-Pyrgos where excavation below a floor behind the ashlar façade of the house produced a packing of poros chips[387]. Chips could be used for wall-filling, as at Malia (*fig.* 254). They were often used to pack joints between wall blocks at Zakros (*fig.* 120), Malia (*fig.* 76), Archanes (*fig.* 74), Knossos (*fig.* 124) and at LM III Kommos[388]. Some were reported by Bosanquet in a dump at Petras[389].

In elevation, the walls generally present a very smooth face of carefully squared blocks set upon a krepidoma. The krepidoma is usually composed of a single course of well-cut blocks of the same stone used for the wall itself, although, as at Zakro, it may simply be of rubble. In medium-sized structures the krepidoma usually projected 3 cm to 6 cm out from the face of the wall and, to judge from those which I have examined in detail, it usually was set 10 cm to 20 cm above floor or pavement level. The blocks are fitted in such a manner that there is hardly any gap between vertical joints. Each course, however, is separated from the next by a thin layer of mud mortar, sometimes pebbly in composition, used to even off the top and bottom of each block, and perhaps to help fit the blocks into place. The mortar ranges in thickness from only a few millimeters to as much as five centimeters, depending on the size of the blocks used and the skill of the masons. In some cases small chips of stones were wedged into the horizontal joints (*figs.* 120, 124); these joints were all plastered. The level of the courses was normally kept uniform throughout a wall, unless an addition was made later (*fig.* 113)[390]; or an unusual arrangement was attempted, perhaps as a patch (*fig.* 103). Occasionally, when blocks of different sizes were combined, rabbets were used, as in *fig.* 124[391].

There is no evidence that the Minoans made any attempt to build isodomic masonry, although in a few walls the courses are almost identical in height (*figs.* 108, 114). It is clear from examination of the well-preserved walls, that few if any of the courses are of the same height, and sometimes vary a great deal. The blocks range from 0.25 m to 1.04 m high, aver-

(Vathypetro); Charbonneaux 1928, p. 352 (Malia); Palio 2001 (Second Palace period houses at Chalara). The style appears at later Mycenaean sites as well, is occasionally used at Classical sites, and I have also seen it used in modern walls in Greece. For an example from the Mainland during the Bronze Age, see Blegen and Rawson 1966, I, pp. 35-37.

385 At Kommos the levels around the Greek temples were characterized by thick layers (5-10 cm) of chips from sizing and trimming blocks robbed out of the earlier Minoan buildings. Ironically perhaps, such working chips did not characterize the Minoan levels despite the massive scale of the ashlar construction there.

386 Palaikastro: Bosanquet 1901-02, p. 308; at Knossos: *MUM*, p. 44. See *Crafts*, p. 213.

387 *AD* 30 (1978), p. 346.

388 *Kommos* V, pl. 1.81.

389 Bosanquet 1900-01, p. 285.

390 Compare the course alignment of the central wall section with that on the left in *fig.* 113.

391 Also visible in the monumental eastern façade of Building T at Kommos in *Kommos* V, plate 1.44, center right.

aging 0.25 m to 0.50 m high. Usually the height of a block falls within about 0.10 m of the computed average height of the blocks in the wall.

While courses may differ in height within the same wall, the blocks of each course are normally of uniform height throughout the length of the wall[392]. In some cases, such uniformity is essential, as for instance in the interior corners of some light-wells where the blocks of courses meeting at right angles have to provide a level base for the course above (*figs.* 97, 114).

There is also some evidence to show that sometimes the builders predetermined the height of a wall of coursed ashlar masonry. This can perhaps be seen best in Houses A and C at Tylissos, where walls are preserved to a considerable height and, for the most part, have not been covered over with modern restoration, as is the case at Knossos. At Tylissos, it is clear that the western wall in Room 6 of House A (*fig.* 114) and a pillar in Room 2 of House C (*fig.* 200) are intact. Mortises for wooden dowels on the top of the topmost course of blocks show where wooden construction began and stone ended. In the western wall of Room 15 of House C, there is a cutting for a wooden clamp in a stone block, with a bedding for a beam alongside (*fig.* 195 a, b). This cutting probably indicates the point at which wood and rubble replaced coursed ashlar construction[393].

In each of the three instances cited above, the distance from the top of the topmost block down to the top of the finely dressed krepidoma is 1.66 m ± 0.01 m. Since the number of blocks varies in each structure mentioned (the first being composed of six blocks, the second of two, and the third of three) it is difficult to believe that the almost identical heights could be due to mere coincidence. I believe, rather, that the builders predetermined the height of the ashlar walls (thus, generally, the height of the blocks to be used) before construction began[394].

At interior wall corners, in order to strengthen the wall, blocks usually were placed in such a way that every other block of one wall projected into the face of the wall that met it at right angles (*fig.* 114). Only in rare instances, such as at elegant Hagia Triadha (*fig.* 241c) were the cornering blocks cut in an angle so as to become part of both walls. A similar corner-strengthening technique was employed at Akrotiri on Thera where diagonal wooden members bound together the corners of rubble walls (*fig.* 185). In exterior ashlar corners (*fig.* 104), the sides of each block were carefully squared. Such terminal blocks, and sometimes blocks bordering entrances (*fig.* 123b), also built pillars, are among the rare instances where blocks of walls were carefully cut on two exposed surfaces.

At some corners this method of overlapping blocks was impractical, such as at the corner bordering a window at Hagia Triadha (*figs.* 212 a, b, c). Here, above the sill level a series of three triangular blocks were stacked one above the other. It is interesting to note that the north face of each of these corner blocks was cut back 0.09 m at a distance of 0.67 m from the wall corner. This formed an inset of the kind into which the gypsum dado slabs were set with their mud backing. When looked at from the north, these neatly superposed blocks give the impression of a pier (*fig.* 212c) which formed an anta for the stylobate that ended at this point.

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[392] As Nelson has commented (2003, p. 273), «when it came time to level and finish a course or to trim the exterior face of a wall back to a flat plane, the masons made only one measurement and carried it across the entire surface», so blocks were often finished in situ.

[393] In this case, the horizontal timber stabilized by the clamp probably functioned as a base for a wooden prop, which was dowelled into it. The prop, which was perhaps 0.70 m long, probably supported one of the two east-west beams holding up the ceiling of the western half of Room 15.

[394] The total distance from floor level to the tops of the blocks (that is, with the krepidoma included) was somewhat greater, being about 1.86 m, 1.76 m, and 1.98 m, respectively.

Wall projections (or «set-backs») were sometimes formed simply by stepping the blocks out from the face of the wall (*figs.* 119, 120). An exceptional case is that of an anta, at the entranceway at Archanes (*figs.* 123 a-c), corresponding to a second anta at the opposite end of the same stylobate. The former anta is formed by cutting back the face of the wall while leaving a squared, smoothed projection of about 0.03 m. Normally in such situations, the Minoan mason used separate piers formed of blocks set out slightly from the wall. The krepidoma here, also made of finely cut blocks, projects 0.045 m beyond both wall and anta. Another example where the projection is formed not by adding blocks but by cutting into the existing block wall occurs in the light-well of Room 6 in House A at Tylissos. Here (*fig.* 114) the western side of the light-well is set back slightly from the rest of the same wall that continued on to the north, the set-back beginning at the line of the stylobate.

Examples of Coursed Ashlar Walls

Our earliest evidence for this method of building in Crete occurs at the great palace sites of Phaistos, Knossos, and Malia. At the first site, for instance, the northernmost block of the orthostate façade of the First Palace, already mentioned above, is partially set into the sloping bedrock of the hillside. Right above this is a well-cut rectangular block (*fig.* 89) which was intended to shield a fragile superstructure from runoff rainwater coming down the slope. The best example at Phaistos, however, is the eastern retaining wall of Room 74 (*fig.* 108) which is about 2.60 m high, consisting of six (perhaps more) courses of carefully cut limestone blocks. Pernier dated this wall to the First Palace period[395], partly on the basis of the location and level of an early, related, room with a series of columns, the bases of which are still visible in the area of Rooms 58, 61, 91, and 92. Platon, however, would date both wall and columned room to the first phase of the Second Palace, that is, to the beginning of MM III[396].

At Knossos the Residential Quarter in the East Wing was originally built in the MM II period and it is to this period that, according to the excavators, at least the lower supporting walls of the great cutting in the hillside (*fig.* 102) are to be dated[397]. Evans identified other early walls within the Northwest Lustral Basin and the North Pillar Hall. He described the southern wall of the south light-well of the Queen's Megaron (*fig.* 100) as the «best preserved example of ashlar masonry dating from the MM II period to be seen on the Palace site»[398]. Here we should note the coping block found on the top of this wall, an unusual feature for any Minoan wall[399]. The lower part of the wall in the lower East-West Corridor (above, *fig.* 102)[400], shows a much more irregular placement of the blocks, perhaps because they were to be covered by plaster or by gypsum slab facing. The unusual feature of this wall is that it is an interior wall constructed of poros blocks. Graham has pointed this out also, concluding that the method of construction may be due to the need to strengthen the lower

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[395] *Festòs* I, p. 442; II, pp. 12, 232.

[396] Platon 1968a, p. 41. n. 3, fig. 6. La Rosa would concur (personal communication).

[397] *Knossos* I, p. 204; *A. of C.*, p. 129.

[398] *Knossos* III, p. 374, fig. 248; also I, p. 204, fig. 153.

[399] Coping blocks are not typical of Minoan architecture. They do, however, occur in the form of squared, rectangular slabs on balustrades (as in *fig.* 151), and occasionally they were used for window benches, such as in the eastern wall of Room iii, 1 of the Palace at Malia, and in Room xxiii (north wall) of the Palace of Karo Zakro. The former example is incorrectly shown as a solid wall by the excavators. «Coping blocks» of another shape are reported from Chrysolakkos. These are half-rounded, plastered, sandstone blocks, which the excavators believe were set on top of a wall associated with the first phase of the ossuary there (*Mallia, Nécropoles*, I, p. 39, pl. liii, 3). These curious blocks, however, were not found in their original positions.

[400] *Knossos* I, p. 349, fig. 252; III, pl. XXXVa.

walls of a multistoried structure[401]. The Northwest Lustral Basin[402] and the North Pillar Hall (*figs.* 99a,b) provide two more examples of walls dated to the First Palace period[403].

Evans distinguished as characteristic features of this early period thick layers of mud between courses, elongated blocks, and deeply cut mason's marks[404]. When, however, I compared masonry of this early period with that of the following period I could not see any clear differences either in the sizes of the blocks used or the thickness of mortar layers. For instance, there was no significant difference between the masonry of the above-mentioned walls dated to the First Palace period (*figs.* 99a,b, 100) and the masonry of the western lightwell of the Hall of Double Axes (*fig.* 97) or the western wall of the Court of the Stone Spout (*fig.* 101), both of which are dated to the MM III period[405]. The blocks here are typical of many of those used in Minoan ashlar walls, being 1 to 3 times as long as they are wide. Nor can I detect any differences in the treatment of their exposed surfaces; nor, as to be expected, is there any attempt made in either case to align the vertical joints of blocks of alternate courses. Of course, there are differences in the height of the blocks, but this is not significant since the height of individual courses differs within walls of the same period, as well as within individual walls[406]. Nor could I see noticeable differences in the thickness of the mud mortar used between courses. In other words, it seems that the size of blocks and the thickness of mortar used cannot be used as a criterion for dating, and thus distinguishing, walls of First and Second Palace periods[407]. The only change that may have occurred is that the blocks of earlier periods may be more rectangular in plan than those of later periods, when blocks tend to be triangular. This is suggested by the orthostates at Phaistos (*figs.* 87, 91) and the back of a wall of MM II date in the North Pillar Hall (*fig.* 99b) as well as by an early, reused block in a wall at Knossos (*fig.* 82). The thought, however, must be substantiated by further research.

At Malia, curiously enough, the highest ashlar wall preserved (*fig.* 117), six courses high, is also one of the oldest. This is the retaining wall of the Hypostyle Crypt, northwest of the Palace, and dated to the First Palace period[408]. However, this wall of sandstone blocks, impressive as it is, is still much inferior, as far as the cutting and setting of the blocks is concerned, to the examples already discussed from Phaistos and Knossos. Perhaps this is attributable to the coarseness of the sandstone used.

There are numerous examples of ashlar masonry dated to the period of the Second Palaces in all major settlements of this period. Certainly in central Crete, at Malia, Galatas, Amnisos, Nirou Khani, Knossos, Archanes, Tylissos, Phaistos, Hagia Triadha, and elsewhere it was the normal method of construction used for certain walls. In East Crete at Palaikastro, Dawkins thought that walls of this type were rare before LM III[409]; but M.R. Popham, one of the later excavators of the same site, has been kind enough to inform me that such con-

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[401] *P. of C.*, p. 153.

[402] *Knossos* I, p. 406, fig. 294 b.

[403] *Knossos* I, note on fig. 286.

[404] *Knossos* I, pp. 347-348.

[405] *Knossos* I, p. 363, fig. 263.

[406] The presence of the coping block on one wall (*fig.* 100) and the course of wood in another (*fig.* 97) can also probably not be considered characteristic of a particular period.

[407] Levi has stated a similar belief (Levi 1960, p. 107), although this does not prevent the walls from being of the date assigned to them by Evans.

[408] MM IB. *Mallia, Centre Politique*, II, p. 74. Also Daux 1961, pp. 943-950; 1962, p. 973; 1963, p. 875, and van Effenterre and Salaün 1961-1962, Prt. A, pp. 186-194, a date apparently also supported by Platon (1968a, pp. 57-58, n. 6). The ashlar base course of free-standing walls of the same MM II period have been reported from the south and western façade walls of Building A in nearby Quartier Mu (Schmid 1996, p. 75).

[409] Dawkins 1904-1905, pp. 283, 286.

struction may have begun there in the Middle Minoan period. At the Palace of Kato Zakro, even further to the south and east, such masonry from the MM III B period is quite common.

Here we shall select a few examples illustrating the use of coursed ashlar masonry in exterior and interior façades, roofed areas, and a few less common structures as well. Among the well-preserved exterior façades, perhaps the most impressive is that of the Second Palace at Phaistos, flanking the stairway leading up to the Propylon[410]. Here four courses, totaling 2.65 m, rise above the projecting krepidoma. Above the top course the wall may have continued up in rubble construction[411]. At Archanes, the façade and entrance to the monumental building at Tourkogeitonia, palatial in character, is equally impressive (*figs.* 123 a-c), not just because of the size of the blocks used but because of the careful way in which they were cut and fitted. The up to eight courses of the back wall of the South House at Knossos, 2.92 m high, are also memorable[412]. Curiously, the bottom course of the wall is made of gypsum and serves as the krepidoma[413].

Another elegant residence distinguished by the quality of its ashlar masonry is House C at Tylissos, where along its southern side (*fig.* 115) there are six courses of blocks which formed the lower part of the façade. Of these the four lower courses were simply hammer-dressed, while the upper two were more carefully finished. The fifth course was cut like a slab and polished smooth on its exterior face; the sixth course, above it, was set back slightly from its edge. No doubt the relationship here is the same as that between the normal bottom course and the krepidoma of most walls[414].

Ashlar façades were also used in interiors exposed to the weather, such as palace and house courts and light-wells and open corridors. At Malia, for instance, the North Court (Areas xxiv-xxviii) was entirely surrounded by walls built up with at least one, and sometimes two, courses of sandstone blocks. To judge from the number of fallen blocks discovered during excavation, it is most likely that the southern and western façades about the Central Court at Zakro were carried up much higher than is now preserved (*figs.* 120, 121). In the western façade here, there were probably at least five courses, three of which had tumbled into the Central Court. One unusual feature of this wall is that, whereas the higher courses are of sandstone, the bottom course, set on a rubble krepidoma, is composed of rough blocks of hard, grayish-blue limestone (*fig.* 120). The combination of two different types of stone is most unusual, the pattern not being repeated in the façade of the south side of the court (*fig.* 121). An unusual feature in the construction of the latter is a pier which seems to have been incorporated into the wall and which suggests that there may have been a window on one or both sides of it, lighting the stairway in Room xlvi a.

The walls of light-wells which would be exposed to weather were also usually built of coursed blocks, both in palaces and houses. For instance, three sides of the light-well (Room 69a) at the east side of the impressive Propylon at Phaistos were built in this manner (*fig.* 131). In the light-well of the Hall of the Double Axes (*fig.* 97), the masonry seems to have been carried up through a succession of stories, being interrupted at points for windows and balconies. On the ground floor this light-well was closed on two sides, the third wall (that on the north) being pierced by a large window (*fig.* 215), above which the ashlar construction was continued. At the Palace of Kato Zakro, in the light-well of Room xxviii (*fig.* 213),

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[410] See *P. of C.*, fig. 138.

[411] *Guida*, p. 50.

[412] See *P. of C.*, fig. 72.

[413] See Driessen 2003, p. 28 for more detail.

[414] This is a curious feature and provokes me to wonder if sometime in the early history of the building the rough courses below the slabs had been below ground level on the exterior of the building.

the arrangement was such that three sides were enclosed by columns, and thus open, while the fourth side (on the west) consisted of a single course of finely cut blocks, 0.36 m high, upon which was set the frame for a large double-window. A somewhat similar arrangement for a window in a light-well occurs in Room 15 of House C at Tylissos[415]. A nearby light-well in Room 6 of House A (*fig.* 114) is built in a slightly different manner, for here two sides were kept open by means of columns, a third was entirely closed, and the fourth (on the west) was pierced by a window[416].

Important corridors were also faced occasionally with coursed blocks, which makes one suspect that they were open to the sky. The most monumental of these, of course, is the great passageway at Knossos, leading up from the Pillar Hall in the North Wing to the Central Court. Here a stepped krepidoma adapted the wall to the sloping terrain (*fig.* 98). In the stepped corridor near the Theatral Area at Phaistos rough stones provided the leveling course on the east. Finally, we should note Corridor 41 at Phaistos (*fig.* 109), which connected the northern residential quarter with the Central Court. It certainly was unroofed except near its southern end[417]. The western wall of this corridor is preserved six courses (1.75 m) high above the pavement.

Ashlar construction sometimes appears in roofed areas as well, doubtless used there as much for its attractive appearance as for its strength. It occurs, for instance, in the form of pier-jambs in important storeroom areas at Phaistos and Knossos (*figs.* 110, 223), on high pillars at Tylissos (*figs.* 200, 201) and elsewhere, and in the pillar crypts in the Palaces of Knossos and Malia[418]. Occasionally it was used for the balustrades of staircases, as in the Grand Staircase at Knossos, and Myrtos-Pyrgos (*fig.* 211 b and cover illustration) and for pillars, as with a pillar within a lustral basin in House A (Room 11) at Tylissos[419].

Interior walls were occasionally of ashlar construction, such as the sandstone retaining wall of the Hypostyle Crypt already described at Malia, or in the Northwest Lustral Basin at Knossos. Other examples occur in the curious basement crypts in the Unexplored Mansion, the Sanctuary of the Temple Tomb, the Royal Villa, and in the basement of the South House (*fig.* 105), all at Knossos, the blocks of the latter two being of gypsum. Perhaps these crypts were built so solidly and carefully because religious functions took place within them[420]. The presence of ashlar walls in certain other areas, which were also probably roofed, is equally difficult to explain, as is the case of Room H 1 in the Southeast House at Knossos[421]. Here three sides of the small rectangular room are enclosed by ashlar masonry, the western wall being preserved up to nine courses (2.37 m) high above the krepidoma. The fourth (east) side was faced with a veneering of gypsum set against a rubble wall. The room could be neither a light-well nor a basement room in its present form.

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[415] See *P. of C.*, fig. 77.

[416] In the topmost (sixth) course of this western wall (*fig.* 114), 1.66 m above the high krepidoma, can be seen three small, square mortises. Into these were set wooden dowels that no doubt stabilized a horizontal beam. As this beam continued to the south, it became the top of the window frame. Three courses (0.85 m) below, on the top of the third wall course, are two similar cuttings for dowels which held the lower window frame in place. The height of the window was, therefore, about 0.70 m (0.85 m minus 0.15 m, the approximate thickness of the lower window frame). As we see the window opening now, it is about 1.56 m wide and, with its timber framing on either side, must have been about 1.26 m wide originally. The dimensions of the window opening, therefore, were about 1.26 m wide by 0.70 m high.

[417] *Festòs* II, p. 429; Graham 1961, p. 165.

[418] For Malia, see *P. of C.*, figs. 95, 98.

[419] For a somewhat similar pillar see *Festòs* II, fig. 185.

[420] *Knossos* I, p. 404; *P. of C.*, p. 53.

[421] See *P. of C.*, fig. 80.

Rooms iii, 5, and iii, 6, at Malia (*fig.* 116) are unusual for the same reason. What is almost unique about them, moreover, is that both wall faces are of coursed ashlar construction[422].

Sometimes horizontal and vertical timbers were incorporated within ashlar walls, although this does not seem to have been the rule, as it was in the case of later Mycenaean architecture[423]. They were used, for instance, in the construction of the drainage shafts in the Residential Quarter at Knossos (*fig.* 168). In Minoan architecture in coursed stone, horizontal timbers appear most often as the upper and lower frames for windows. It also seems that the top stone course for such walls was often terminated by means of a single horizontal beam. In the western light-well of the Hall of the Double Axes at Knossos, however, wood appears (*fig.* 97) above the third course (excluding krepidoma) and was apparently matched by a similar beam on the opposite face of the same wall[424]. These beams, which were linked at intervals by small round transverse timbers, must have helped to stabilize the wall courses above. Wood was also used above the second course of the back wall of the Little Palace at Knossos (*fig.* 103). Vertical timbers seem to have been used occasionally at the Northern Entrance to the Palace of Knossos (*fig.* 98).

But the most noteworthy function of timber in coursed ashlar wall construction was to provide a framework that was filled up with reused blocks. Such usage can be seen for example in the Residential Quarter at Knossos (*figs.* 181, 182a, b) and perhaps at Kato Zakro along the northwest side of the Central Court. At Hagia Triadha, in Room 9, a roughly built ashlar wall has similar features[425].

At Knossos, in particular, coursed ashlar construction (the type is surveyed in *figs.* 108-123) is used outside the palaces and houses. The most massive masonry found thus far from Minoan times is that of the Viaduct (*fig.* 106)[426] that leads from the Caravanserai to the Palace. Here there is a system of headers and stretchers bound by clay mortar[427].

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[422] The north and west walls of Room 49 at Phaistos are built in a similar manner (*Festòs* II, p. 432). At Tourkogeitonia in Archanes, Room 33 has three sides made up of at least four ashlar courses set within a wooden framework. The fourth side of the room has not been excavated but may lead to an open space. In its final days the room functioned as a storeroom for pithoi. That it was roofed is shown by the collapsed remains of an upper room paved with colored marble and schist slabs (Sakellarakis and Sakellaraki 1999, pp. 259-289, also *AR* 1999-2000, p. 128; *AR* 2002-2003, figs. 129, 130).

[423] In this connection, it is interesting to note that in miniatures showing walls of coursed blocks, such as in certain of the faience house-fronts from Knossos (*Knossos* I, fig. 226, nos. S, T, U; S. Hood, *The Home of the Heroes*, London, 1967, figs. 42, 43) wood is not shown to play an important part in the construction except to frame windows and doors, and perhaps is shown as part of the roof structure. The wide strips between blocks are no doubt the plaster bands sealing the joints and not, as Evans thought, the mortar between the blocks.

[424] *Knossos* I, p. 347, n. 1, fig. 250.

[425] The technique is discussed on p. 100.

[426] *Knossos* II, p. 93, fig. 46, pl. XV.

[427] *Knossos* II, p. 98. Theodore Fyfe, Evans' architect, restored corbelled arches between the piers of the viaduct. At the point where piers came sufficiently close together, the gaps between them were presumably spanned by long slabs. Five or more courses higher up was the roadway proper. Fyfe's restoration seems reasonable, and if so, the viaduct may be the only Minoan example of corbel vaulting used outside of tomb architecture (Concerning the last, discussion of corbelling in Early and Middle Minoan tholos tombs can be found in Pelon 1976, Branigan 1988, as well as Cavanagh and Laxton 1982, also 1988; and Warren 2007. For the corbelled ashlar façade within the LM I-II tomb at Isopata near Knossos, see *Knossos* IV, pp. 771-776, figs. 753, 754 and Evans 1906 pp. 526-562, fig. 145 and pl. xcvii. Also, in the same, Theodore Fyfe's note on «Architectural details of the Isopata tomb», pp 551-554. For the impressive Kephala tomb at Knossos see Pini 1988 p. 83 and fig. 90). Incidentally, there is no evidence that the true arch was ever used in Minoan architecture (see also *P. of C.*, p. 160). The comparative roughness of the lower three courses of the viaduct sug-

Strong supports for a bridge between the Little Palace and the Unexplored Mansion at Knossos are built in a similar manner (*fig.* 104)[428].

Cornices

There is little evidence for rooftop cornices in formal Minoan architecture. Perhaps the closest one can come is one atop a retaining wall in an exterior light-well at Knossos (*fig.* 100), or another above a niche in a façade imitating a tripartite shrine in a spring-house near the Caravanserai at Knossos (*fig.* 107)[429]. Evans published «stepped cornice blocks» from Knossos but their identification is far from certain[430]. To judge from the well-preserved buildings at Thera, save for an occasional line of thin slabs projecting from upper exterior walls (*fig.* 263)[431], there were no projections or overhangs along the tops of the walls. On the other hand, single continuing projecting courses of ashlar blocks characterized many multi-storied Theran buildings. They were often set at the transition point between one story and the next[432].

Other cornice-like projections are frameworks of slightly projecting ashlar blocks around Theran door and window openings[433]. At this point there is little evidence on Crete for such frameworks, so the custom may be purely Theran, as the especially reinforced ashlar and wood construction at Theran building corners appears to be[434].

After LM I major Minoan building is sharply reduced, with reuse and rough extensions of earlier buildings becoming normal at many sites. Aside from revival at an apparently

gested to Evans that its original construction might be of a very early date, although I doubt that shabbiness of technique can be used as a reliable guide for dating. Other instances of header and stretcher masonry are in a MM II house at Stou Kousé, south of Phaistos, where all were headers 0.80 m to 1.00 m long (*A. of C.*, p. 132), and in pillars of limestone blocks in a house at Gypsadhes, where both headers and stretchers were used (*Knossos* II, p. 548).

[428] *MUM* I, p. 103.

[429] J.W. Shaw 1978c. Ashlar was also used to construct shelf-like niches, each built of five slabs of poros limestone, set into the western walls of Rooms 45-46 at Phaistos (*Festòs* I, fig. 206; II, figs 155, 156; *P. of C.*, fig. 99).

[430] *Knossos* II, p. 814, figs. 532, 533. He describes and illustrates the two blocks found, the first (*Knossos* II, fig. 533 a) from the Little Palace, the second (*Knossos* II, fig. 533 b) from the Stepped Portico in the Palace proper. I think, however, that the identifications are not certain. Although cornices may have been stepped (their shape can be judged from representations in wall paintings and miniature art), the fact that no other blocks of this shape have been found at Knossos or other Minoan sites makes it unlikely that cornices of stone were actually used along the edges of roofs. Of the two blocks mentioned, the first, of gypsum, was once in a sheltered spot on the roofed landing of the restored staircase in the Little Palace. The second, of poros limestone, is now set up on the balustrade of the Stepped Porch. The first block is especially improbable for a cornice, for it is of gypsum, and gypsum blocks were hardly ever, if at all, set where rain would fall upon their upper surface. Moreover, there are dowel holes in the presumed face of the block, which indicates that it was joined to something else (or vice-versa): but to what, if it is a cornice block? Finally, if set on the edge of a roof, only slightly less than half of the block would be projecting from the side of the wall, which seems hardly sufficient for stability.

[431] Palyvou 2005, p. 129.

[432] Palyvou 2005, pp. 96, 116, 160. There is no evidence on Minoan sites for such horizontal projecting cornices, perhaps because exteriors there are rarely preserved that high. The best evidence for them on Crete is the clear depiction of one in the Archanes model (*fig.* 264) which, after all, is most likely to be based on local prototypes. Palyvou suggests that at Akrotiri such cornices protected building exteriors and timber structure from rain and dampness, but also that they were also important simply for the sake of their appearance (Palyvou 2005, pp. 116, 160). Apparently the cornice blocks were structurally independent of the floor structure.

[433] Palyvou 2005, pp. 115-116, 180.

[434] Palyvou 2005, pp. 115, 118, and fig. 157.

small scale at Tylissos[435], a major initiative occurs in the Mesara in south central Crete, at Kommos[436] but especially at Hagia Triadha where elegant, imaginative «public» building replaced the earlier stylish residences[437]. There some of the Neopalatial techniques continued in use, for instance the method of setting columns within stylobates (as in *fig.* 129)[438], or (somewhat different) pier-and-door partitions (*fig.* 188), or the use of «single-block» pier or pillar bases (again, with a difference)[439]. One apparently new technique, but reminiscent of that used in connection with earlier orthostate construction (*fig.* 87), was the introduction, at the base of the exterior wall, of a finely crafted ashlar course upon which were laid wooden beams. A first instance is in well-preserved Shrine H (*fig.* 125 a) where the wooden «course» was surmounted by at least three courses of fine ashlar[440]. Also, a gap in each of the northern and southern walls shows that a vertical beam was once socketed into the wooden course that ran below. In turn they were probably linked to other horizontal wooden beams above, set at ceiling level.

A similar methodology was followed in at least two contemporary structures at Hagia Triadha. The first was in Building P, where a horizontal wooden beam was secured to an ashlar course facing the eastern exterior wall by rectangular (rather than the usual square) dowels[441]. The second is the «Megaron» (Building 'ABCD') where the finely made, mortised ashlar base course (*fig.* 125b) was surmounted by a beam which, like the Shrine in *fig.* 125 a, could also have supported ashlar construction.

In the LM III Stoa at Hagia Triadha, without precedent plan-wise in the Aegean, the «low-block» pillar type alternated with columns in the colonnade, but simple rectangular

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435 Hayden 1984. The closest dating possible of the Postpalatial remains there is LM III.

436 While reuse and rough extension was the rule in the Kommos town, a huge building, LM III Building P, consisting of six galleries perhaps for housing ships, was built over its Neopalatial court-centered predecessor, Building T. Architecturally, P is distinguished by its size, for now the largest Minoan building of its date. From the technical point of view it is perhaps most informative for the nature of its re-use of building materials quarried from T's collapsed walls. The façade on the northeast, for instance, is composed of reused ashlars roughly coursed, with wide joints featuring the usual clay mortar but stone chips as well (*Kommos* V, pl. 1.43, right, 1.78A, 1.81). The façade of the same wall, but to the north, quite monumental in scale, featured a roughly made horizontal course of wood with vertical timbers at intervals, all binding together courses of mixed ashlar and rubble (*Kommos* V, pl. 1.78B-D, 1.79), reminiscent of the technique used in interior walls in the Residential Quarter at the Knossos Palace.

437 There appears to be a gap in major construction between LM I and before LM IIIA2 when the first large buildings (P at Kommos and ABCD and H at Hagia Triadha) arose (*Kommos* V, and for the second site, Vincenzo La Rosa, personal communication). At Knossos little elaborate building is reported during LM II, with the exception of the possible LM II «Gypsum House», made partly of reused materials, near the Stratigraphic Museum (Warren 1983, pp. 63-65, figs. 2 [top], 3-4). For the later use of gypsum at Knossos, see also Driessen 2007 b, p. 181. For the perspective of «Mycenaean» or Mainland Greek styles in post-LM I Crete, see J. Wright 2006, pp. 21-22.

438 Cucuzza 2001, in the south court (Ciosco E) and Stoa FG; seen also in the LM III stoa at Tylissos (Hayden 1984).

439 See *fig.* 203 and M.C. Shaw 1999.

440 This may be the best preserved example of fine LM III ashlar work. The cement now filling the chase where the beam was has obscured any (probable) dowel holes that might be there. Palyvou (2007 b, p. 40) notes that Minoan ashlar walls were usually not interrupted by beams unless they were at lintel level. The custom was common, however, in Mycenaean architecture on the Mainland (e.g. Wright 2006, figs. 1.15 a, b).

441 Cucuzza 1997, p. 78 and note 16. Both rectangular and square mortises were used in the Mesara area (cf. our *fig.* 208). Of interest from the structural point of view is that this thick (ca. 1.75 m) exterior wall appears to have been built as if in two separate parts, with a presumed ashlar face acting rather like a veneer on an interior wall of rubble consolidated by lime mortar. See Cucuzza 1997, p. 78 and fig. 6. It is therefore unlike the wall in the Shrine (our *fig.* 125a) where the wall would collapse if the ashlar work were to be removed.

jamb-bases, rather than Γ-shaped Neopalatial style bases, were used in the numerous doorways opening on to the stoa. Also, in the U-shaped stairway leading from one level to the next in the same building, typically Neopalatial style mortised end blocks (*fig.* 204b) were not used to reinforce the end of its 'spine' wall[442].

Plaster on Ashlar Façades

Most of the joints between blocks are now open, with only the mud mortar used between the blocks showing. However, traces of plaster at certain points of ashlar walls (*figs.* 51 [2], 63c, 124, 126, 127) suggest that the joints were originally sealed. Such a filling would have been essential for three reasons: to minimize the moisture which the poros stone and dry earth used in the wall would draw in from the exterior; to protect wood, sometimes used within the walls, from rotting; and to prevent the mud-plaster on the interior wall face from splitting away in sections and carrying along with it the thin lime plaster coating applied over it. Additionally, it would reduce the moisture within the room itself.

The lime plaster, about half a centimeter thick, was applied to the vertical and horizontal joints after the mud mortar had dried and, in at least one instance, probably after the faces of the blocks were given their final smoothing (*fig.* 51)[443]. In some cases the plaster was spread evenly out from the joints for a few centimeters or more, so that each joint of many wall blocks was marked in ancient times by a ribbon of white plaster up to ten centimeters wide (*fig.* 126). Occasionally, plaster penetrated over two centimeters into the joints themselves. The same plaster was used liberally in the joints at the base of the walls, where the first course rests on the krepidoma, as can be seen at Zakro (*fig.* 120) and Hagia Triadha.

Interestingly, this custom of plastering between courses is used in modern ashlar walls on the Greek island of Syros, but with cement replacing the lime plaster. No doubt this attractive technique, which was adopted consistently for some Minoan walls, developed from the efforts of the masons to force plaster into the joints with a trowel or flattened tool, which left a slight surplus about the joint. To judge from the impression of a finger that was drawn along the plastered joint of a pillar block at Phaistos, hands were sometimes used for this work (*fig.* 127)[444]. A tool which I have tentatively identified as a trowel for «pointing» masonry joints can be seen in *fig.* 246.

Here arises the question of whether the entire surface of an ashlar wall was plastered over. Hitherto, this has been assumed to be the case. Heaton, who studied specifically plaster decoration at Knossos, concluded that although evidence for the complete plastering of light-wells was inconclusive, «as regards the exterior of a Late Minoan Palace, it presented an expanse of white plaster, relieved in places perhaps by flat washes of color or some decoration»[445]. The excavators of the Palace of Phaistos came to the same conclusion as Heaton[446]. After close observation of the various examples, however, I am inclined to believe that this is generally not true.

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[442] I am indebted to Nicola Cucuzza for the information about the 'spine' wall in the staircase. This implies (but it only one, and a unique example at that) that the style of staircase construction did not carry on beyond LM I in Crete. For Minoan stoas see *Kommos* I, Table 1.4. For the stoa being discussed, see Cucuzza 2001. The latest example of the Neopalatial-style staircase construction mentioned may be the «Gypsum House», possibly of LM II date, at Knossos, for which see Warren 1983, *fig.* 3, end-block with mortises just visible, of stairway in center, right of illustration.

[443] See Appendix F, no. 5, for an analysis of plaster used to seal a joint at the Palace of Kato Zakro.

[444] An almost exact parallel to the finger marks in our *fig.* 127 at Phaistos can be seen at Akrotiri on Thera (Palyvou 2005, fig. 161).

[445] Heaton, p. 704.

[446] *Festòs* I, p. 185, figs. 77, 78; II, p. 430, fig. 139; Levi 1956, p. 239; *Guida*, p. 40.

My major objection to this general theory is that plaster, found only at the joints of the blocks, has been unjustifiably assumed to be the only trace of a coating that covered the entire wall. Heaton infers the same from the presence of plaster which overlapped the edge of bottom wall blocks, where they joined the krepidoma. The evidence from Phaistos is comparable, and the illustrations used by the excavators in support of their statement show plaster only at joints between blocks, especially those at the level of the krepidoma.

If plaster had been used as extensively as Heaton and others maintained, I find it difficult to believe that it would not have been preserved on most of the walls that it covered. The strong, thick coat of plaster which we find at the joints could not have weathered away from the entire surface on which it was applied, and still have been so well preserved around the joints. I myself tested the tenacity of the plaster while gathering samples for this study. It could not be chipped off in flakes from sandstone or poros limestone blocks, but had to be ground off in powder form with a knife.

On the other hand, at Malia there are definite traces of a thin (1 to 2 mm) covering of plaster on the faces of some of the blocks of the West Façade (*fig.* 255 b). This coating does, admittedly, imply that at least the lower blocks of the façade were plastered over. At many Minoan sites, however, this was probably not the case. Certainly at Zakro, where the furthest extent of the plaster is clearly visible (*fig.* 126), there is no indication of plaster in the center of the block's face.

I conclude, therefore, that ashlar masonry used in most Minoan buildings remained uncovered, the natural color of the stone remaining visible. Occasionally, as at Malia where a particularly friable sandstone was used for most of the walls, they were covered with a thin layer of «whitewash». Elsewhere, thick plaster was applied instead only around the joints themselves, occasionally forming decorative bands.

Among the faience plaques from Knossos, described as the «Town Mosaic», there is a number showing buildings constructed of coursed ashlar masonry[447]. Relatively wide separations between the blocks of these buildings were interpreted by Evans as thick layers of clay mortar which, as already mentioned, he thought to be characteristic of the MM II period. The separations between the blocks, he thought, confirmed a MM II date for the plaques[448]. It is more likely, however, that what is being portrayed is actually the wide plaster strip covering the joints. Some of these strips on the Town Mosaic are dark (painted?); others are the natural white color of the plaster. A similar interpretation can be applied to the white lines between blocks shown on a small terracotta shrine[449].

«Mason's marks»

The term «mason's mark», when used in reference to Minoan architecture, describes a variety of symbols incised during Minoan times (MM I - LM III)[450] on gypsum, poros limestone, or sandstone blocks[451]. The marks do not occur in village architecture; villas have a few, but the palaces, especially those in Central Crete, may have as many as a few hundred

[447] As *Knossos* I, fig. 226, nos. S, T, U. See also fig. 223, bottom row.

[448] *Knossos* I, p. 301; see also *A. of C.*, p. 132.

[449] Shown in *Knossos* I, fig. 225; another, *Knossos* II, fig. 101.

[450] The earliest are those in the MM IB foundations of the Knossos Palace (*Knossos* I, fig. 97) while the latest in Crete may be some in LM III construction at Hagia Triadha (Cucuzza 1991, pp. 57, 59).

[451] For an extensive bibliography see Sakellarakis 1967, especially p. 277, n. 4. That article reported the discovery of five such signs on blocks belonging to the important Minoan building there at Archanes (*fig.* 123 a-c). Its real importance, however, was in the summaries of the varieties of past opinion, before reaching a conclusion. Many of these opinions are summarized in

each[452]. The term «mason's mark» is drawn from the name given by archaeologists to signs of an alphabetic or numerical nature on blocks of Classical Greek buildings, where it is clear they aided the workmen in the process of assembly and construction. In Minoan architecture, however, there is as yet no clear proof that these signs performed a similar function, even though it is evident in some cases that people involved in the cutting or assembling of the blocks carved the signs. These people could have been the masons themselves or others empowered with special responsibility, such as foremen, overseers, or even priests.

The signs, of which only a few are illustrated here as examples (*figs.* 128a, b), have been variously interpreted in the past as symbols of gods[453], as having a «religious meaning»[454], as a means of sanctifying a building[455], or as having a practical purpose such as the positioning of blocks[456]. The presence of two signs on the same block was also thought to indicate two different stonecutters[457]. The belief that the signs were made by some of the masons and used by them has been held by Mosso, Dussaud, Chapouthier, Nilsson, Pendlebury, Shaw, and Myres. It is also believed that the signs have an alphabetic value[458] and that they have a purely decorative function[459].

In view of the variety of interpretations, I prefer here to present what tangible information we have about the signs rather than attempt a more extensive summary and lengthy interpretation:

1. The signs are consistently the same at various Minoan sites but are not fully represented at each site. Some signs, however, seem to enjoy more popularity at certain sites, such as the double-axe[460] at Knossos, and the trident and the cross at Phaistos[461]. The size and shape of the individual signs are inconsistent from site to site and within the same site, the signs ranging from about 3.5 cm to as large as 72 cm[462]. The greater size and depth of the incision has been taken to be an indication of an early date[463]. The placement of the signs on the face of the blocks seems to be inconsistent and insignificant, as is the direction in which each individual sign is inscribed[464]. The same signs continue in use over a long period of time, an indication that they are not casual doodles.

2. There is no proof that such marks guided the placement and orientation of individual blocks within a specific structure, as classical mason's marks did[465]. There is some indication, on the other hand, that sometimes the signs could indicate points of orientation. For instance, the trident, incised on many of the blocks in the North Wing at Knossos, could be pointing in the direction of the sea[466]. Also, signs at Malia seem to be roughly distributed by type in various areas of the palace[467], as they do at least in parts of the West Wing of the Knossos Palace[468], This may equally signify that identical signs symbolized the characteris-

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my own text. See also Graham's short discussions in *P. of C.*, pp. 154-155. For two important new examinations and proposals with up-to-date citations see now Begg 2004a and 2004b.

452 Begg 2004a, p. 17.

453 Sakellarakis 1967, p. 285 (Rouse).

454 Sakellarakis 1967, p. 285 (Glotz, Picard, and more recently Hood 1987, pp. 205, 210); a view opposed by Nilsson.

455 Sakellarakis 1967, p. 285 (Evans, Karo, Mosso; Shaw in *MA:MAT* 1).

456 Sakellarakis 1967, p. 286 (Evans, Pernier, Reinach).

457 Sakellarakis 1967, p. 286 (Evans, Reinach).

458 Sakellarakis 1967, p. 285 (Evans, Reinach, Burrows, Pernier, Xanthoudides, in part by Chapouthier).

459 Sakellarakis 1967, p. 285. (Pernier, Ventris, Chadwick).

460 Sakellarakis 1967, p. 285.

461 Sakellarakis 1967, p. 285.

462 *P. of C.*, p. 154.

463 *P. of C*, p. 154, also Sakellarakis 1967, p. 286, n. 144. Hood (1987, p. 205), who has been preparing a corpus of the marks, still thinks of this as being generally true.

464 Sakellarakis 1967, p. 278.

465 As for instance those in Martin 1965, p. 227, fig. 106.

466 *P. of C.*, p. 155; *Knossos* I, p. 394.

467 Sakellarakis 1967, pp. 285-286.

468 Begg 2004a and 2004b, and below.

tic function of the area in which they are concentrated. There is also a third possibility, that groups of workmen or «guilds» of masons working in the specific areas used them as identification signs[469].

3. There is evidence that at least some signs were not visible after the blocks on which they were engraved were set up, either because they occurred on the inside face of a block, and thus were hidden by wall construction[470], or in other cases because they were on foundations below floor or ground level[471], on the undersides of blocks[472], on the upper surfaces of blocks which would have been covered by the wall above[473], or were covered by plaster or were not visible in drainage channels[474].

Pernier decided that if the marks were invisible a religious significance was precluded. This is not necessary, however, for a religious symbol can be believed to exert its magical effect even when it cannot be seen. To draw a modern parallel, religious inscriptions appear in a zone around the wall right under the ceiling in mosques where, because of the darkness and their height above floor level, they cannot possibly be read by the worshippers below. It is clear, in any case, that at least some of these obscure signs were incised when a building was in the process of construction or even before the blocks were set in place. Pernier believed that some signs were inscribed before leaving the quarry[475].

4. From the philological point of view, there is enough similarity between some of the marks under discussion and the still undeciphered signs of the Linear A and Hieroglyphic Scripts to suggest that there is some connection between them, although this connection still remains undefined[476].

5. In some cases, signs concentrate on certain pillars and walls as, for instance, at the Zakro Palace where five of the double-axes appear on a single wall in Room xxx. These represent more signs inscribed on blocks in situ than in the remainder of the excavated Palace. At Knossos 29 signs of the double-axe, certainly a religious symbol in many Minoan contexts, are cut into the eight blocks of the two pillars in the crypts west of the Central Court[477]. All these signs could not have had a practical, purely secular function as proposed by some. Rather, I suspect that the people who carved them there hoped either to obtain a special grace from an area that was already sacred, or to sanctify the area by the religious nature of the signs themselves[478].

Actually, the marks' broad chronological range and variety may not be compatible with simple, general explanations for them all. Possibly signs incised at different times and/or places originated through differing circumstances. Most recently, in a departure from the

[469] *Knossos* I, p. 134, an interpretation that still seems likely for at least some signs.

[470] Evans 1904-1905, fig. 11, p. 22.

[471] *Festòs* II, p. 423, fig. 270.

[472] *Festòs* II, p. 423.

[473] As the wall illustrated, *Festòs* I, fig. 238.

[474] Sakellarakis 1967, p. 285, n. 116; *Knossos* I, p. 133; II, p. 818; Evans 1902-1903, p. 29; *Festòs* II, pp. 413, 424.

[475] *Festòs* II, p. 423. Since he wrote, single marks have been reported in three quarries, one at Palaikastro (Driessen 1984, p. 149 and *fig.* 24 here), another at Malia (Whitley 2005, p. 108, fig. 156), one near Kommos (Watrous 2005, p. 291 and pl. 10.2), and ten near the Bronze Age quarries on Ailias east of Knossos (Hood 2002, p. 101). The circumstances of each sign, however, hardly ensure that signs on blocks in buildings were incised in the quarries rather than at the building sites (see Chapter 1 on quarries here, as well as Begg 2004b, p. 221).

[476] Knossos I, p. 134; Sakellarakis 1967, *passim*; Hood 1987, p. 208.

[477] *P. of C.*, p. 155.

[478] In their own evaluations, Sakellarakis and Graham favor a religious interpretation. For his purposes, Graham concluded that the marks offered «little hope of providing information useful to the student of Minoan architecture». See also Hitchcock 2003.

usual approach, Begg[479] focused on a limited number of LM I signs (the cross *pommé*, the double-axe, the star, the gate, and the branch) lightly engraved on wall blocks in the West Wing Magazines of the Palace of Knossos, where they occur in groups within architecturally definable areas, the storeroom blocks that project out into the West Court. He concluded that the groupings are to be associated with gangs of workmen responsible for completing adjacent projects[480], not unlike suggestions made by others in the past[481]. Such an approach could lead to our exploring more thoroughly why, for instance, the signs usually occur only in palatial contexts – perhaps the «palaces» were, in their own ways, thought to be community buildings and so groups within a particular area or community played specified roles in building construction[482]. If similar patterns can be isolated elsewhere, then a single coherent explanation for at least some of the signs at different sites during specific periods could be welcomed. It would still not «free» us, however, to disassociate the signs from aspects of religious motivation, for the palaces clearly played important roles in social and cultic activity, and those building them were participating in the cultural activity celebrated within them.

E) Special Uses of Cut Stone (*figs.* 129-172)

1. Column Bases

Although a stone intended for column bases was sometimes chosen for its decorative qualities, such as color or veining, its strength was of primary importance[483]. A base had to be able to retain, without fracturing, the load transferred down from the architrave by way of the wooden columns. Besides, since many columns were set alongside courts, the stone bases which elevated them slightly above floor level had to withstand rain as well as freezing weather. For these reasons soft poros limestone or sandstone were rarely used, and gypsum bases appear only on interiors or in the sheltered parapets of staircases.

Stone types employed for bases were varieties of limestone, gypsum, schist, marble, opheiolite, and conglomerate. This is true for at least 90 percent of the bases which I have seen on Minoan sites[484].

The stone most commonly used for bases is a hard bluish or dark gray («boulder») variety of limestone, called «sidheropetra» (ironstone) locally. Such stone is rare in Central Crete[485] but as one progresses eastward, where this stone becomes more plentiful, bases made from it appear more frequently, becoming dominant at Zakro. Other bases are made of a white or creamy limestone[486]. Unlike ironstone, this is the most common type of base at Knossos (*fig.* 134), appearing at Phaistos as well. A crystalline limestone of a dark blue, gray, or red

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[479] Begg 2004a, and 2004b.

[480] Begg 2004a, p. 20; 2004b, p. 221.

[481] Begg himself notes (2004a, note 166): Boyd Hawes, Chapouthier and, more recently, Driessen (1989-1990, pp. 20-21).

[482] Marks might also play a role in suggesting aspects of building function. For instance, at Akrotiri on Thera, where many mason's marks occur chiefly on one building (Xeste 4) (Palyvou 2005, pp. 181, 130-131), the building may possibly have played a communal role.

[483] Here I deal exclusively with the varieties of material used, the shapes, and methods of setting up Minoan column bases. See also the section here on building stone (p. 17). For more specific information about the use and arrangement of columns (p. 104), the reader is referred to the chapter here dealing with wood and to Graham's account in *The Palaces of Crete*, pp. 190-197 and *passim*.

[484] The composition and geographical distribution of over two hundred bases is given here in Appendix B, p. 180. Since the Table is arranged by site, one can compare the use of various stone types by region.

[485] See distribution in Appendix B, p. 180.

[486] The same stone is used for jamb-bases, exterior walkways and interior pavements.

color, streaked by orange or white veins, also occurs in Central Crete; it is most attractively used at Phaistos where it is so placed as to contrast with other bases of different colors set nearby.

Gypsum bases occur mainly at Knossos, where gypsum was used because of availability and its decorative effect. With the exception of Myrtos-Pyrgos, gypsum was rarely used extensively east of Nirou Khani. Although such bases appear occasionally at entrances, as for example at the Western Entrance to the Palace of Knossos (*fig.* 2), they generally occur in connection with parapets alongside stairways.

Bases of green calcareous schist and white cipolin marble seem to have been used only in the region of Malia. White marble bases seem to be confined to the north and east borders of the Central Court there, but the green ones appear along the earlier façade of the West Wing of the Palace, facing the Central Court (*fig.* 137), as well as in Houses E and Za, and at Chrysolakkos. Along the east side of the Central Court the beautiful white bases alternate with piers on a stylobate (*fig.* 132), while on the north they are set in a long, continuous row (*fig.* 135).

Green opheiolite bases, locally called «serpentine», were used at Phaistos (*fig.* 56), and there is one example at Hagia Triadha, in the small light-well northeast of Room 13 (*fig.* 241a). There is a base of a more compact type of limestone mixed with opheiolite at Kato Zakro, in Room xxviii (*fig.* 136D). Bases of the material were also used at Knossos[487] and Palaikastro[488].

Conglomerate was rarely used for any building purpose, although it was occasionally used for bases (*figs.* 18, 131). Like other stones it was often used for the sake of contrast between bases set into a stylobate.

As noted earlier here, there is a good deal of evidence that Minoan architects deliberately combined special types of stone for the sake of their visual appeal. Such a contrast is particularly noticeable in pavings, especially at major palace entrances, such as the Western Entrance to the Palace of Knossos (*fig.* 2) or the Northern Entrance to the Palace of Malia (*figs.* 4-6). The same principle is evident in their choice of column bases at certain Minoan centers where polychrome and veined stones were used with discrimination. For instance, bordering the court of the establishment at Pyrgos near Myrtos-Pyrgos there is a single veined red-limestone base set into a white gypsum floor. Along the court side the stylobate is bordered by a line of irregular reddish stones and, in turn, they are paralleled by a fine walkway of squared white limestone slabs. Bluish-gray slabs of ironstone make up the remainder of the preserved court surface. Polychromy was sometimes achieved in East Crete, however, at sites such as Palaikastro and Zakro, by colored plastering and perhaps by the use of woven materials. In Room xxviii at the Palace of Kato Zakro there seems to have been a conscious attempt at polychromy in the use of stone. In that room the four bases in the stylobate of the light-well (*figs.* 129) are of a gray ironstone, and of the three bases (aligned north-south) to the east, the two smaller ones are of hard white limestone, while the larger is of a hard limestone mixed with green opheiolitic material (*fig.* 136).

We find the white marble bases, already mentioned above, used at Malia along the north and eastern sides of the Central Court (*figs.* 132, 135). This court was only partially paved with limestone slabs, so that the vivid contrast between the white marble and the reddish color of the earth must have existed in ancient times. The present color of the earth is typical of the entire plain in which the large Minoan city was built.

At Knossos, the three column bases in the Southeast House, for example, are, respectively, of fine-grained white limestone, gray limestone, and reddish conglomerate. In the

[487] Hatzaki 2005, p. 69.

[488] Driessen 1999, p. 232; 1998, p. 249.

Palace itself, the use of polychrome stone for bases was apparently most typical of the MM II-IIIA period[489]. To the south, at Vathypetro, each of the three bases at the entrance to Room 1 of the mansion was of a different type of stone, one being grayish-blue ironstone and the other two of conglomerates quite different in color and texture.

At Phaistos and Hagia Triadha, such colorful effects are fairly common. In the Peristyle (Room 74) of the former, there was probably an attempt to alternate between the colors of gray and blue veined limestone, or at least to contrast them[490]. The main ceiling beam of a corridor south of this room was supported from below by a column resting on a large base of hard blue limestone laced with veins of calcite. The Great Propylon of Phaistos, part of the Late Palace, had at its entrance a base of hard blue limestone with white veins, while the three huge bases in the light-well directly to the east (Room 69), beyond the main doorway, are of bluish ironstone, hard whitish poros limestone, and conglomerate (*fig.* 131).

At Hagia Triadha polychrome bases were also used, but since much of the court area is destroyed, we are limited to a few examples. For instance, there is a red limestone base east of Room 16 and there are three bases north of Room 14. One of the latter is of green opheiolite and the two others, each of a different shade of red limestone, are set into the stylobate of a small light-well (*fig.* 241a). There is also a single, cruciform-shaped base of diabase in Room 21 (*fig.* 150)[491].

Column bases were either set within a «stylobate»[492] or partly inserted into floors and pavements. The method of setting bases into a stylobate should be emphasized, for it is typically Minoan. The stylobate slabs were cut at one end in a half-circle, slightly larger than the diameter of the base (*figs.* 129, 133, 134). Two slab-ends thus cut embraced the base when they were set in place, and gaps between slabs and base were often plastered to ensure a waterproof joint[493]. Sometimes the stylobate slabs were finished along only one side, the side that would be seen from the light-well or court upon which the columns faced. The other side was often left rough, covered over with plaster, dirt, or paving. Since it was not visible, it was apparently not worth perfecting, a philosophy which is traceable throughout Minoan construction.

In contrast, setting columns in position, as in *fig.* 141, might appear simple, perhaps because our information about some of the nuances of technique is limited, but the Minoans could take great care with this task. At Kommos, for instance, column bases of the South Stoa provide suggestive information about how both their relative elevation and position were achieved. As to the first, when a base was removed from its sub-base, as in *figs.* 147a, b,

[489] *Knossos* I, pp. 211-213. For more information about these bases, see the end of the section here on building stone (p. 28) and the end of this section on column bases.

[490] However, not all of the bases that can be seen in this room now are in their original positions. According to pl. VI in *Festòs*, only the two northernmost bases on the western and eastern sides of the peristyle were found in situ.

[491] For more information on serpentine, see Warren 1965, pp. 154-155, and ns. 11 and 12. Professor Papastamatiou identified the stone as diabase (diorite), whereas Halbherr, Stefani and Banti 1980, pp. 155-56, fig. 98 identify it as serpentine.

[492] Like «mason's mark», the term «stylobate» is borrowed from Classical architecture, in which the columns rested directly upon floor slabs rather than having separate bases set within them. The slabs of soft stone used for stylobates by the Minoans could hardly have withstood the strain of the columns. The only instance of which I know where the term «stylobate» can be accurately applied in the sense used in Classical archaeology is at Knossos, where apparently four columns of the «Tripartite Shrine» rested on a series of cut slabs alongside the Central Court (*Knossos* II, p. 804, figs. 525-527). Panagiotaki (1999, pp. 235-238) has questioned whether columns were positioned here at all. Also, along the eastern side of the Central Court at Malia, columns (or posts) were set directly on slabs and stabilized from below, to judge from the mortise holes visible, by means of wooden tenons, about 8 cm to 12 cm in diameter. See also *P. of C.*, p. 77.

[493] The technique was not as generally used in the Mesara region as elsewhere. In the Mesara, slabs occasionally ended at right angles, such as in *fig.* 150.

it was revealed that a thin layer of pebbles had been placed there to improve stability and, probably, to adjust the base to a predetermined height. As to the second, and as seen in a section (*fig.* 130), the column bases in that stoa were set on a stack of large slabs continuing down below central court level to the solid clay bedrock, a technique also used at Knossos (*fig.* 156). When the uppermost, triangular slab below the easternmost Kommos column was cleared, a series of straight grooves carved by the masons at a tangent to the base (*fig.* 148b) became visible. The purpose of the lines is unclear. Were they incised to mark the exact spot where the column base was to be set? If so, why are there so many tangent (and other) lines when surely three would suffice for positioning? If the column base were removed (which it has not been), possibly some of the lines would be found to continue below the base, which would tend to confirm this possibility. On the other hand, the lines may have been incised after the base was already in place, which might suggest that the lines were made in order to mark the exact spot, so that the column base could be removed temporarily and then reset, perhaps at a slightly higher or lower level, by adjusting the thickness of the layer of pebbles placed between it and the triangular foundation block below[494].

An interesting application of the technique of fitting can be seen at the Palace of Kato Zakro, along the stylobate of the East Wing facing onto the Central Court. Here a base, now missing, was set within a stepped stylobate and was stabilized on either side by slabs cut so as to fit about it.

In some cases, as at Phaistos, stylobates were set on foundations over two meters deep (*fig.* 153) and were held in place, especially if they were short, by piers or pilasters set within or cut out from the walls at either end, as at Archanes (*fig.* 123b).

Many bases were simply set directly into floors or pavements, from which they often projected slightly in order to protect the bottoms of the wooden columns from dampness (*figs.* 136, 138). Usually the finishing of the bases was carried down only to floor level (*figs.* 136, 137, 146).

The amount of projection of such bases seems to vary not only from site to site but, at least in the case of the Palace of Kato Zakro, within the Palace itself. This leads me to conclude that exact calculations as to the height of bases above floor level were never made by the Minoans. The maximum amount of projection is represented by that of three large bases set in a row within the Propylon at Phaistos (*fig.* 131) and the column base within the Northwest Portico at Knossos, the former projecting 25 cm to 30 cm above the stylobate, the latter about 10 cm[495]. At Phaistos, the average projection above either stylobate or pavement is a few centimeters[496]. In some cases, however, the projection was even less, as in the case of the bases set flush with or slightly below the level of the stylobate along the eastern edge of the Court at Malia (*fig.* 132), or the disk-like bases of gypsum or limestone at Knossos[497] and Phaistos[498]. Also to be mentioned in this connection are bases simply set on floor or pavement level, so that their «projection» is actually their total thickness. Examples of this type exist in the Peristyle (Room 74) at Phaistos where the disk-like base rises 20.5 cm above the floor[499] or at the Palace of Kato Zakro where the two disk-like bases, each about 30 cm thick, are set on the pavement of blocks in the veranda (Room xxxiv) (*fig.* 140).

Many bases are drum-shaped (*figs.* 136, 145); others are lower and more disk-shaped (*figs.* 139, 140, 142). Some examples, beautifully executed such as are most of those from

[494] For the technique, see *Kommos V*, p. 93.

[495] The height of the base from Knossos is 0.55 m (*Knossos* I, p. 422; III, p. 361).

[496] *Festòs* II, p. 472.

[497] As in *Knossos* I, p. 441, fig. 318; III, p. 165, fig. 109a.

[498] As in Levi 1957-1958, figs. 166-168.

[499] *Festòs* II, p. 350.

Kommos (*fig.* 148a), are truncated cones. Another common type consists of a large stone or boulder, the lower, unworked part of which is embedded below floor level, with only a dressed and polished cylindrical projection, tapering slightly towards the top, appearing above floor level (*fig.* 146).

Oval bases occur mainly at Phaistos and Knossos, as for instance the four polychrome bases of the Propylon (*fig.* 131) or the two at the South Propylon at Knossos[500]. The shape of the bases implies that oval columns were set upon them. Perhaps the columns were made up of two or more tree-trunks adzed along their sides and then joined, for they are of substantial size, ranging from 0.91 m to 1.42 m in their minimum and maximum horizontal measurements. The probability that the shape of the base and that of the column may have some connection is suggested, at least at Phaistos, by the fact that the major axis of the base is parallel to the architrave[501].

Semi-circular bases for «half-columns» are known only at Phaistos, where they occur on either side of the entrance to Corridor 41 from the Central Court (*fig.* 159). Here the bases are actually only portions of large slabs of hard white limestone, cut with a semicircular projection on which one end of the vertical timber was set[502]. Square or rectangular bases exist in various materials. Some are set on or near ground floors (*fig.* 143); others are elevated to second-story levels on piers (*fig.* 157); but it is difficult to say whether there was a round column or a squared post set upon them. At Knossos, for instance, along the front of the Stepped Pavilion of the Caravanserai, a circular column has been restored on a rectangular base[503]. A circular column was also restored on the parapet of the Lustral Basin of the Queen's Megaron at Knossos, where the carbonized remains discovered by the excavators were roughly circular[504]. On a similar, nearby parapet (*fig.* 15D)[505] a square pillar topped by a stepped cornice has been restored. There is no reason, therefore, to believe that square or rectangular bases require square or rectangular wooden supports above. A case in point is the beautiful white-speckled base of dark gray diabase, 37 cm by 37.5 cm, in Room 21 at Hagia Triadha (*fig.* 150). This sawn base is cruciform in shape, with a small «step» left in each of its four interior angles. On its upper surface, and barely visible in the photograph here, is a definite roughening which now appears circular but which, when first exposed in excavation[506], had the form of a square with indented corners. The roughened area can only be the unpolished surface on which a perhaps unique pillar, probably wooden, was designed to rest. Such intentionally rough areas on bases are not uncommon.

In some cases, as in that of gypsum parapet slabs from Knossos (*fig.* 151A) or Phaistos (*fig.* 151B) both base and slab were cut from the same block of stone[507]. Also at Knossos, the columns of the stepped parapets alongside the Grand Staircase either were set directly into

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[500] *Festòs* II, p. 323; *Knossos* II, p. 688.

[501] *P. of C.*, p. 194.

[502] It has likewise been suggested that columns may have been placed at the southeastern entrance to the Palace of Malia (*Mallia* III, p. 8 and n. 2) as well as at an early phase of the West Entrance to the Palace of Knossos (*Knossos* I, pp. 670-671, fig. 426), but as the excavators themselves state, there is no concrete evidence for their existence. Actually, the bases at Phaistos may not have been for half-columns at all. Graham has suggested (*P. of C.*, p. xii, reprinted ed. 1969; Graham 1970, pp. 232-234) that on them were set tall masts topped by banners such as Alexiou has recognized in various representations of Cretan sanctuaries (cf. Alexiou 1963, pp. 339-351; 1969, pp. 84-88).

[503] *Knossos* II, fig. 49.

[504] *Knossos* III, p. 381, n. 3, fig. 253.

[505] *Knossos* I, fig. 261. The pillar here may simply be Evans's means of supporting a large gypsum block found here at a higher level. For an idea about the remains at the time of excavation, see *Knossos* I, pp. 360-361.

[506] Halbherr, Stefani and Banti (1980, pp. 155-156 and fig. 98) reported it as being of serpentine.

[507] For the former, see *Knossos*, I, p. 410, figs. 293, 294.

sockets cut in the parapet slab (*fig.* 151C)[508] or, as Evans's perhaps incorrect restoration suggests (*fig.* 152), were set upon separate bases placed in the sockets[509].

The size of column bases usually varies according to the load to be carried and the size of the column shaft necessary to support ceiling and architrave beams. Diameters of bases range from as small as 0.32 m (Zakro) to 1.42 m (Propylon at Phaistos), although the majority are 0.35 m to 0.60 m in diameter. There appears to be no standard size between sites, nor at any one site, not even in the case of groups of bases probably manufactured at one time and of the same material, for use in a colonnade[510]. Bases which can be examined from all sides, most often those which are no longer set in their original positions, are not uniform in height, a nicety that must have been considered unnecessary by the builders, since most of the base was hidden below floor level.

We can be sure that some columns had dowels projecting from their lower ends, as shown by single mortises, ranging from 5 cm to 14 cm in diameter and from 2 cm to 14 cm in depth, drilled in column bases, usually in their center. It is most probable that these holes received tenons projecting from the bottoms of the wooden columns that stood upon the bases, for they do not seem to have any connection with the process of manufacturing the bases[511]. One oval base (*fig.* 149) has two drilled holes. The 14 with single holes are from only four sites (Hagia Triadha [3], Knossos [1], Malia [6], and Phaistos [4]), and are listed in Appendix C. Seven are not in situ, so cannot be used in a study of their ancient contexts. Of the 7 remaining, 4 are in situ in Protopalatial contexts (1 from Phaistos, 3 from Malia); and 2 are in Neopalatial contexts at Hagia Triadha. Such bases were used more often at Malia (6), and then during the Protopalatial period.

The two in MM II Quartier Mu at Malia are a pair (*fig.* 139), each with a single mortise, set alongside a light-well (*fig.* 184). The third at Malia (*fig.* 142) also belongs to the Protopalatial period, for it is set in the First Palace remains below the level of the later North Court Area. Of the over two hundred bases known from Neopalatial contexts, only two are mortised. Those are at Hagia Triadha, in situ in the western part of the Villa. It is suggestive that one of the two is in an almost miniature portico (*fig.* 241a) along with two «normal» bases, which implies that the mortised base is in reuse in its present position[512].

If mortised column bases are a MM, probably Protopalatial phenomenon, then we can suppose that such bases were not made during the Neopalatial period. In other words, a specific MM mortising technique was abandoned to favor bases with undrilled upper surfaces. One wonders, therefore, why the tenon type went out of use. One general explanation that I can think of, since the custom was ongoing at at least four major sites, is that tenoned columns, once relied on, turned out to be liabilities during an earthquake, for they could not shift and thus reduced the elastici-

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Evans thought the base at Knossos to be an «archaic touch» in conformity with usage during the Protopalatial era.

[508] One of these slabs, partially preserved in fragments, was found at Malia (Mallia, *Centre Politique*, I, pp. 51-52, pl. XV) but was not recognized as such by the excavators.

[509] Such inset bases seem to be missing in excavation photographs (*Knossos*, I, fig. 238).

[510] As, for instance, along the eastern border of the Central Court at Malia (0.645, 0.63, 0.65, 0.60, 0.64, 0.57 m) or along the western border of the Central Court (0.57, 0.62, 0.57, 0.53, 0.50 m), or along the northern border (0.59, 0.56, 0.63, 0.61, 0.53 m).

[511] I think that since no corresponding hole appears on the other side of the bases, it is doubtful that the bases were gradually cut on a lathe. Also, the fact that sometimes the hole is not in the center of the base (*fig.* 142) makes it unlikely that a compass-like instrument, with one of its two arms set in the mortise, could have been used. See also the description of round mortises in Chapter II (pp. 111-114). The mortise hole in *fig.* 144b is 14 cm in diameter. See also *P. of C.*, p. 156.

[512] It also implies, if such mortised bases are actually MM in date, that earlier elite architecture may lie below the present Neopalatial Villas at Hagia Triadha.

ty of the structure they supported[513]. If an untenoned column shifted slightly on its base, the entablature it supported would probably still remain in place. Perhaps that explains why all the lower ends of columns had significantly smaller diameters than their respective bases (see below) so that some shifting was possible, having been built into the original design. The technically simpler and superior solution, therefore, was preferred, and the earlier technique was abandoned[514].

Considering the multitude of columns used in Minoan architecture, there is relatively little information about the foundations which supported their bases. This is due to the fact that Minoan floors are generally fairly well preserved and thus cover the foundations. The information we do have, however, indicates that elaborate foundations were often built, especially in the case of columns set on loose fill or on slopes.

For the foundations of the columns of the Stepped Portico at Knossos, which led up the hill to the southern entrance to the Palace, for example, a method of stacking coarse flat limestone blocks, one upon the other, was adopted (*fig.* 156). The bottom block was set into a hollow excavated in the bedrock, and the superposed blocks were stabilized by means of mud mortar laid between them. Thus these MM I foundations at some points consisted of as many as eight blocks, and rose 4 m high[515]. A similar method was employed for the early East Hall, also built on the slope of the hill, and of which one of the original bases is still preserved in situ (*fig.* 155)[516]. At Phaistos a foundation for a base in Room 85, exposed during stratigraphic tests, reveals a similar technique[517]. At the same site, shallow circular depressions or settings up to 0.80 m wide were cut to accommodate bases of an early colonnade (*fig.* 154)[518]. In the northeast Residential Quarter of Malia the bases were set on large cut blocks (probably reused) concealed just below floor level. A similar technique was used for the foundations of walls (*figs.* 71, 111, 115).

Other solutions are somewhat different. For instance, the base in Room xxxiv at Zakro (*fig.* 140) rested directly on the pavement, which was supported from below by a rubble wall continuing down to bedrock. In upper stories, where columns were used extensively, a number of solutions were employed. For instance, uncut blocks stacked one above the other, in a way similar to that already described for the Stepped Portico at Knossos, were used at Zakro within House A excavated by Hogarth (*fig.* 158) as well as in the Middle Minoan ossuary discovered at Archanes (*fig.* 157)[519]. In more luxurious surroundings, this pillar of large stones was replaced by one of cut ashlar blocks which sometimes reached practically all the way up to the level of the upper floor where, as Evans states, they «formed in fact the direct support of the stone bases and wooden shafts of overlying columns, only separated by the intervening beam of the upper floor»[520]. The thickening or addition of a number of walls on the ground floors of buildings has also led a number of scholars, in particular Graham, to believe that such walls formed the lower supports for columns on the floor above[521].

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[513] Tsakanika-Theochari (personal correspondence) also suggests that setting up a column with a projecting tenon would be quite difficult.

[514] By way of analogy, the Doric columns of the Classical Greek period were not affixed to the stylobates they rested on, even though each separate column drum was joined to the adjacent drum by means of an empolion (Dinsmoor 1973, p. 171).

[515] *Knossos*, II, pp. 143-145, figs. 72-75.

[516] *Knossos* I, p. 386, n. 3, fig. 280, suppl. pl. viii. Only part of the base was found in situ. The holes visible in the top of the base are natural in origin.

[517] Levi 1957-1958, p. 324, fig. 168; see also *Festòs* II, pp. 288, 472.

[518] Levi 1957-1958, pp. 325-326, figs. 171-174, 195. *Festòs* 1976-1988, II (Part 1), pp. 262-267, figs. 408-410.

[519] I consider the topmost block of the stack set within the basement at Archanes to be a base for the column or pier that may have rested here.

[520] *Knossos* I, p. 441.

[521] See *P. of C.*, pp. 43, 117; also Graham 1956 *passim*, and «The Cretan Palace: Sixty-Seven Years of Exploration», in *A Land called Crete*, Northhampton 1968, p. 21.

To conclude our examination of column bases, we should consider the question of whether the shape or material of a base can be considered an indication of its date. To start with, the cylindrical base type seems to have characterized Protopalatial architecture at Knossos[522]. If the colonnade along the western side of the Central Court at Phaistos, investigated by Levi, also belongs to this early period (Platon maintained that it belongs to the first stage – MM IIIB-LM IA – of the Second Palace), then the cylindrical bases of green opheiolite that were set there may indicate a First Palace tradition at Phaistos as well, but perhaps only in the case of this specific colonnade. However, such bases also appear in a Neopalatial context at Zakro (*figs.* 136, 140). At Knossos, Evans maintained that the disk-shaped bases appeared during and after the MM IIIB period[523] and they also appear at Phaistos in a Late Palace context in Room 85[524].

Related to a discussion of cylindrical bases is their material, for both Evans and Pernier thought that cylindrical bases of polychrome stone usually belonged to the period of the First Palaces[525]. Levi has questioned at least part of the earlier excavators' statements, objecting that neither the shape nor height of a column base can be used as criterion for distinguishing early and late palace structures at Knossos[526]. Nevertheless, he does not exclude in his statement the possibility that the material used for bases may be an indication of date.

2. Stone Drainage Channels

The construction of channels and pipes for the conduction of water was a major concern of many Minoan architects. Indeed, Minoan «waterworks» are characteristic features of many major buildings, especially at Knossos, Zakro, and Hagia Triadha.

The major purpose of stone channels was to drain away water accumulated during torrential rains from within courts, from flat or sloping roofs[527], and from the light-wells in the interiors of buildings. Such channels were seldom, if ever, used to bring fresh water within the buildings. At least at Knossos and Tylissos, this need may have been answered by round, flanged pipes of terracotta (*figs.* 237, 238)[528]. U-shaped channels of terracotta (*figs.* 164, bottom row; 239) also served chiefly for drainage[529], and channels of plaster (*fig.* 257) are also known. We should also mention here roughly made drainage channels composed of fieldstones, such as that in Area xlix in the Palace of Kato Zakro, as well as street drains. There are also channels cut in bedrock, for example, in the East Wing of the Palace of Phaistos (*fig.* 160).

The sturdiest drainage systems, however, were fashioned from blocks of soft, easily cut poros limestone or sandstone. These blocks were cut in a U-shape and fitted together to form the familiar channels which visitors to the sites can see used within interior light-wells and courts. Where the volume of runoff water was great, higher and wider channels were built (*figs.* 168, 170a, b), almost invariably below ground level. These channels were usually composed of two rows of blocks floored and capped by slabs.

The U-shaped type consists of a series of roughly cut oblong blocks set end to end, with a channel cut along their length. Some of these drains were probably not covered. The blocks used seem to be of an arbitrary length, even within a single drainage system. They range

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[522] *Knossos* I, pp. 211-213.

[523] *Knossos* I, p. 441, see fig. 318.

[524] Levi 1957-1958, p. 323, fig. 167, showing the bases exposed during a sounding below floor level.

[525] *Knossos* I, pp. 211-213, 370, 422; IV, p. 235; *Festòs* II, pp. 419, 472; also Pendlebury, *A. of C.*, pp. 131, 153.

[526] Levi 1960, p. 107; also *P. of C.*, p. 148, n. 8.

[527] For roof drainage see Chapter IV here.

[528] These are described here on pp. 135-136.

[529] See preceding note.

from only 0.35 m to at least 1.53 m in length. The length no doubt simply depended on the size of blocks available at the time. The widths of the channels range from as narrow as 7 cm, as in drains at Zakro (*fig.* 165), to as wide as 31 cm, as in that from the Royal Road at Knossos, and seem to remain roughly consistent within one drainage system. The width of a drain must have been determined by the builders' estimation of the volume of water that might accumulate at any one time during the rainy season. In some channels (see *fig.* 164, top row), the sides of the channel slope slightly inward toward the bottom. This type is common throughout Minoan Crete. Plaster was not generally used to seal the narrow gaps between adjoining drain sections.

Often the paths of such channels run straight, although slightly curving courses could be made by trimming off the edge of the block ends. A change in direction was sometimes accomplished by a right-angle turn cut into the block itself, as at Knossos (*fig.* 167) and Zakro (*fig.* 166), discussed below. Near the «East Hall» at Knossos the engineers seem to have carried the length of the drain section beyond the actual turn so as to prevent accumulation of water, and hence leakage, at that point (*fig.* 162b).

Sometimes the terminal sections of such drains were cut in special ways. For example, the channel of the drain at the outlet leading overflow water away from the LM I springhouse at Archanes terminated at the outlet in a wide cutting. It projected into the springhouse and was intended no doubt as a small settling basin[530]. Sometimes the course of the channels was interrupted by large settling basins, which collected the silt that might block the drain. No doubt these settling basins were cleaned out regularly when the water-system was in use[531]. Such basins have been found at Tylissos (*fig.* 52), where the basin[532] may belong to the LM III period, and below the northwest corner of the Central Court at Knossos[533].

The terminal block of the drains was sometimes set at a high level, and the water flowing down through it must have been an attractive sight as it arched out into cistern or court. For instance, in the water-system at Tylissos, mentioned above, the terminal drain section, which contained a smaller channel, projected into a large round cistern, waterproofed with plaster along its sides. When the cistern was being filled, the water splashed down upon a stone slab set in the floor. The stone spout in the Court of the Stone Spout at Knossos (*fig.* 101) emptied into the light-well there, being set within a cutting in a wall block high above the floor. This cut block held the drain section in place. The other end of this drain section was cut so that another section, which brought the water down from above and to the west, could rest upon it (*fig.* 163).

Particularly interesting examples of the care which the Minoan craftsmen would exert when they knew that a particular system would not be underground, and therefore would be visible, can be seen in the interior of Room xxviii at Zakro and along the side of a stairway at the East Bastion at Knossos. The drain at Zakro (*figs.* 165, 166) dating to the MM IIIB - LM IB period, was composed of 10 blocks of unequal length. It connected a light-well in the West Wing with the Central Court, and ran alongside the north wall of Room xxviii. It is quite likely that the drain was always open, for no traces of slabs or any other covering were found during the excavation. The peculiar position of the drain above floor level may be due to the slight, 0.20 m, drop between the top of the pavement within the light-well and the

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[530] See Sakellarakis 1965, pl. 701 d; Daux 1968, p. 986, fig. 2; *Knossos* II, fig. 30.

[531] Such settling basins are occasionally referred to inaccurately as «cisterns», which store water.

[532] About 1.71 m by 1.20 m by 0.66 m.

[533] *Knossos* I, p. 230, n. 1; p. 225, fig. 152; III, p. 19 fig. 9.

tamped earth surface of the Central Court[534]. Also to be noted in the example from Zakro is the cutting of the drain blocks, in particular the sharp angles cut in the two terminal blocks. Nowhere else, except at Knossos, as far as I know, are right-angle turns executed in this stylish manner.

At the Palace of Knossos, a much more elaborate drainage system, similar to that at Zakro, was already in use in the MM III B period. Here the system of sharply turning, finely cut drain sections of poros limestone was aligned along the sides of stairways in two parts of the East Wing of the Palace, along an open stairway south of the Residential Quarter[535] and, a better preserved example, along the outside edge of the steps leading down from the East Bastion outside the Palace grounds (*fig.* 167)[536], perhaps to a washing basin of which, however, no trace was found. Nor has the point of origin been discovered. By looking at the actual remains we can see features which differ from that of Zakro referred to above. Perhaps it is best to quote Arthur Evans's eloquent description of this installation, which «affords ... an extraordinary illustration of the skill of the Minoan architects in everything that concerned the passage of water. We may infer that this system, the objects of which were the collection, scientific direction, and safeguarding from impurities of the rain-water from the successive flights and landings, began on the terrace level immediately outside the postern gate and at the head of the uppermost flight of stairs.... [The channel was made up of six] limestone slabs, the bottom of which formed a succession of rounded falls, one for each of the steps, of which there were originally six».

«For enabling the current of water to pass around these and the other abrupt angles in its course without splashing over the pavement beyond, the retardation of its velocity by the curving course of the channel was a most efficacious method. The curves themselves almost exactly agree with the natural parabolas that the water falling down a slope of such an angle would execute, and the additional friction due to the increased length of its course necessarily diminish[es] the speed. It has been calculated that the water reached the bottom of the flight with about half the impetus that it would have attained had it poured down the slope in a straight line instead of a series of leaps. The current thus reached the critical point – namely, the sharp turn at the foot of the flight – with such diminished force as to enable it to pursue its changed direction without shooting over its border»[537].

After a deepened turn at the bottom of the flight, «the current at this point reached the central platform of the staircase, which has two slight steps at each end and a gently sloping pavement between, giving in all, a fall of 20 centimeters in a length of five meters. [...]

While at the same time collecting an additional supply of water from the whole of the paved platform, which slightly slopes toward the channel, the main object [...] was to secure a certain local retardation of the current, favorable to the deposit of sediment in a shallow square basin beyond. The channel [...] makes a double bend to check the velocity of the flow»[538].

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[534] An alternative solution to the problem of draining this light-well would have been to bury the drainage system below floor level, with a drain head or a catch basin within the light-well (*figs.* 162a, 169), and with a stone-lined sump set within the Central Court to receive the water. It does seem curious that instead of using the elaborate system they chose, they did not simply channel runoff water from the light-well into a nearby and presumably contemporary system of terracotta channels to the south of Room xxv. The cleansing action of the rush of fresh water within these channels, however, was apparently not considered.

[535] *Knossos* III, pp. 245-246, fig. 171.

[536] *Knossos* III, pp. 236-244, figs. 166-170. A somewhat similar duct, but of plaster, was found along the steps of the Theatral Area (*Knossos* III, pp. 246-251). Another drain of plaster was found near the eastern angle of the Throne Room (*Knossos* I, p. 230).

[537] *Knossos* III, pp. 241-242. The brackets are mine.

[538] *Knossos* III, pp. 242-243.

Despite Evans's belief that this unusual water system was intended for washing purposes, there is no proof that this was the case, nor that it had indeed any special function save to carry water, in the way described by him, along the course of the stairway. As in the example from Zakro, however, it is clear that other methods of dealing with the problem of runoff water could have been used: for instance, a vertical shaft leading to a sloping drain channel below, such as that in the Residential Quarter at Knossos (*fig.* 168), or a ramp-like arrangement leading to a shaft, such as that at Hagia Triadha (*figs.* 161, 172)[539]. Should either of these solutions have been rejected by the builders on grounds of expense in the first case, or unpleasant appearance in the second, one can nevertheless argue that a simpler method might have been adopted such as simply shifting the course of the drain to the north or south of the East Bastion. There is reason to believe, therefore, that the unusual method described by Evans was adopted simply for its attractive appearance. One is tempted to go even further and suggest that despite lack of corroborating evidence, if there was a continuous supply of fresh water to the Palace, as Evans suggests[540], perhaps these very channels provided an aesthetic means of disposing of the overflow. Such a theory would add some credence to Evans's belief that the chief purpose of the system was to supply a washing basin somewhere below, which, if it existed, would hardly have been constructed just for temporary use during the limited spells of rainy weather.

Spacious conduits, designed to carry greater volumes of water than the U-shaped drains just discussed, formed the basis for much of the hydraulic engineering of the Minoans. Generally, these were constructed of blocks of poros limestone or sandstone, and occasionally gypsum. These blocks formed two sides of the channel while slabs of the same material formed the floor and roof (*fig.* 170a [A, B])[541]. Usually the channels ran below floor or ground level and, except for shafts above through which water would enter, were usually structurally independent of the building itself. One interesting exception to this rule can be seen at Hagia Triadha, where in Room 12 the stylobate slabs covered the course of the drain.

Usually these conduits drained runoff water away from the courts and roofs of large buildings. At Knossos, however, there is sufficient evidence to show that drainage and sanitation systems were combined in the north and east wings of the Palace (*fig.* 168)[542]. Evans also suspected that a channel of similar construction, but with a rectangular cutting 6 cm high by 15 cm wide in its base slab[543], found some distance from the palace, at Mavrokolybo, might have brought fresh spring water to the Palace[544]. An example at Archanes carried fresh water, perhaps for domestic use, away from a circular springhouse of LM I date, already mentioned above[545].

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[539] The drains shown in *figs.* 161 and 172 are of LM III date (*Guida*, p. 34).

[540] *Knossos* II, p. 463.

[541] The simple, four-sided channel type in *fig.* 170a (B) was also used to drain streets. Impressive examples of a complex network of such street drains are at Palaikastro (MacGillivray, Sackett and Driessen 1998, pp. 258-259; also MacGillivray *et al.* 1988, pp. 265-266). The beginning of this type of built drain type goes back in Crete at least as far as a channel that drained liquid out from within the EH II house found below the West Court at Knossos (J. Evans 1972, p. 118 and Wilson 1985, p. 288).

[542] *Knossos* I p. 226.

[543] *Knossos* II, fig. 273.

[544] *Knossos* II, p. 463; also *P. of C.*, p. 219, n. 28. Todd Whitelaw (personal communication) finds this unlikely since, because of differing ground levels, aqueducts would have been necessary to carry the water across the dips on the way to the Palace.

[545] See *Knossos* II, pp. 64-67, figs. 29, 30. Evans's original excavation was extended by Sakellarakis (1965, p. 559, pl. 701-702; Daux 1968, p. 986, figs. 2, 3, now see *Archanes*). In the Archanes palatial building a major vertical drain for the (apparent) North Wing was probably carried down next to the main staircase, in the wall shared by Rooms 9 and 10 (for the rectangular opening in a stone slab see *Archanes* p. 97, fig. 75, and drawing 15). The drain likely ran south below that wall and out

Conduits of this type were in use from as early as the MM II and III periods, to judge from examples found in the East Wing at Knossos, as well as in the North Wing there[546]. In the former they are part of a complex drainage system especially adapted to the needs of the multistoried buildings. The channels are quite large, at least 30 cm to 50 cm wide and 57 cm to 78 cm high. They often collected water from light-wells by means of stone basins, or catch-basins, set in the floors (*fig.* 169). Apparently they were covered on the inside, especially along the lower joints of the bottom blocks, with a layer of plaster[547]. Evans remarks about them: «The stone channels themselves, ventilated by air-shafts and made accessible by manholes, were so roomy, that in the course of their excavation, my Cretan workmen spent whole days in them without inconvenience. It would thus have been easy to clean them out when necessary»[548].

Although the drainage system at Knossos remains the most sophisticated and monumental from Minoan Crete, complex systems of a similar nature existed elsewhere as well. At Zakro, for instance, a series of interconnected channels in the East Wing (*figs.* 170b, 171) received runoff water from roofs as well as from the neighboring hill to the northwest. These conduits join in the area bordering Room lxiii and continue eastward. Unlike other examples cited here, these drains were built with only a single course of blocks of poros sandstone. Those illustrated here range from 25 cm to 43 cm in width and 23 cm to 25 cm in height. The drainage system at Akrotiri on Thera was also linked with a sewage system[549].

At Hagia Triadha, along the north slope of the hill upon which the building complex is constructed, there are numerous drains of this type, some of which drained the large court to the south and, no doubt, the roofs of the buildings as well. Their potential capacity is much greater than that of those from Zakro, ranging from 40 cm to 46 cm in width and from 64 cm to 126 cm in height. Small, flat slabs and a thin layer of mud or clay filled the interstices between blocks (*fig.* 170a [C]). In at least one instance (*fig.* 1701a [B]), the blocks forming the sides of the channel seem to have been set on their edges rather than on their sides, as is more usual. The floor of the drains was set at a slight slope, as at Knossos, and vertical shafts (*fig.* 172) transferred water at various points to conduits at lower levels[550].

Vertical drainage shafts cut within ashlar façades are also known at Chania, Knossos, Kommos, Gournia, and Palaikastro[551]. From what one can tell, they discharged their water to the outside at the base of the walls, in the case of Knossos perhaps into cisterns. They were usually set into the back walls of their respective buildings.

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into the open court where, below a large stone cover slab, it joined an ample stone drain that carried the rainwater outside the building (*Archanes*, drawings 31 and 33).

[546] *Knossos* I, p. 226; III, fig. 249. These storm drains have been re-examined in detail by Colin Macdonald and Jan Driessen (1988, 1990). Macdonald (2005, pp. 65, 151) views the drains as a combination of First and Second Palace efforts.

[547] *Knossos* I, p. 227, fig. 171a; *A. of C.*, p. 131.

[548] *Knossos* I, p. 228.

[549] Palyvou 2005, pp. 39-43; also 1999a for a short review of drainage systems in the Aegean.

[550] For the Hagia Triadha drains, see Halbherr, Stefani and Banti 1980, pp. 221-227.

[551] Hallager 1990, p. 287 and fig. 2, also at the South House at Knossos (North wall, *Knossos* II (1), pp. 374, 377, fig. 310); in the south wall of the South Stoa at Kommos (*Kommos* V 2006, Ch. 1 and pl. 1.122; possibly at Gournia, in the back face of the wall of House Ad where it joins House Ac (Fotou 1990, fig. 14); and in Room 5 of House N at Palaikastro (Sackett, Popham, Warren and Engstrand 1965, p. 265, fig. 1 and pl. 66). I am indebted to Vasso Fotou for the observations about Gournia and Palaikastro.

CHAPTER TWO

WOOD AND TIMBER

A) Types of, Evidence for, and Chief Structural Uses of Wood in Architecture (*figs.* 173-192)

According to the somewhat conflicting evidence, cypress and/or fir were used a great deal by the Minoans for their larger wooden architectural members.

Evans reported that the columns and the timber framework of the Grand Staircase at Knossos were shown by analysis to be *Cupressus sempervirens* variety *sempervirens;* later he concluded that it was probably of *Cupressus sempervirens* variety *horizontalis*, a type of cypress that still grows near the site of Knossos, though no longer in great numbers[552]. Cypress is also reported in the construction of the Royal Villa at Knossos[553] and was found in both Early and Second Palaces of Phaistos[554], and at Malia, where it was used in Quartier Mu[555].

On the other hand, a series of careful studies made after Evans's, and before World War II, by Netolitzky[556] have shown that at least one of the carbonized fragments from Knossos – thought previously to be cypress – is actually a type of fir[557]. This same fragment, studied

[552] *Knossos* I, p. 344, n. 1; II, p. 7, n. 3; III, p. 321, and n. 1. I have somewhat altered Evans's statement (and I have replaced the *y* in cypress with a *u* according to modern usage). Actually, Evans was probably confused in his terminology, for he states that he first thought that the wood was *Cupressus sempervirens*, and then he changed his mind to think that it was *Cupressus horizontalis*. B.F. Kukachka, of the U.S. Forest Products Laboratory (Madison, Wisconsin) was kind enough to furnish me with the following information (Letter, 9 March 1970) which should clear up any confusion: «The Mediterranean cypress is botanically designated as *Cupressus sempervirens* and the several varieties are designated as follows: *Cupressus sempervirens* variety *horizontalis* in which the branches spread out flat like in Lebanon cedar. This is the common wild form. *Cupressus sempervirens* variety *indica* when the tree assumes a stiff and fastigiate habit. *Cupressus sempervirens* variety *sempervirens* which is the form seen in cultivation in southern Europe where the branches are erect, giving the tree a pyramidal or columnar outline». Dr. Kukachka continues in his letter to point out that simply from fragmentary ancient wood specimens one cannot determine the actual variety of wood. Evans was, therefore, most likely determining the variety only on the basis of an analogy with a tree type that grew in the area of Knossos when he was excavating. His original statement (that the wood was *Cupressus sempervirens*) is therefore the most correct. Botanist Oliver Rackham, whom I consulted about this matter, also pointed out that *Cupressus sempervirens* is the name of the species that includes both varieties; using the name alone avoids stating what variety is meant.

[553] *Knossos* IV, p. 970.

[554] *Festòs* II, p. 420, fig. 269; p. 471. Follieri and Coccolini 1986, p. 181; *Festòs* 1976-1988, II, p. 97, fig. 122.

[555] Poursat and Schmid 1992, p. 38, positioned on the base with the circular dowel hole in our *fig.* 139.

[556] F. Netolitzky 1934, p. 176. In Athens copies of this excellent article can now be found in the libraries of the Greek Archaeological Society and the American School of Classical Studies. For a summary of the article, included by Marinatos in a review of archaeological activities in Crete, see Marinatos 1935, p. 255.

[557] Probably *Abies alba*. Kukachka (above, n. 1), writing some 30 years later and with extensive experience in ancient wood analysis and identification, however, noted that *Abies alba* cannot be distinguished (in samples such as those which are found on most archaeological excavations) from more southern species such as *Abies cephalonica*, *Abies cilicia*, and others.

by him in the workroom of the Herakleion Museum, had apparently been mislabeled as «cypress» by either the excavators or the museum authorities[558]. Netolitzky identified the same wood type (fir) from other samples from Knossos and from Phaistos.

Picea orientalis, a type of spruce which now grows on the mountains of Asia Minor, also appears at Knossos, and Netolitzky, moreover, identified oak (*Quercus ilex*), bits of which were found at Amnisos and on an offering table in a tomb at Knossos[559]. The unburned wooden shafts of the double-axes from a cave at Arkalochori were also partly preserved. Their remarkable state was due to the protective chemical action of the copper of the axe-head, which kept the cellular structure of the wood from disintegrating. Of the seven shafts which he studied, five were probably of fir (*Abies*) and the others were probably of cedar of Lebanon (*Cedrus libani*)[560]. As to the former, it is known to occur in other areas of Greece aside from the island of Cephalonia and is now called «Grecian fir»[561]. Asouti[562] has analyzed charcoal examples from stratified Bronze Age levels at Akrotiri, and identifies three species, cedar of Lebanon (*Cedrus libani*), beech (*Fagus*), and yew (*Taxus baccata*) that were probably imported onto the island from elsewhere (Crete, Mainland Greece, Cyprus, Anatolia, or the Lebanon range). She thinks that the cedar of Lebanon may have come from Lebanon itself given the known history of importation of that wood into Egypt and Levantine sites from there[563].

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[558] According to what Dr. Platon has told me, this wood fragment was lost and/or destroyed during the turmoil of World War II. A third set of analyses of other wood fragments from various sites would probably resolve the matter. When sufficient samples are assembled, therefore, a series of independent analyses should be conducted. Botanist Oliver Rackham also provides perspective, noting that «Wood identification is not a static discipline ... and that in the 1930s, and even now, there were no proper criteria for publication of wood identifications. They should include, at a minimum, a description of the wood structure, what alternative identifications were considered and rejected, and a list of the diagnostic features, with drawings and even a scanning micrograph of the wood structure.». The Shays (*Kommos* I [1], Chapter 4, 1995) followed this procedure at the Kommos site which, however, produced little charcoal from actual timber used in architecture.

[559] Netolitzky 1934, pp. 176-177.

[560] Netolitzky 1934, pp. 177-178. For preservation of wood by chemical action, see also infra, p. 93, n. 569. Meiggs (1982, pp. 100, 411-416) has also pointed out an ambiguity in the Greek and Latin terms used, for in Greek and Latin the words kedros and cedrus are used for juniper as well as cedar, and Cretans still call the juniper κέδρος. In this connection, although the Shays list many plant and tree species identified in their detailed study of Minoan flora at Kommos, cedars from the Minoan period are not mentioned whereas juniper (*Juniperus*) is a common occurrence.

[561] Kukachka (above, p. 91 n. 552) also notes that in most archaeological samples it may not be possible to distinguish between Cephalonian and other types of fir (above, p. 91, n. 557). In *Crete and Mycenae* (Marinatos and Hirmer 1960, p. 12), Marinatos states that Cephalonian fir was used for the columns at Knossos. His source here is unclear, but is probably given in note 1 on page 110 of the same book, the note not having been entered in the text itself. The full reference is: F. Netolitzky 1940, pp. 154-156. The short article cited by Marinatos, however, simply states that Cephalonian fir (*Abies cephalonica*) was used for the handles of the double-axes discovered in the cave of Arkalochori. Kukachka also notes concerning references to 'Kephalonian pine' (rather than fir): «Presumably the designation 'pine' comes from very old literature and from a period when the species of the present genus Abies were included in the genus Pinus, the present day pine». Since then, Marinatos (1974, p. 95) has revealed that there was an editorial mishap in versions of his *Crete and Mycenae*, noting that «Three samples of wood, of which one [was] from a great portion of a carbonized column of the Palace of Knossos, were identified as '*Abies* (*alba*)'», or fir (as distinguished from that of pine, spruce, or larch [*Webster's Third New International Dictionary*]).

[562] Asouti 2003, pp. 474-475, 479.

[563] Asouti 2003, p. 481. None of the three woods mentioned was identified by the Shays at Kommos (Shay and Shay 1995, Tables 4.9-4.10) or Myrtos-Phournou Korifi (Rackham 1972) in Crete. With the new emphasis in archaeological investigation on information gathering and analysis, future publications will no doubt place our knowledge about woods in perspective.

Our other evidence for the use of wood varies. The wood is hardly ever completely preserved in its original dimensions and color, as it is in Egypt and other extremely dry lands. Aside from the axe-hafts mentioned above, the only well-preserved examples of which I know are from Zakro and Poros [564]. The former are a few stout pieces, perhaps from a well-rig, found in the water of a small well (Room xli) in the Palace of Kato Zakro, near the southeastern corner of the Central Court [565]. The latter are long wooden poles, some linked by bronze, and which probably belong to a bier, which were found in a burial cave at Poros, just east of Herakleion [566].

Next are carbonized remains of wood, usually the result of burning. The most impressive remains of this type are the various carbonized architectural members that are sometimes found fallen within rooms and courts of Minoan buildings. At the Palace of Kato Zakro, for instance, a number of carbonized beams, fallen from nearby walls or an upper story were found collapsed in the northwestern corner of the Central Court [567]. At Gournia, Hawes reports, «a large tree-trunk, which had supported an upper floor or roof, completely charred through, but retaining its original shape; the Central Hall of the Palace was choked with such timbers» [568].

In the Domestic (or Residential) Quarter of the Palace of Knossos, certainly the best preserved and most monumental architectural unit known from Minoan Crete, the excavators found ample remains of large wooden architectural members. Evans thought that most of them had been carbonized by slow chemical processes rather than by fire [569]. One, a column, was preserved up to 2.60 m of its original length, which was perhaps 3.00 m to 3.50 m; its lower end was 0.45 m in diameter [570]. Some of the ceiling beams were preserved as well [571]. Carbonized column fragments have also been found at Phaistos [572].

Excavation at EM II Myrtos-Phournou Korifi, a burned site, produced a good deal of carbonized wood, especially oak (*Quercus ilex* L.), olive (*Olea europaea* L.), and pine (*Pinus*).

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[564] F. Netolitzky 1934 pp. 174-175.

[565] Platon 1964a, p. 158.

[566] Lebessi 1967, p. 204, fig. 1 and Plate 184b, 185 a and b. These pieces of wood, described in the report as rotted rather than charred, were coated with gypsum and then transferred to the Archaeological Museum of Herakleion. A sample of the wood was identified as κέδρος (*cedrus*) (P. Muhly 1992, p. 353).

[567] Platon 1964a, p. 154; 1965a, p. 193. Significant quantities were also found in Room xvi and in the area of Room xviii (Platon 1964a, p. 145).

[568] *Gournia*, p. 21.

[569] *Knossos* III, p. 287; IV, p. 1. J. Boardman has challenged Evan's statement. He maintains that climatic conditions at Knossos were such that unburnt wood would have disappeared with time. To explain the pieces of wood that were blackened on the exterior only, Boardman states that «stout columns or beams of seasoned wood could well be badly scorched yet not burnt wholly through» (Boardman 1963, p. 83, n. 2). Dr. Kukachka (above, p. 91, n. 552), however, while agreeing with Boardman's second statement, would disagree with the first, and would substantiate Evan's original statement of carbonization by chemical processes: «Certain species of wood, such as the members of the white oak group, when exposed to ground water for long periods of time give the appearance of being carbonized and although completely blacked, are not carbonized. In this instance the 'ebonizing' of the wood is accomplished by the reaction of the tannins in the wood combining with iron salts in water solution producing the black iron tannate». Botanist Oliver Rackham (personal correspondence) agrees with Boardman on this issue, noting that «Charcoal can only be produced by heat ... Most if not all timbers ... go black when kept in permanently wet conditions ... but this happens only in waterlogged sites, which Zakro may be in part but Knossos is not».

[570] *Knossos* I, p. 343; III, p. 321.

[571] See Durm 1907, p. 58, fig. 16; also p. 43, fig. 11. This section of wood was published by Durm as a column fragment. Evans, however, later identified it as part of a beam from the northeast corner of the Hall of Colonnades (*Knossos*, I, p. 343, n. 4).

[572] *Festòs* II, p. 73, and fig. 269.

They were identified by Rackham, who suggested that most of the wood appeared to be from roof timbers, with «joists of oak and probably olive and pine laid at intervals from wall to wall, with branches and scrap laid across them on top»[573]. Olive wood, usually being neither straight nor sturdy, must always have performed minor building tasks, for instance in the Early Phaistos Palace where it was found[574], although an olive wood threshold has been reported from Neopalatial Palaikastro[575]. At Kommos in the Mesara most of the charcoal samples probably represent fuel wood, for there was no conflagration there. Two hardwoods (olive and evergreen oak) and two conifers (cypress and pine) were the most abundant and made up nearly 70 percent of the Minoan charcoal[576]. The only definite architectural member identified was part of a ceiling beam, fallen within a small burned room in Neopalatial Building T; it was of evergreen oak (*Quercus cocciferalilex* L.), 0.08 m in diameter[577].

Fir (*Abies*) and cypress (*Cupressus*), therefore, often served as the structural timbers used for Minoan columns and joists, with oak (*Quercus*), pine (*Pinus*), and olive (*Olea*) playing subsidiary roles.

The presence of wood is more usually indicated, however, by the chases, or beddings, of horizontal and vertical timbers that were built into rubble structures such as walls, piers, jambs, and sills. In the EM II house below the West Court at Knossos, for instance, two narrow slots (minimum 12 cm by 18 cm) were noticed in the top of a meter high wall. The slots may well have held the ends of wooden beams supporting an elevated floor furnished with a trap door in order to access lower storage space[578]. Sometimes carbonized remains are found where the bases of the timbers once rested. More commonly, however, we have simply the dirt-filled hollows, once filled by wood, which are often quite adequate for inferring its general dimensions and positions. In some instances, the chases assume a tubular shape within the walls, showing where the wood has disintegrated completely (as in *figs.* 64, 66). When lime or mud-plaster was used around the wood, it is often possible to decide whether a wall or ceiling beam was squared or left circular in section (*figs.* 192a,b,c). Even the form of a wooden pivot block set in a plastered floor has been preserved in this fashion[579]. Plaster or clay accumulated around a column can also record fluting[580]. Sometimes rubble and mud partitions or walls were built up against columns in situ, so that even though the columns have disappeared we have their negative impressions in the mud of the walls (*figs.* 173, 174).

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573 Rackham 1972, p. 303.

574 Follieri and Coccolini 1979-1980, *passim*. Probably that illustrated in *Festòs* 1976-1988, II (Part 1), p. 97, fig. 122. Others, from Room LIV, discussed on p. 85 and in fig. 109 (above), may not be mentioned in Follieri and Coccolini 1986.

575 Sackett, Popham, Warren and Engstrand 1965, p. 314.

576 Shay and Shay 1995, p. 129. For the unusually broad spectrum of woods identified by the Shays from Minoan contexts at the site, see their table 4.9.

577 Shay and Shay 1995, p. 122. Also *Kommos* V, p. 41.

578 J. Evans 1972, p. 117, fig. 2; Wilson 1985, p. 288.

579 *Mallia, Centre Politique*, II, pl. II, XVI 3.

580 For instance, at Knossos a number of clay impressions of fluted columns were so clear that the excavators could approximate the number, size, and shape of the flutes. This was true in the case of the wooden columns set in connection with a «throne» in the room next to the western light-well of the Hall of the Double Axes, where the columns were about 0.25 m in diameter and with 28 flutes (*Knossos* III, p. 336, fig. 223). Similar but even better preserved molds were found in the Fetish Shrine of the Little Palace. Here, also, the shafts were small, being 0.247 m in diameter with 15 flutes (*Knossos* II, pp. 521-523, fig. 324). A single impression of one such column was found on the East Slope near the Palace; it had a diameter at one point of 0.35 m, with perhaps 28 flutes (*Knossos* III, p. 323; suppl. pl. XXXV B). The carbonized remains of another small column, of 0.35 m diameter and with 24 flutes, were found in the area of the Hall of Colonnades (*Knossos* I, p. 344, and note 7). In all these examples the fluting seems to have been convex.

In coursed ashlar masonry, carbon- or dirt-filled horizontal gaps (*figs.* 97, 103) show where beams have burned or rotted away. Cuttings in many of these walls can also indicate wood. These cuttings can be in the form of beddings along the length of the top course of the wall (as in *figs.* 220, 216G) or shallow beddings cut on windowsills (as in *figs.* 216A, D, 219). Sometimes there are even sockets cut in the tops of walls for the setting of horizontal ceiling timbers (*fig.* 191). The earliest may be in the West Court House (EM IIA) at Knossos[581]. Square or round mortises for wooden dowels (*figs.* 196, 197-212b, 216-223) also indicate the presence of wooden beams, since dowels hardly ever, if ever, joined stone to stone. Cuttings for wooden clamps (*figs.* 193-195b) also may show where vertical supports or horizontal ceiling beams were secured, although they also linked the opposite faces of walls (*fig.* 93).

The presence of wood can be inferred indirectly. For instance, since no large stone columns have been found in Minoan Crete, every column base we see in Minoan buildings must have been surmounted by a wooden column. For analogous reasons wood should be restored on top of certain stone jamb-bases and certain types of pillar and pier bases, since there are so many well-preserved examples that indicate the original method of construction. Similarly, pivot-holes as well as scorings on thresholds lead us to restore wooden doors. Evidence for wooden stairways is equally convincing. For example, in a stairway in Room xviii in the Palace of Kato Zakro, the lower steps, which were made of permanent material, have been preserved, while the higher ones have disappeared. If the upper steps were made of plastered rubble (as the lower steps), or slabs of stone, surely traces of them would have been found fallen onto the floor of this well-preserved part of the Palace. In this case, since the plastered construction ends at a point where the steps lead nowhere, it would seem logical that the stairway was continued up in wood. Wooden stairways seem to have been so common, indeed, in some buildings, that they can often be restored simply on the basis of the shape of the narrow, parallel corridors that often enclosed Minoan staircases[582]. At the open end of such pairs of narrow corridors were the entrances to lower and upper floors, while at the closed end was a landing at the halfway point of the ascending stairs. Stairways that were probably all or mostly of wood have been found at a number of sites, among them Phaistos[583], Gournia[584], Malia[585], and the houses of Kato Zakro[586]. Within the Palace of Kato Zakro itself we can detect possible wooden stairs in Rooms xviii, x, xxx, lii, lviii, and xlvi a, among others.

Wood used in the buildings was cut by saws and axes, and some no doubt was adzed and chiseled. A surprising number of the bronze tools that were used for working wood and stone have luckily been preserved[587]. The same tools were probably used to shape and to smooth the wooden treads of staircases and the boards that were occasionally used for flooring. Possible traces of wooden boards have been reported from Chania[588], Malia[589], Knossos, and Archanes[590], as well as Zakros[591].

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[581] Wilson 1985.

[582] This is the U-type described by Graham (*P. of C.*, p. 182).

[583] Possibly in Room 76 (*Festòs* II, pp. 419-420); Rooms 42-43; and possibly Corridor 71 (*Festòs* II, p. 446).

[584] *Gournia*, p. 21.

[585] *Mallia, Maisons I*, pp. 25, 69, n. 5; Charbonneaux 1928, p. 360. Also, Quartier Mu (Schmid 1995, fig. 45 (our *fig.* 262).

[586] House B, Rooms D, E (Platon 1961, p. 221; 1962a, p. 149); Room O (Platon 1962a, p. 152); Room M (Platon 1963a, p. 162).

[587] Tools for cutting wood and stone are described here on pp. 38-53.

[588] Hallager 1990, p. 285, fig. 4 (our *fig.* 192c).

[589] *Mallia, Maisons I*, p. 25, and in a room at Ayia Varvara (Pelon 1966, p. 561), where a carbonized but otherwise intact wooden board was also found upon a separating wall (Pelon 1966, fig. 10).

[590] Daux 1967, p. 785. At Archanes boards were apparently set within borders of plaster painted red. At Knossos there may have been a wooden floor in an inner room of the Domestic Quarter (Hood 1971, p. 72; also in Room M in the Unexplored Mansion [*MUM*, pp. 112, 117]).

[591] Platon 1971, p. 172.

Wood was also used for the construction of bins and for shelving. Bins with charred wooden planks and remains of barley nearby were found in the Caravanserai at Knossos[592], and shelves are reported from both Zakro and Gournia[593].

From as early as the EM II period, wood was extensively used to reinforce rubble walls. This is especially evident at Vasiliki. At contemporary Myrtos-Phournou Korifi to the south, however, the use of wood was suspected only in a few doorjambs[594]. At the former site, which in its construction is more similar to later Minoan buildings than is Myrtos-Phournou Korifi, slight horizontal timbers, about 10 cm in section, appear at the sides of walls at short intervals (*figs.* 64-66)[595]. One of the tubular-shaped chases I measured in the mud and rubble structure was about 10 cm by 14 cm. Saplings some 5 cm thick were set transversely in the wall[596], and appear at wall-ends as well (*fig.* 65). In the latter, they reinforced the wall-ends and no doubt served to stabilize the door frame. In *fig.* 64 one can see, where the exterior plaster has flaked off, the casing for a horizontal beam (1) and that for a flat transverse section of wood (2). Above them (3) is a small «window» opening which was spanned by a small board, now disintegrated, which left clear traces of graining on the plaster[597]. The custom of setting vertical posts within rubble walls, which appears in later structures, mostly dated to the Second Palace period, was apparently not practiced here[598]. There seems little doubt that the ceilings here were supported by wooden beams[599], and that much of the superstructure of the building, above the ground floor, consisted of mud brick.

During the Protopalatial period, rubble walls were also often strengthened by horizontal and transverse timbers. Excavations in Quartier Mu at Malia has shown, for instance, that horizontal timbers were used within the walls there[600], perhaps a meter above floor level. While I have not seen wood used in a similar way in the Hypostyle Crypt to the northeast, it was used for framing a well-preserved interior window there (*fig.* 183), which has been carefully consolidated by the excavators. The technique of placing the window framing here

[592] *Knossos* II, p. 105, and in Corridor L at the Unex-plored Mansion (*MUM*, pp. 112, 117).

[593] Platon 1963a, p. 176 (Room xvi), for shelves that may have held the Linear A archives discovered there; *Gournia*, p. 22, for traces of a wooden shelf in House Fd. There was also evidence of a plastered wooden shelf from Building 6 at Palaikastro (MacGillivray, Sackett, and Driessen 1998, p. 241).

[594] The excavator, Peter Warren kindly provided the following information: «...wood does not appear to have been used either to support the roofs or as tie beams in the walls. In both of these cases we should have found beam slots, if not actual charcoal remains. Nor is there charcoal evidence for wooden doorjambs, although I'm inclined to think we must assume these, in view of the door sockets» (16 March 1969).

[595] *Gournia*, p. 49.

[596] *Gournia*, p. 49.

[597] If one can judge from modern custom, there is little doubt that this little «window» was intended as an entrance for the local cats! I have seen similar «windows» in humble structures in Crete and in the Corinthia on the Mainland. When I asked about their purpose, the townspeople explained that they were not for air or light, but only to allow she cat to get in to eat mice. The same people pointed out that such holes are left open only in storerooms where grain and other harvested products are kept, not in the walls bordering living areas.

[598] Evans (*Knossos* I, pp. 72, 209; II, p. 353) and Pendlebury (*A. of C.*, p. 63) both state that vertical beams were used in the houses at Vasiliki, specifically in walls of sun-dried mud brick. This is also assumed by Branigan (1970, p. 46). See my review of this book in *AJA* LXXV, 1971, p. 220. During my visits to the site I did not see any traces of vertical timbers within the wall structure on that part of the site which has not been refilled, and I have concluded that while such timbers may have been used in walls of mud brick above the visible ground floor or basement rooms, they did not play a major role in the construction near ground level. As far as I know, Seager does not report any vertical timbers within the wall structure at Vasiliki. Peter Warren, who was kind enough to inspect the Vasiliki remains in this light, confirms that no vertical chases are now visible.

[599] Seager 1904-1905, p. 209.

[600] Daux 1968, p. 1134.

is reminiscent of that used in later windows, such as those at Hagia Triadha (*figs.* 212a-c). The doorjamb next to this window at Malia was composed of vertical posts with rubble packing set between them. We can tell that this ceiling was supported by wooden beams as well, since sockets, into which the butt-ends of such beams would have fitted, were discovered on the top course of the wall (*fig.* 117)[601]. This is particularly clear in nearby Quartier Mu (*fig.* 261) where the now empty sockets left by the ceiling beams remain in the still-standing walls. The positioning of the wooden limbs and boards can also be seen in the stairs there (*fig.* 262) and thus can be restored with confidence[602].

Wood is used in the rubble walls of the First Palace of Phaistos in the same way as it was at the earlier site of Vasiliki[603]. The southern section of the First Palace presented great problems to the excavator, since working conditions were cramped, the walls were preserved to an unusual height, and the rooms contained a hard cement-like filling material called *calcestruzzo* or *astraki* (see Chapter 4). Despite this, Levi's exemplary work enables us to see small, tubular casings in the walls left by the disintegration of timbers that ran parallel to and occasionally transversely to the line of the wall[604], and in some instances without apparent order. Small niches in the wall were spanned by wood as well, in the manner described above for the small window at Vasiliki. In some of the easternmost rooms here one can discern two floor levels, often separated by doorways. For instance, in one wall (*fig.* 72) a double row of beam holes, 10 cm to 15 cm in diameter, suggests that the floor level may have been altered at two periods during the long history of this building complex[605]. The holes left by the ceiling beams are also visible.

In the northern section of the First Palace here, small horizontal and transverse timbers were also used in the walls, to judge from examples still visible in the small rooms now covered over by the building of the Later Propylon (Room 69a)[606]. Pernier and Banti were puzzled by the apparent lack of organization in the placement of such timbers[607]. In both sections of the First Palace here, vertical timbers were also used for doorposts, as in Room XLIV[608] and Room LVI. Moreover, large beams, probably squared, were affixed to the tops of the orthostate façades by means of wooden dowels (*figs.* 87, 90)[609].

In the First Palace at Phaistos, rubble walls, strengthened by sections of wood laid horizontally, continued into the upper stories[610]. These walls took the entire weight of the upper stories and transferred it to the ground. Since mud brick was rarely used at Phaistos in either the First or Second Palace periods, it is quite possible that the method of constructing a wooden frame supported by props may have developed elsewhere in Crete, where mud brick was the material normally preferred for upper stories.

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[601] Daux 1961, p. 949. *Mallia, Centre Politique* II, pl. II, our *fig.* 117 here.

[602] See Schmid 1996 in *Mallia, Mu Artisans*, pp. 81-82.

[603] See also Fiandra 1961-1962, p. 126. In this matter, Fiandra sees a close similarity between these sites and Knossos and Gournia, but, apart from differences in placement, wooden members at Knossos and Gournia were generally much larger than those in walls in the southern section of the First Palace at Phaistos.

[604] See also Levi 1957-1958, p. 204, fig. 14; p. 229, fig. 47.

[605] The row marked A in *fig.* 72 is 1.80 m above the bottom of the rubble wall; that marked B is 1.30 m above the same point. Row B probably represents holes for another phase of floor. See *Festòs* 1976-1988, II (Part 1), fig. 110.

[606] See *Festòs* I, p. 316 ff. One horizontal timber I measured was about 1.20 m above floor level.

[607] *Festòs* II, p. 433.

[608] *Festòs* II, p. 444.

[609] See also pp. 58-65 (on orthostates) and pp. 114-126 (on the use of square dowels).

[610] Tsakanika-Theochari (2006, p. 45) noted in one of these walls a grid-like-pattern of branches laid horizontally, with three to five along the length of a wall. For olive wood used in these walls, see Fiandra 1997, p. 64.

As already mentioned, mud brick walls set in a wooden framing have been reported at EM II Vasiliki[611]. This technique can be observed in the limited remains of mud brick construction on certain ground floors, such as in the southeastern section of the Palace of Malia, in the eastern rooms of the Hypostyle Crypt there, and in the walls of two rooms at the Palace of Kato Zakro. At the last site, vertical props are used within mud brick walls of Room L, and in Room xxiv (the Lustral Basin of the West Wing), three sides of the room were enclosed by walls which were partitioned by wooden uprights set at surprisingly close intervals. Although only a rubble socle is now visible here, it is reasonable to assume that at one time the wall was continued up with mud brick. In such cases it is quite possible that the frames were built first and the gaps were filled later, section by section[612].

During the period of the Second Palaces, it seems that certain details of the framing technique used in mud brick walls were transferred to rubble and, more rarely, to ashlar construction as well. For instance, vertical timbers were introduced as props for the upper stories and at the same time relieved the lower walls of weight. The increased use of piers and pillars that would transfer the weight down from above is another sign of the transition between Early and Second Palace architecture. Such vertical supports probably made possible lighter and higher superstructures. Concurrently, the use of small horizontal timbers as binders at many different levels within the rubble walls was abandoned.

Evans inferred a shortage of timber after the MM IIIA period at Knossos from the lack of heavy timber frameworks in most later walls and from the reduced size of timbers used. He thought that monolithic jambs of gypsum (*fig.* 13) were substituted for the usual wooden ones because of this shortage[613]. However, the changes of style in construction outlined here may have done more to bring about the absence of wood in certain structures than deforestation did. Even if we admit that there was a shortage of wood, it must have been a local one, confined to the region of Knossos. In his study of timber in the ancient world, Meiggs[614] suggests that the substitution of gypsum for wood had less to do with deforestation than with a change in fashion encouraging exploitation of ample supplies of gypsum nearby[615]. Pernier pointed out that at Phaistos there were changes in the use of timber from one major palace period to the next, but that wood was still used in the construction of the Second Palace period[616]. The extensive use of wood in the MM IIIB - LM IB Palace of Kato Zakro, which was destroyed in the LM IB period, implies a rich local supply of timber in the region at that time.

Vertical timber props were set in various ways. The simplest method, of course, was to set them on a slab at floor level. Usually they were flush with the face of the wall, and were plastered over. Occasionally, the rounded side of a timber which was exposed may have been adzed flat, the rest usually being left circular in section. At the Palace of Kato Zakro, all such supports were set on hard limestone slabs buried in the floor, so that the upper surface of the slab was at, or a little below, floor level. Mud was usually packed around the timber where it was set into the wall. In some cases, the mud was faced with a thin coating of lime plaster. In other instances, the wood was covered with plaster as well. To judge from the size of

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[611] *A. of C.*, p. 63. See above, p. 96, n. 598.

[612] Cf. Blegen 1964, p. 118 f.

[613] *Knossos* II, pp. 518, 565; A. of C., p. 188.

[614] Meiggs 1982, p. 99

[615] In their analysis of the Minoan charcoal from Kommos, the Shays (*Kommos* I [1], pp. 116-156) refer to the deforestation issue introduced by Evans as «difficult to evaluate» (p. 117). They also note (p. 130), however, that a decline in evergreen oak coincides with a rise in the evidence for cypress and pine after LM I, but Evans was referring to an earlier period beginning in MM IIIA.

[616] *Festòs* II, p. 420 and n. 243, p. 588 (mislabeled no. 245 in text).

the chases left in the walls, the timbers ranged from 10 cm to 40 cm in section. Their lengths must have been at least 2 m, but since the original height of a wall is nowhere known at Zakro, and can only be approximated from existing remains and analogy with better preserved Minoan structures elsewhere, this measurement cannot be more closely specified[617].

Sometimes at Kato Zakro, a chase for a vertical wooden post would be discovered in the upper part of a wall when rain had washed it clean of loose earth, so that the contours and colors became more obvious than they had been during actual excavation. In such cases, one could usually find the slab on which the post was set by cleaning the floor at this point.

At Zakro the props were sometimes set next to one another (*fig.* 175), no doubt to support a major ceiling beam that passed overhead, or to support a column or pier at the second floor level. In two cases in Room xxviii (as *fig.* 175, top and bottom right; *fig.* 176), such wooden posts were set about a rubble core to form pillars. The pillar illustrated, preserved 0.84 m above the floor level, was found to have been made up of at least six long, stout timbers. In another instance, three posts, plastered over, take up the entire width of a partition wall at a certain point[618]. Elsewhere, as in Room L, the props were placed at set intervals along the eastern wall, about 0.85 m apart, no doubt to support a wooden beam upon which rested the ceiling beams. At the same time this beam supported the framework of the upper steps of a wooden stairway that led to the next story[619]. Props also strengthened wall sides, forming piers (*fig.* 177).

Similar posts were used at Gournia, in walls of the Magazines (Room 24). Here posts 15 cm to 25 cm in diameter are set at intervals of about 1 m. The major difference between the technique used here and that at Zakro is that here pairs of posts were placed at corresponding points on either side of a wall. At Tylissos, where the same technique was used, posts, most about 20 cm in section, started 40 cm to 80 cm above floor level (*fig.* 178)[620]. They rested upon a short board that ran transversely through the wall. At a higher level the posts of each pair were joined together by a short horizontal strut. At ceiling level they either were mortised into the ceiling beams, which they were designed to support, or (according to the excavator) may have been surmounted by a short horizontal timber similar to that used at their bases[621].

The most unusual use of wooden uprights, however, was discovered in Rooms 68 and 69 at Phaistos, where a series of many squared timbers, about 9 cm to 11 cm in section and packed one next to the other, was apparently used to support the jambs and central pillar of the entranceway. Unlike the pillar described from Zakro (*fig.* 175, top and bottom right),

[617] One way of conjecturing the height of the ceiling here is by estimating the height of the columns in the nearby light-well of Room xxviii, and then allowing for the projection of the column base and the thickness of architrave and ceiling beams. Thus, taking the average base in the light-well as 40 cm in diameter, we can multiply 40 by a number from 5 to 8, which is the range of approximate height-to-base-diameter of columns found elsewhere (*P. of C.*, p. 194; *Festòs* II, pp. 472-474). This gives a range between 2.00 m and 3.20 m for the column shaft and the (presumed) capital. If we add to this range the projection of the column base above the stylobate (7 cm) and the possible thickness (total height) of architrave and ceiling beams, which was perhaps 40 cm, the height of the ceiling, and hence that of the props set within the walls, ranges from 2.47 m to 3.67 m.

[618] In the southern wall of Room xi.

[619] It is interesting to note, with reference to our discussion above concerning changes in style, that small lengths of wood are not built into the walls of the Palace of Kato Zakro, as they were in earlier walls elsewhere. Indeed, at Zakro horizontal beams were probably used in rubble walls only at the level of the lintel or ceiling.

[620] *Tylissos* (2), pp. 49-50, fig. 11.

[621] Upright posts were also used at Phaistos. A particularly conspicuous example is that of a blocked doorway leading from Corridor 41 into Room 94, where the impressions of posts have been preserved within the clay and rubble filling. See *Festòs*, I, fig. 203; also fig. 207 (Room 51).

where the wooden supports were on the exterior, the very core of those at Phaistos was composed of wood. Pernier and Banti, as well as Levi, have commented on this curious technique[622]. Upon each of the bases there were substantial amounts of carbonized wood and clay from the original structure. Some of the imprints, such as that illustrated here (*fig.* 190), lay almost directly in contact with the stone bases. Mortises cut into the bases suggest that some of the timbers may have been doweled to them, although this doweling may have been intended to stabilize a horizontal framework of wood into which the numerous uprights were set[623].

At Hagia Triadha, pairs of posts occur in a number of walls, such as the northern wall of Room 1 (*figs.* 212a, 212b). These were about 17 cm in section, and were hidden completely by the gypsum dado and wall plaster applied over them. In Room 4 (*fig.* 180), which was built up against the hillside, posts were probably placed only on one side of the eastern and southern walls. These posts, as well as those along the northern side of the room, were exposed, for there are vertical chases between the dado slabs[624]. Also, the back edge of the top slab of the bench has squared cuttings at the points at which the posts were set. Two beams were set at either side of the interior corners along the eastern wall, to furnish extra support. The timbers, according to the size of the cuttings in the bench slab and the vertical sockets in the walls, must have been about 21 cm by 26 cm in section. Also at Hagia Triadha, in the southern wall of Room 3, one can see the sockets of vertical posts, terminating slightly above floor level and set on flat slabs of gypsum or limestone. The three sockets visible, spaced 1.35 m apart, contained timbers that must have been about 18 cm in section[625]. Graham suggests that these beams, like those already discussed from Tylissos, may have been joined by transverse bars or struts at a higher level[626]. Examples of a similar propping technique can be seen both at Knossos (*fig.* 83) and, less commonly, Malia[627].

The technique was rarely used in the case of dressed stone masonry, although an example can be seen in the southern part of the restored Northwest Bastion at Knossos (*fig.* 98)[628], and also in the rather roughly coursed ashlar construction forming the eastern wall of Room 9 at Hagia Triadha. It is understandable that such instances are infrequent since walls of coursed ashlar masonry were stronger than rubble walls, and did not need the auxiliary help of props to support heavy superstructures. Supports of this type hardly ever occur in connection with exterior walls of palaces or houses, no doubt because if a vertical chase for the wooden prop is to be installed, the technique of overlapping ashlar blocks, which gives the wall its lateral strength, must be abandoned.

The most monumental application of this technique occurs in the interior walls of the well-preserved eastern Residential Quarter at Knossos. Here a series of heavy wooden beams, set vertically and horizontally, was used to encase ashlar walls composed of blocks reused from the destroyed walls of the First Palace (*fig.* 102)[629]. This method of building, Evans believed, was introduced at Knossos in the MM IIIA period and, since

[622] *Festòs* II, pp. 313, 317, 335, 436-437, figs. 191, 195, 197, 201; Levi 1951, p. 340, fig. 14; see also *P. of C.*, pp. 157-158.

[623] D. Levi kindly allowed me to inspect and photograph the large clay lump in *fig.* 190. The only trace of a horizontal beam on the impression, perhaps from the framing which must have gone about the small sections of wood at the top and bottom of the pillar or jambs, can be seen on the left side of the illustration.

[624] They may have had grooves into which the slabs fitted, similar to those in the thin vertical «pillars» in the Temple Tomb at Knossos (*fig.* 222).

[625] *P. of C.*, p. 151, fig. 67.

[626] *P. of C.*, p. 151, fig. 67.

[627] At the latter, unexcavated sockets for timbers once lined both sides of the parapet wall bordering the Central Court on the west. These sockets, which are not clearly visible now because of weathering of the wall, I observed during the summer of 1964.

[628] As *Knossos* IV, fig. 3.

[629] *Knossos* I, pp. 347-348; II, 349.

it did not appear in later building on the same site, was taken by him to be a characteristic architectural feature of that period at Knossos.

During the Protopalatial period, and most evident at MM II Malia, builders were constructing carefully joined, flexible wooden frameworks to partition off interior space. The window-door combination in the Hypostyle Crypt (*fig.* 183) is one example, but the technique can be seen elaborated on a larger scale in a series of «pier-and-door partitions» («polythyron»), the earliest examples known, which regulated entrance into Maison A of Quartier Mu (Rooms I 13 and I 1 in *fig.* 184). This room group was composed of three consecutive rooms, including a light-well within one of the earliest known columned porticoes, on the east (*fig.* 139)[630]. The structural arrangement is an early expression of «xylodesia», or half-timbering technique, which was to epitomize later Neopalatial architectural style, in which a building is literally held together by joined timber frameworks (*figs.* 181, 182b, 185) on each floor, with upper frameworks supported by ashlar and wooden piers carried up from the lower stories.

The development of the style, perhaps originating at Malia, and then becoming generalized throughout Crete, cannot be due to simple careful building or chance but, rather, to intention. In a land subject to frequent earthquakes, the structures provided elasticity and flexibility to offset the destructive lateral shifting caused by earthquakes. The technique was surely an effective antiseismic measure, as suggested by studies carried out by Porphyrios, Schaar, Driessen, Palyvou, and Tsakanika-Theohari[631]. Palyvou's view, focusing on Minoan-influenced Theran architecture, is nevertheless quite apposite for Crete: «The answer to the quest for building in an earthquake resistant manner, however, was given primarily by the extensive use of timber. ... [I]t has become clear that this was a ... technology, where timber and stone supplement each other. A sophisticated timber technology is applied everywhere: in the reinforcement of stone walls, horizontal and vertical, in the elaborate construction of openings, where wood is the main load-bearing element, and in the staircases where timber frames embrace all the surrounding walls, carrying the loads of two and three stories down to foundation level. The pier-and-opening (door, window, or cupboard) structure (a true invention of the south Aegean people) is the boldest manifestation of this timber technology»[632].

In the interior walls of the Hall of the Double Axes at Knossos (*figs.* 181, 182a), great squared timbers were first set vertically at intervals along the sides of the walls, with their lower ends resting on the masonry some distance above floor level. At the ends of walls or at openings for doors and windows they were set upon especially cut gypsum bases. The wooden framework apparently went all the way through the wall, splitting it into separate sections[633]. On top of the timbers here rested a series of horizontal beams at lintel level that ran all around the room[634]. The same system continued at lintel height above the pier-and-door

[630] Poursat and Schmid 1992, fig. 30.

[631] Porphyrios 1971, Schaar 1973, Driessen 1987, Palyvou 2005, especially pp. 173-179, and Tsakanika-Theohari 2006 pp. 251-253.

[632] Palyvou 2005, p. 175.

[633] *Knossos* II, p. 565. However, the plan (*Knossos* III, fig. 218) shows one vertical timber on each side of the wall. In the East Corridor, the base of one of the vertical timbers was socketed into a clamp-like cutting in the MM II masonry below (*Knossos*, III, suppl. pl. xxxv a). Nearby, the method adopted for the MM III rebuilding was different, for most of the wooden superstructure seems to have been set directly upon a massive horizontal beam or beams set at a high level of the wall (*Knossos*, I, fig. 252). Near the Court of the Stone Spout to the north a method similar to that described in the Hall of the Double Axes seems to have been used (*Knossos* I, fig. 267).

[634] Most likely, the vertical and horizontal beams were joined by mortising. Evans hypothesized open, transom-like spaces above lintel level, since proven to have existed occasionally at Akrotiri on Thera (Palyvou 2005, p. 144 and fig. 213), and also that there were

partitions that divided the large room into separate sections. These partitions, fitted with a series of doors, could be opened or closed as the residents preferred. The same horizontal beam formed the lintels above the entrances to the room and the top of the window frame in the western light-well (*fig.* 215). The top of the window frame was composed of four beams, about 30 cm by 30 cm in section, which were laid side by side, and supported some five and a half tons of masonry[635]. Above this level was set another series of vertical posts, in line with the above-mentioned posts at the lower level, which ran up to a second line of horizontal beams which paralleled the course of those running below them. Upon these horizontal beams rested the ceiling beams, which were apparently set across the short east-west spans created by the pier-and-door partitions. This same series of heavy horizontal beams formed the architrave for the columns of the light-well to the west, and also carried the ceiling beams of the eastern part of the Middle East-West Corridor (*figs.* 181, 182a, at A).

The floor plan of the next story seems to have been quite similar to that of the Hall of the Double Axes below, for gypsum doorjamb bases and paving slabs were found in situ, although at a lower level because of the collapse of the wooden beams on which they were set[636]. The same framing technique may have been used to form the walls of this upper story.

In the Residential Quarter at Knossos (as well as in most other fashionable buildings of the Neopalatial era), much of the weight of the upper walls was distributed down to ground level not only by means of woodwork used within the walls, just discussed, but also by stout timbers set on bases at wall-ends, corners, the sides of window and door frames, and in piers set next to stylobates. Free-standing pillars and columns performed similar functions.

Props at wall-ends, like those set within walls, were often set simply at floor level, examples being one on the south side of Room xxviii at Kato Zakro (*fig.* 175), one along the west side of the Central Court at the same site (*fig.* 165, right), and another, at Malia, in about the same position relative to the Central Court. Sometimes the slabs on which they were set were roughened by hammer-blows to prevent the wood from slipping on the stone (*fig.* 55b). Occasionally slabs or bases were omitted altogether. In various doorjambs they are replaced by flat wooden boards, as in examples in the northern Residential Quarter at Malia[637]. In some instances the framing of a door would be set directly upon the large stone threshold block, as in House Za at Malia (*figs.* 59, 197B)[638].

Despite the variety of ways used to set such timbers, especially in Eastern Crete, it seems that at an early point in the MM III period, especially cut bases of gypsum and limestone (*figs.* 186-189) were introduced[639]. Pernier and Banti, for instance, thought that the constant use of such bases was a characteristic which differentiated the First from the Second Palace at Phaistos[640]. They provided firm platforms for the wooden construction, elevating it only a few to as much as 10 cm or more above floor level so that the wood would not rot, a device paralleled in the use of stone column bases for wooden columns. The use of such bases for jambs and piers became a standard technique in Central Crete, especially in the fancier areas of buildings near Knossos (Nirou Khani, Amnisos, Archanes, Tylissos, and Knossos itself) and in the Mesara (Phaistos and Hagia Triadha)[641]. East of Nirou Khani the

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double leaves for the doors, found as well at Akrotiri (Palyvou 2005, p. 147, fig. 208).

[635] *Knossos* III, p. 319.

[636] *Knossos* III, p. 291.

[637] *Mallia, IV*, pls. XXXI, XXXII, 1; *Guide*, pl. VIII, 2; *P. of C.*, p. 46 (double doorway into iii, 7 from iv, 6). See also Schmid 1983, *passim*.

[638] For other examples see Charbonneaux 1928, pp. 355-357, figs. 2, 3; *Tylissos* (2), p. 51. Roughening for wooden jambs can be seen on thresholds at Gournia and Zakro as well.

[639] For details see J.W. Shaw 1999, pp. 765-766.

[640] *Festòs* II, p. 420.

[641] For a description of their use at Phaistos, see

use of special jamb-bases becomes the exception rather than the rule, for they occur only occasionally at Malia and Gournia, and while common at Myrtos-Pyrgos, appear only in certain areas of the more important structures at the sites of Palaikastro, Petras, and Zakro. Sometimes an unusual stone, serpentine, was used for jamb-bases, as in the Northwest Entrance to the Malia Palace (*fig.* 5) and alongside Court A in Building 6 at Palaikastro, where two gamma-shaped and three T-shaped serpentine bases supported the pier-and-door partition framework at the entrance to the Minoan Hall there [642]. Use of an uncommon, perhaps even «exotic», material for the bases here seems incongruous since they were presumably hidden by wooden construction.

Such bases (*figs.* 186-189) characterize the lower parts of the pier-and-door partitions that divide up many large rooms (as *fig.* 181), but they appear in other parts of buildings as well. At Phaistos, where the excavators made soundings near certain bases, these were found to rest on solid foundations. The shapes of the bases vary, those set next to piers, pillars, or wall-ends being L- or C-shaped, while those between doors had T or I shapes in order to provide reveals for both door leaves. The wooden doors either pivoted in or closed against the inner angles of the projecting «tongues». The size of the blocks used varied according to the scale of architecture. In many cases, because of the empty chases in the otherwise rubble construction, the size and positioning of the wooden members used can be estimated (*figs.* 190-192c). At Knossos, occasionally timber was replaced by a jamb of solid gypsum (*fig.* 15)[643].

The custom of setting in gamma- (or C-), T- (or I-) shaped bases [644] seems to have lasted at least through the LM II period when they appeared in a «Minoan Hall» at Knossos [645]. Elsewhere, it is unclear whether a pier-and-door partition found at a high level above House C at Tylissos [646] is of LM III date or earlier. Perhaps the closest one can come at this point to LM III continuation of the form are the C- and I-shaped pier-and-door partition bases incorporated into the double doorway arrangement within the Shrine (Building H) at Hagia Triadha (*fig.* 188)[647]. Unlike most partition bases, these are carried out almost in relief on the separate rectangular slabs, with the rectangular part into which the door closed also provided with pivot sockets. The inclusion of close-fitting slabs, almost wedged in, for the thresholds themselves has been thought by some to be a Mycenaean characteristic [648], but one can point out that separate threshold slabs were used in the classic pier-and-door partitions of the Residential Quarters of the Knossos Palace, also that a threshold made up of a close-fitting, slab cut at an angle was discovered at Neopalatial Pyrgos IV [649].

Often a single squared or rectangular block was set within the face of a wall at such places as wall-ends, corners, or the ends of stylobates, or as the base of a pier. In certain pier and pillar bases, timbers were set upright at each corner with a single upright timber placed in between. In the case of L-, I-, or T-shaped doorjambs mentioned above, timbers were usually set one on each end and another in the middle. The number could vary, however, depending on the length of the block; as few as two timbers and as many as four occur in certain instances at Phaistos [650]. In the few examples where the size of the timbers could be

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Festòs II, pp. 434-442, figs. 273-276. For the distribution of these and other Neopalatial stylistic leitmotifs see Driessen 1989-1990.

[642] Driessen 1998, pp. 252-253 and fig. 3.

[643] *Knossos* II, p. 518, fig. 319.

[644] For their distribution throughout Crete see Driessen 1989-1990.

[645] Driessen 1999, p. 228. For the «Minoan Hall» form, see Driessen 1982.

[646] Hayden 1984.

[647] For the date and earlier references see Cucuzza 2001, p. 170.

[648] For a review of Mycenaean aspects of the LM III architecture at Hagia Triadha, see Cucuzza 2001.

[649] Cadogan 1978, fig. 38.

[650] *Festòs* II, p. 440.

measured at this site, they were 15 cm to 20 cm thick, and were not covered with plaster[651]. Spaces between timbers were filled in with mud and rubble, which was coated on the outside with lime plaster that was sometime painted over, usually in red. Only at Phaistos and Hagia Triadha were the vertical posts doweled to the jamb-bases (*fig.* 208). In some cases these timbers were set upon horizontal boards about 10 cm thick laid directly upon the jamb base[652] although this board could be omitted, as can be seen at Tylissos (*fig.* 189), Malia[653], and also at Nirou Khani. Exactly the same process was followed for timbers set on edge along the sides of some window frames (*fig.* 212b). Some were stabilized by wooden clamps or dowels, a technique often used when ashlar was involved (*figs.* 193-223).

The Minoans appreciated, as we do, the natural appearance of wood. This is indicated by the fact that timber which could easily have been covered over by plaster was usually left exposed. There is some evidence at Phaistos that wooden jambs were not plastered over[654], and at Zakro beam sockets are usually left without a casing of plaster about them. Sometimes wooden beams were even simulated in wall paintings found at Knossos, where wood was rendered with its graining in red on an ochrous ground.

In certain cases, however, plaster was applied to wood. At Zakro, for instance, vertical timber supports within a wall near Room xi were entirely hidden from view, and in the Hall of the Double Axes at Knossos a horizontal beam that could easily have been left exposed was, instead, painted over with a frieze of colorful rosettes (*fig.* 181)[655]. Often wood might be covered by dado slabs although, as we have seen in an example from Hagia Triadha, a special effort was sometimes made to fit dado slabs between vertical wooden props set into the wall (*fig.* 180). Certainly in this case it would have been easier to set the bench edge slightly out from the wall and run the dado without interruption around the room.

Since Minoan columns were made of wood, they have almost entirely disappeared, and usually the only indications we have of where they stood are their bases. The few carbonized remains or imprints left by them do not provide sufficient information by themselves for restoration of the column in all its dimensions with absolute certainty. Moreover, there is evidence that the shape and height of columns varied from site to site and sometimes within the same building[656].

To cite one of the problems, almost all Minoan columns as shown in ancient representations are surmounted by capitals, and yet there are no actual examples of capitals, which were probably made of separate blocks of wood doweled to the tops of the column shafts[657]. It is clear, however, that the shafts of the columns were usually round, although as suggested by bases at Phaistos and Knossos, they may occasionally have been oval. To judge from carbonized remains found on their bases, the lower part of a column was somewhat smaller than the base on which it was set, perhaps to ensure structural stability[658]. Of eight examples from Phaistos, where there was sufficient evidence from which to infer the original diameter of the shafts, the diameter of the bottom of the shaft was about two-thirds to seven-eighths of the

[651] *Festòs* II, p. 440.

[652] *Festòs* II, p. 440.

[653] See *Mallia*, III, pl. XIX, 1.

[654] *Festòs* II, p. 440.

[655] See also Fyfe 1902, p. 112: «... probably painted and left flush».

[656] See Festòs II, pp. 472-473. For a lengthy and informative discussion of some of the evidence, see *P. of C.*, pp. 190-197, also *Festòs* II, pp. 471-474, and Charbonneaux 1928, pp. 361-362. For a description of column bases see the discussion here, pp. 79-85.

[657] See the fine miniature stone capital (probably part of a lamp base) found in a house at Zakro (Platon 1963a, p. 165, pl. 142b). For a discussion of Minoan and Mycenaean capitals, see Wesenberg 1991, pp. 3-26, with pl. 1-67.

[658] Allowance for possible «slippage» at Akrotiri on Thera is also generous (Palyvou 2005, fig. 187).

size of the base[659]. Evans, however, thought that there was a constant difference of about 0.05 m between the diameter of the base and that of the shaft[660], a figure arrived at Malia[661] and Palaikastro[662] as well[663]. The diameter of the shafts probably ranged from about 0.28 m[664] to as large as 1.35 m[665], although the normal range was probably about 0.33 m to 0.58 m.

Since no Minoan column has been preserved in its entirety, the column height can only be estimated from such criteria as the height of existing ceiling levels, the proportions of columns in miniatures of various materials and those from wall paintings, and from the columns associated with monumental doorways in Mycenaean architecture, such as that at the «Treasury of Atreus» at Mycenae (*fig.* 270). At Knossos, Evans estimated that the height of many of the columns was about five times the diameter of the base[666]. Pernier and Banti, however, emphasize that there is no constant relationship between base diameter and column height in cases when the approximate original height of the column is known[667]. We can probably conclude, therefore, that while the distance between stone base and wooden architrave can be estimated in certain cases, there is no sure method for deducing the exact height of a Minoan column even if we know its lower diameter and/or the diameter of its base.

As already mentioned, in the Residential Quarter at Knossos, Evans discovered the carbonized remains of a column which, he believed, showed a definite downward taper[668]. Since,

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[659] In the entranceway at Archanes (*figs.* 123a, 123b), the excavator discovered burnt remains of columns still on the stone column bases (*Archanes*, pp. 80, 144, figs. 63-64). The diameters of these carbonized remains, when excavated, were about half the diameter of the bases on which they rested. This has led some people (such as J. Alsop, «A Reporter at Large», *The New Yorker*, 13 August 1966, pp. 81-82) to assume that here resides proof of the original column size at Archanes. In turn, this led to the unwarranted generalization that this was true at other sites as well. In his article, Alsop goes even further to speculate that the «ugly» columns at Knossos were restored more according to the so-called «Late Victorian» taste of Evans's time than according to the size actually used by the Minoans.

I think that this interpretation of the Archanes remains, however, is questionable. I also think, as pointed out throughout this book, that the Minoans were not as concerned as other peoples (for instance, the Classical Greeks in their temple architecture) with conforming to established architectural norms. To this extent, what they did in their art and architecture is not predictable in its detail, although it may be readily recognized by its general appearance to be Minoan. This is the source of much of the joy of studying Minoan remains. Therefore, in order to substantiate a particular Minoan tradition, one must have more than a few examples from one site (as at Archanes) before making generalizations.

As to the actual remains of the wooden columns at Archanes, it is my experience that when a substantial piece of wood burns, the exterior becomes ash while the interior slowly becomes carbonized. This process advances with the outside ash layer gradually dispersing until the wood has been reduced to ash. At Archanes I suspect that the building was burning, and had been burning for some time, when the upper story collapsed down into the ground floor and court. This partly smothered the flaming timbers on the ground floor and, when the fire had gone out, only a percentage of the original column diameter, itself completely carbonized, was preserved. The rest had dispersed in the form of ash, some falling down onto the ground nearby, with the majority being sucked up into the column of rising air created by the intense heat of the fire. For more reliable visible evidence for the relationship of column base to diameter of column, I much prefer a mold or form made of the column before it was burnt, such as those at Malia, in figs. 173 and 174, which generally confirm the range of ratios established by excavators such as Evans and Pernier.

[660] *Knossos* II, p. 674, n. 1.

[661] Charbonneaux 1928, p. 361.

[662] In Building 6 at Palaikastro a column base had upon it a raised curving line of plaster that outlined the column shaft once set there. The diameter of the column was 0.40 m, 0.06 m less than that of the base (Driessen 1998, p. 249).

[663] Charbonneaux 1928, p. 361.

[664] This I estimate from a base, 32 cms. in diameter, which was found in Room Z of a building northeast of the Palace of Kato Zakro.

[665] This is slightly smaller than the diameter of one of the large bases in the Propylon at Phaistos, 1.42 m.

[666] *Knossos* III, p. 336.

[667] *Festòs* II, p. 474; see also above, p. 99, n. 617.

[668] *Knossos* I, p. 343; III, p. 321

in architect Doll's restored section of the Grand Staircase[669], he has made all the columns of the same uniform diameter at the bottom and top of the shaft, I sense that there was a difference of opinion between the excavator and his architect. At one point, moreover, Evans conceded that there was «an element of doubt in the matter»[670]. To complicate the matter further, another of Evans's architects, Theodore Fyfe, shows the same columns with a downward taper (*fig.* 181), much as they were restored later in reinforced concrete.

A second test of the question of whether or not the columns actually had a taper came with the discovery of the Fetish Shrine in the Little Palace. Here a partition wall was built up against a series of small columns, and the convex fluting on the shafts of the columns was preserved in the mud and rubble of the partition. Once more there was a difference of opinion about a taper, for Fyfe's measurements showed a taper while Doll's did not[671]. Doll's measurements were accepted by Evans, apparently, and as a result the published restoration does not indicate a taper[672]. This instance led Evans to propose that columns of Late Minoan times (in contrast to the earlier columns found in the Residential Quarter of the East Wing) may not have tapered[673].

In the northwestern corner of the Central Court at Malia, partition walls were built up against two columns of an early colonnade that was partly incorporated into an eastward expansion of the West Wing. The forms of the columns, which were not removed during the rebuilding, can still be seen clearly (*figs.* 173, 174). These examples show that the shaft of each column was set only a short distance from the edge of its base. The excavators state that these impressions definitely tapered down[674]. I find it difficult to imagine, however, that a taper amounting to 1 cm to 2 cm in the height (0.80 m) preserved, could be detected on a rough clay impression where only such a small part of the column height was preserved[675]. My own measurements of the example to the west (*fig.* 174, left), now partially restored to keep it from dissolving in the rains, show a uniform diameter of about 48 cm; but, again, since so little of the original column height has been preserved, this cannot be taken as an indication that the shaft was of a uniform diameter either.

It seems to me, therefore, that neither impressions nor carbonized remains of columns in Crete can yet be said to prove conclusively that the columns had a downward taper. Such a taper can only be inferred from strong corroborating evidence provided by representations in the minor arts and in wall paintings, and in later times from Mycenaean examples in stone (*fig.* 270)[676]. The point can be labored, but one hopes that clear and positive evidence, probably in the form of a mud or plaster «cast», will someday confirm a hypothesis which is now usually accepted without question.

We have a good deal of evidence about the size and placement of ceiling beams. For the early period, for example, such evidence exists in the rooms of the southwestern section of the First Palace at Phaistos (*fig.* 72). Here the walls are preserved over two stories high, and one can see on their sides the sockets left by the floor beams, which rotted out. The floor level in the illustration is evident because of the slight projection of the wall at this point and the sockets for floor supports, also because of a blocked doorway nearby. Below the level

[669] *Knossos* I, fig. 247.

[670] *Knossos* I, p. 342, n. 1. Lawrence (1957, p. 299, n. 6) says: «The excavation obtained no evidence whatever for the shape of the columns and did not ascertain their precise height».

[671] *Knossos* I, p. 343, n. 2.

[672] *Knossos* II, p. 521, figs. 321, 322 and n. 3.

[673] *Knossos* III, p. 321. See also *A. of C.*, p, 192.

[674] Charbonneaux 1928, p. 357, n. 2, p. 362. See also *Mallia*, I, pp. 33-35, fig. 7.

[675] The taper of the Lion Gate column at Mycenae, for instance, was only 1 in 36 (*P. of C.*, p. 193).

[676] See Wesenberg 1991 for the variety.

of the floor, a row of sockets for the beams can be seen, about 1.80 m above the bottom of the wall. The sockets average 10 cm to 15 cm in diameter. Also, there is a second row of sockets, about 50 cm below the first (*fig.* 72, at B). These indicate another, earlier or later, floor. Similar, roughly contemporary ceiling/floor support was provided by many round beams, ca. 0.18 m in diameter, ca. 3 m long, and spaced apart ca. 0.70-1.20 m, in Quartier Mu at Malia (*fig.* 261).

At Knossos, both sockets in the upper parts of the walls, as well as carbonized remains, were found in the Domestic Quarter (*figs.* 181, 182a)[677]. Some beams were as large as 40 cm in section[678]. Similar sockets were found on the top of the ashlar walls of the Hypostyle Crypt at Malia (*fig.* 117)[679]. In the Temple Tomb at Knossos (*fig.* 191), gaps left between wall blocks of the northern and southern walls of the Pillar Crypt make it clear that two very heavy beams, probably about 5.60 m to 5.90 m long (minimum) and about 0.50 m in section, crossed the room, and were supported in the middle by stone pillars. Upon these were set some eight crossbeams, each about 6.10 m long. Seven of these were set in sockets cut in the top course of the eastern and western walls[680]. The end of one beam was set on a horizontal timber spanning the passageway leading into the innermost chamber.

Beam sockets were also discovered in the «crypt» of the Royal Villa. From them Evans deduced that a single tree trunk, over 4.20 m long, spanned the room from north to south. This must have rested on the pillar set in the middle of the room. The beam, which may have been split, tapered from its base, which was about 0.80 m thick, to about 0.50 m at the other end. Upon it were set three crossbeams, each 4 m long, which were no doubt socketed into the top of the great trunk[681].

Occasionally impressions of ceiling beams, in clay or plaster, have been found, fallen, on the floors of rooms. A number of such clay impressions, for example, were found at Gournia and Nirou Khani. They consist of adjoining half-circles of clay which Hazzidakis interpreted as the result of the pressure of the clay roof upon the upper ceiling beams[682]. The impressions indicate a round timber about 11 cm in diameter. Perhaps they were preserved through having been baked in the fire that destroyed the buildings[683]. Impressions in plaster from Kommos also preserved the shapes of reeds once laid over beams (*fig.* 192a), probably from the Neopalatial South Stoa there[684]. Other molds were recovered from MM Phaistos (*fig.* 192b), where round poles, ca. 12 cm to 13 cm in diameter, were once set close to one another; perhaps they were perhaps set above a horizontal beam along the edge of the open side of a building, to judge from their smooth outside edge[685].

Upper floors using round beams below a layer of earth was the rule, but evidence for the use of wooden boards and planks on upper floors is beginning to appear. For instance, as early

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[677] See above, p. 93, notes 570, 571. Some of these sockets, which appear to me to be original, can be seen in the East-West Corridor (*fig.* 102, top).

[678] *Knossos* I, p. 328.

[679] These sockets, admirably described and illustrated by the French excavators (*Mallia, Centre Politique*, II, p. 19, fig. 2 and pl. I) ranged from 40 to 80 cm in width, 40 cm being the minimum dimension for beams which spanned about 4.00 m. See also Daux 1961, p. 949.

[680] *Knossos* IV, pp. 968-970, figs. 931, 932, 938, 950; *P. of C.*, pp. 159-160.

[681] *Knossos* II, p. 408, fig. 235; IV, p. 970; Evans 1902-1903, pp. 150-151, fig. 90; *P. of C.*, pp. 158-159, fig. 97.

[682] See *MA:MAT* 1, fig. 186.

[683] *Tylissos* (2), p. 54, pl. XII, 2. A smaller triangular piece of clay, 8 cms. by 6 cm, was found at Malia (*Mallia, Centre Politique*, II, p. 20, n. 3).

[684] M.C. Shaw 2006, no. 134, from south of the South Stoa (Trench 90B/22). See also the section here in Chapter 4 on ceilings.

[685] From Militello 2001, fig. 34 (see also pl. XIII, 3), from below Geometric houses and likely belonging to Levi's Protopalatial Phase 3 (p. 123).

as MM II, planks, their forms preserved by the plaster once set around them, were used in connection with staircases in Quartier Mu at Malia (*fig.* 262)[686]. Two other groups of plaster impressions are particularly informative. One is at Kato Zakros in the so-called «Banquet Room» (Room xxix) where forms of the ceiling structure have been preserved, like «cut-outs», in the upper border of a running spiral plaster frieze that circled the room at ceiling level[687]. On the north-south axis, these «cut-outs» indicate at least three adjoining, rounded beams, each probably sectioned in half longitudinally, which crossed the room near its center. The clear span was about 6.60 m. Their diameter along the southern side of the room ranged from 34 cm to 38 cm. On the east-west axis of the room, 7.00 m wide, squared «cut-outs», some distance from each other, indicate that planks were set at what appear to have been equal intervals, and they no doubt rested on the main, semicircular beams. The planks, to judge by their impressions in the plaster, were at least 7 cm thick and at least 26 cm wide.

The use of planks here, rather than the usual circular beams, must be explained; for squared timber requires special cutting with saws and adzes, and perhaps even aging to prevent warping. A possible explanation is that boards were laid in a north-south direction upon the east-west planks, the result being a wooden floor. Of interest in this respect is a group of baked clay «ceiling» molds from Chania. One, illustrated here (*fig.* 192c), shows that roughly cut wooden planks were laid at right angles to, and upon the ends of, beams some 13 cm to 25 cm in diameter[688]. Perhaps the planks prevented the beams from shifting while a thick layer of earth was spread over them, and before a slab floor was to be set in place. More evidence for possible wooden floor construction on upper floors will no doubt be gained from future recovery and study of similar molds[689].

An idea of the maximum thickness of beams used in ceiling structures can be obtained from the two basement rooms or crypts in the Royal Villa and that in the Temple Tomb. A more reasonable estimate of the average-sized timber used for major structures at Knossos, however, may be made from the size of the beams restored in the Domestic Quarter, 30 cm by 30 cm. It is probable that beams used in places other than Knossos, where a monumental effect was desired and more manpower may have been available, may have been smaller. Little evidence for ceiling structure exists at other sites, but the size of timber used as props in walls and for interior framing about windows and doors averages about 15 cm to 25 cm in section.

Nor can the short spans within the Knossian crypts be considered as representative, for even at Zakro, in the example discussed, the uninterrupted span is 6.50 m, and the beam must have been at least 7m long. As Graham has pointed out[690], spans from 5 m to 7 m are known from a number of sites. If we knew the exact plan of a number of upper floors at the major palaces, where the rooms were larger and the weight carried was less, I imagine that some of the spans would be surprisingly long.

B) Wooden Clamps and Dowels (*figs.* 193-223)

As we have seen, the strength of a Minoan wall usually depended upon the mason's ability to lay stone carefully and to pack clay, pebbles, or small stones in interstices.

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[686] Schmid 1996, fig. 45. Palyvou has also reported that at Akrotiri on Thera certain Neopalatial staircase landings had wooden floors (2005, p. 127).

[687] Platon 1971, p. 172; also Platon 1964a, p. 150, and 1964b, p. 138.

[688] Hallager 1990, p. 285 and fig. 4.

[689] At Akrotiri on Thera, wooden floors have been suspected but have not yet been shown to have existed (Palyvou 1999b, pp. 211, 226, n. 414).

[690] *P. of C.*, pp. 159-160.

Unlike the technique used in later Classical Greek buildings, this process did not usually involve joining stone blocks by means of clamps and dowels. Even in the case of the ashlar masonry used for façades or occasionally for walls in the interior of buildings, clamps and dowels were not used for most of the construction.

There are some cases, however, when clamps and dowels were used. We infer their presence exclusively from mortise cuttings, usually found on the upper surfaces of building blocks. Apparently the tenons fitting into such mortises were wooden, for no stone or metal examples have been found so far in Minoan buildings. Carbonized matter found within mortises, moreover, confirms the presence of wooden tenons burned when the buildings were destroyed.

1. Wooden Clamps

The use of clamps is restricted almost exclusively to the Palace of Knossos where it occurs on poros limestone and gypsum blocks[691]. The only examples reported in archaeological publications dealing with Knossos are on the double orthostate wall fronting the great Western Court of the Palace (*figs.* 92, 93). Although most of the top of this wall is now obscured by modern restoration and by remains of the upper part of the wall, which originally must have been of rubble[692], clamp cuttings are still clearly visible at a number of points, especially just east of the West Entrance to the Palace[693]. The long block of gypsum on the western face contains two clamp mortises, while on each of the two smaller blocks forming the eastern face there is only one. The two transverse wooden clamps linking the blocks were about 1.10 m long and 0.28 m wide. Nowhere, on parts of the wall now visible, is there any indication that blocks of the same face were joined by clamps. Running along the top of the wall, however, were probably horizontal wooden beams fastened down by tenons set in small square mortises, at least one of which is still visible on these very worn gypsum blocks (*fig.* 93 at C).

Clamps were used occasionally on poros limestone walls, as shown by a series of large blocks, which lie along the interior face of the west wall of Storeroom 18, in the northwestern section of the Palace (*figs.* 193,194)[694]. Of the three blocks, only A can be studied in its original form, for B is broken off at its north end and C, now partially covered by a stone, may have been reduced in size when being reused. A and B are quite long, 2.43 m and 1.50 m (minimum), respectively. All three blocks are roughly equal in width, averaging 0.52 m to 0.79 m, and are 0.45 m to 0.50 m high. There are no mortises for dowels cut into their exposed upper surfaces. Both blocks A and B have three deep (13 cm to 16 cm) cuttings for dovetail clamps, their lengths ranging from 16 cm to 25 cm, their widths at the exterior 5 cm to 9 cm, and at the interior 8 cm to 19 cm. The four mortises along the western edges

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[691] As far as I know, the only variation in material or in shape of the clamp is to be seen on the hard limestone frieze (our *fig.* 19) discovered in the area of the Northwestern Entrance of the Palace of Knossos. The slab was apparently hung on the wall by means of a bent metal or a wooden tenon first fixed to the wall and then fitted into a vertical trapezoidal slot («joggle»), tapering inwards, that was cut into the back of the slab. (*Knossos* II, pp. 592, 605, suppl. pl. XXIIa).

[692] See also the discussion of this wall on pp. 62-63.

[693] For previous references to the clamps on this wall, see *Knossos* I, p. 128, fig. 95; Evans 1900-1901, pp. 3-4, fig. 1; also Mosso 1907, fig. 56; Durm 1910, fig. 36; Bell 1926, pp. 121-122; Orlandos 1958, p. 179, fig. 134 (from Durm); *P. of C.*, p. 152, fig. 118.

[694] The blocks are probably reused in their present position, to judge from the fact that there is no clamp mortise on Block A to correspond with that on the southern end of Block B (*fig.* 193).

were certainly designed to hold transverse clamps crossing over to blocks, now missing, originally forming the other face of the wall. The position of the remaining mortises, at the southern ends of A and B, suggests that the clamps here were designed to join blocks of the same face, a phenomenon not noticed on the gypsum orthostates to the southwest[695].

Outside Knossos, there is a lone dovetail clamp cutting in a poros limestone block along the interior of the western wall of Room 15 of House C at Tylissos (*fig.* 189). There it probably joined the block illustrated with a horizontal beam set upon a ledge cut along the side of the block.

In summary, clamps on Minoan buildings in Crete usually appear at Knossos, being restricted to the western half of the Palace and being only of the dovetailed variety. As might be expected, they were always set into the tops of blocks, and they functioned to join opposite faces of walls as well as adjoining blocks of the same wall. The use of such clamps of wood, which were almost invariably of the dovetail shape, probably came into fashion in the closing phases of the MM period[696]. They may very well reflect a practice more common in wooden construction where the sides of horizontal timbers set along each side of a wall face were joined to each other through the rubble core of the wall by wooden clamps, or in which the ends of individual sections of timber laid end-to-end along a wall face were joined to each other, although there is no tangible evidence to prove that this is so. There are only three examples of which I know where stone and wood may have been joined together by wooden clamps (*figs.* 195a, b, 196 [A])[697]; normally, round and square dowels, to which we now turn, performed this important function.

The small square or round holes chiseled or drilled[698] into the upper surfaces of blocks in Minoan buildings were, generally speaking, intended to receive round or square dowels, almost invariably of wood[699]. Similar holes occur in association with doorways and colonnades, but were used there for a different purpose. In the case of doorways they can be circular pivot holes cut either in a threshold or a separate block; sockets for doorposts, which are usually square or rectangular; and sockets for bolts and other locking mechanisms. In the case of the colonnades, wooden columns or posts were occasionally set between columns or piers, as for example along the stylobate of the East Wing of the Palace of Malia, presumably as a part of a fence-type structure which closed off the East Wing from the Central Court[700]. These posts were equipped with round tenons, 10 cm in diameter, which fitted into corresponding cuttings in the stylobate slabs.

The ordinary dowel stabilized horizontal and vertical wooden members from below. During the period of the later palaces, square dowels (at Phaistos and Hagia Triadha the shapes of mortises often tended to be oblong) seem to have been confined to particular types

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[695] For similar clamp cuttings at Knossos, particularly on reused blocks in the Palace, see *MA:MAT* 1, p. 159, fig. 190, and Appendix G there.

[696] For a discussion of the date of the West Façade at Knossos, which is crucial for the dating of the use of wooden clamps by the Minoans, see pp. 62-63.

[697] The third example is cut into the back face of the elegant north façade at the Palace of Galatas. The lower end of a vertical supporting timber in the East Wing of the Palace of Knossos, however, was cut into a dovetail shape that was inserted sideways into a corresponding notch in a large wall block (see *Knossos* III, Supplementary Plate xxxv, a.)

[698] They may sometimes be oblong.

[699] The use of metal dowels or pins has been suspected by Evans in connection with a gate in the House of the High Priest at Knossos (*Knossos* IV, pp. 206-208, figs. 157-159), although metal remains are not reported to have been found.

[700] As *P. of C.*, p. 77 ff.

of construction and, consequently, their presence on coursed ashlar walls, piers, pillars, window sills, and bases for doorjambs may serve as a guide to architectural interpretation.

2. Round Dowels

The least common type of mortise, the round type, seems to have been used mainly at Malia. A few have been reported at Knossos[701], and perhaps they were used in a threshold at Zakro[702]. In all instances the holes are drilled in relatively hard stone. Their diameters vary from 1.5 cm to 6.5 cm, averaging 3 cm to 4 cm. Their depth varies from 0.25 cm to 5 cm, also averaging some 3 cm to 4 cm. The cuttings themselves are of two types. One (as in *figs.* 61, 144b, 149, 197A) is a shallow, smoothly polished cavity, called «saucer-shaped» here for convenience. The other (as in *figs.* 59; 60 at 2; 197B) is deeper, and with vertical sides. It is difficult to explain how the former type was made, except to suggest that it was probably ground out by a blunted object, perhaps a stick, which was turned by a bow-drill such as that described below. On the other hand, a hollow, circular drill was certainly used for the excavation of the second type; for in a number of cases the smooth drill penetration can be seen, enclosing the rough inner core that was broken off incompletely when the drilling was terminated. In one instance, the drill hole was apparently not completed, and its mark is clear (*figs.* 59, 197B)[703].

At Malia round mortises apparently do not occur on wall blocks belonging to the Palace itself, although there is at least one column base in situ with a drilled mortise (*fig.* 142), and there are a few nearby in MM II Quartier Mu (*fig.* 139)[704]. Instead, they are found in doorways of houses and on building blocks used within the ossuary of Chrysolakkos. Two doorways are instructive in this matter, for they illustrate the use of both types of round mortise.

The first doorway is near a court in House E, south of the Palace[705]. Here a rectangular threshold of calcareous schist of a green color was flanked on either side by fine, uncut slabs of hard limestone (*figs.* 61, 197A). Each one of these flanking slabs has two mortises, 5.4 cm to 6.4 cm in diameter, 0.5 cm to 1.0 cm in depth, placed 69.5 cm apart[706]. Judging from analogies with mortises on stone bases flanking thresholds elsewhere, these probably held short tenons stabilizing vertical wooden members of the door framing. An alternative interpretation is that these holes served as pivots for a series of doors opening up into the court from the south. In the former solution, each tenon would have been fastened into the end of

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[701] Evans reported blocks of schist with round dowel holes in them, reused in the pavement of the Western Entrance (*fig.* 2) (*Knossos* II, p. 670, n. 2). Along their sides were dowel holes 4.2 cm in diameter and 4 cm deep. Two of the holes were drilled out, but the cores had not been removed. Also at Knossos, in the House of the High Priest there were holes in a threshold, 1.5 cm in diameter and 0.25 cm deep, which Evans interpreted as pivots for metal gates (*Knossos* IV, pp. 206-208, fig. 158).

[702] In House A at Zakro, Hogarth found a threshold block about 1.22 m by 0.54 m by 0.39 m, which bore three dowel holes, two at the south and one at the north (Hogarth 1900-1901, p. 132)..The type of stone and size and shape of the holes are not given, nor can one inspect the threshold block today. If the threshold was of hard gray limestone, which is typical of thresholds in the area, circular holes are inevitable, for the stone was too hard to be cut by a bronze chisel but could be penetrated by a circular drill.

[703] For more information about the drilling procedure, see the discussion of drills on p. 51. For thresholds and door frames at Malia and elsewhere in Crete, see Schmid 1996, pp. 77-79; for those at Akrotiri on Thera, as well as window frames, see Palyvou 2005 pp. 136-142 and 1999c, pp. 289-422.

[704] For a discussion of such column bases, see p. 84 and Appendix C, p. 181.

[705] For previous discussions of this doorway, see *Mallia, Maisons* II, pp. 99-100, pl. XXXIV, 1, 4, 5, 6; Daux 1967, pp. 509-510, figs. 12-14; *Guide*, p. 70 ff., fig. 22.

[706] Distances between dowel mortises will be given throughout this section as from far edge of one hole to the far edge of the other.

a wooden post set vertically and joined to the horizontal wooden door-framing above. The posts could well have been round, to judge from the distances (about 20 cm) from mortise to slab edges.

A second doorway at Malia is that in House Za, directly east of the Palace. It served as the main entrance to the house from a street on the south[707]. Here (*figs.* 59, 197B) the entire wooden door-framing and passageway were accommodated on a single slab of hard limestone about 1.58 m long and 0.98 m wide. While the central part of the threshold was left smooth, at each end an ample area was cut down, presumably sawn and then split off with a hammer and chisel, about 1.6 cm deep, in order to provide a rough footing for the wooden door frame set upon it. Of the three pairs of drilled holes visible on the plan (AA', BB', and CC', following the labeling introduced by the excavators), the pair CC', 2.6 cm in diameter, was left incomplete, for the drill mark penetrates only slightly below the top surface of the stone[708]. Pair AA', 4.8 cm in diameter and 3.4 cm deep, probably contained long dowels mortised into the bottom of vertical members of the door frame which supported the lintel, also presumably of wood, as was the custom in domestic and palatial architecture[709]. In this case the jamb probably did not rest on a horizontal board, for there is not a second pair of mortises to the north of pair AA', such as one sees in the case of squared mortises on jamb-bases on sites in the Mesara (*fig.* 208), where the horizontal board seems always to have been used. B and B', 2.6 cm in diameter and 2 cm deep, have been interpreted in the past as pivot-holes, which they could very well be[710].

Elsewhere at Malia, at either side of the southern entrance to the «Agora»[711], northwest of the Palace, are two large, triangular bases of hard limestone. The surface of the base on the east is quite damaged, but that of the larger western one (*fig.* 196C) has been roughly cut down for about 20 cm along its northern and eastern sides, and has two circular mortises at the two best preserved corners[712]. The third corner is so weatherworn that any trace of a third mortise that probably once was there has disappeared. To judge from similar techniques employed on wall corners elsewhere (as in *figs.* 196B, 206), the two mortises were designed to receive wooden dowels. Moreover, comparing the slight ledge cut along the sides of the block with similar ledges on windowsills of poros limestone, there seems little doubt that these dowels were keyed to horizontal beams of wood laid along the two exposed ledges (as in *fig.* 212b). On these beams were set vertical wooden supports for the lintel of this monumental entranceway. That horizontal timbers were stabilized by round wooden dowels is important for the discussion that follows.

The most interesting example of a building consisting in part of blocks with drilled holes is the ossuary of Chrysolakkos at Malia, the large rectangular burial enclosure which

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[707] See *Mallia, Maisons* I, pp. 65-66, figs. 6, 7, pl. XXII, 2; *Guide*, p. 66, fig. 20, pl. XVI, 2; also the detailed description in *P. of C.*, p. 174, and fig. 110.

[708] There remains the possibility, however, that pair CC' was drilled before the end sections of the threshold were cut down, and thus may have been deeper originally.

[709] Although Graham (*P. of C.*, p. 174) states that «blocks» may have been held from below by such dowels, he later agreed that the word «posts» should be substituted.

[710] Graham reports that the edges of these holes show clear traces of wear (*P. of C.*, p. 174), although I did not notice this during my reinspection of the threshold block. For a comparable situation at Knossos see *Knossos* IV, p. 207 fig. 158. See also the somewhat different interpretation by the excavators in *Mallia, Maisons* I, fig. 6.

[711] For general plan, see Daux 1963, fig. 3 opposite p. 876, also fig. 6, p. 237; *Guide*, p. 53. Most important is *Mallia, Centre Politique*, I, *passim*.

[712] Also described in van Effenterre 1963, p. 236; *Guide*, p. 53, and *Mallia, Centre Politique*, I, pp. 34-35, pl. XXXV. The dimensions given on pl. XI are somewhat different from my own. See also van Effenterre 1980, p. 404, note 4.

was originally built during the first part of the Protopalatial period. Most of these blocks now make up part of the northern and western walls, where they function as a wide krepidoma (*figs.* 198, 199)[713]. To judge from the better preserved wall on the east (*fig.* 96), the krepidoma served to support large orthostates which are now missing, undoubtedly hauled away for use in some other structure.

In the past, the round holes (*figs.* 60, 199)[714] mostly in the front sides of the blocks as we see them now, and clearly made by hollow drills of the type already discussed, have been interpreted as being the result of, or having some function in, transporting or lifting the blocks into place[715]. This interpretation is doubtful, however, since the Minoans did not use elaborate lifting devices (such as pulleys or lewises), and in the case of the blocks at Chrysolakkos the holes are only on one side. Also, in their present position the blocks could simply have been dragged and then slid into place. Another possibility arises, namely that the holes may be the result of quarrying operations. But if used in quarrying (and there is no indication elsewhere that the Minoans ever used drills in such operations), wouldn't the holes have been used for splitting the stone and, as we see them now, wouldn't they occur on the edges rather than closer (as they are) to the middle of the blocks? The explanation, I think, lies elsewhere, and is to be found if we consider the holes as functional elements within a building.

But how could they have performed a function as we see them now, on the sides of krepidoma blocks? Their most likely use would be, I suppose, to retain wooden dowels, but would the other ends of the dowels have held elaborately carved revetment blocks? Or wooden sheathing? Either at this low level to the ground seems highly unlikely and, besides, the holes appear to occur on blocks set at random intervals. These blocks seem to bear no physical relationship to each other in their positioning, nor are they set at significant points in relationship to the rectangular outline of the ossuary.

However, if we free the blocks from their present context and place them on their edges «mortises up» (the normal position for mortises, as we have seen), then their original use becomes obvious: they must be orthostates which were reused by the builders of the ossuary. When set on edge, with their smooth edges up, they would have been surmounted by a series of timber beams that were held in place by dowels set in the holes drilled in the blocks' upper surfaces.

One could object to this explanation on at least two grounds, the one being that although we can position the reused blocks in almost any way that seems reasonable, they are not squared on their bottom (at present, back) edges and are also of uneven height. If they are to be interpreted as reused orthostates, then their height when in place in the building should be the same. The second objection is that although there are examples of Minoan orthostates with square dowel cuttings in their tops[716], there are none with round dowel cuttings to show that their function would be analogous.

Both of these objections are answered readily by the large orthostates along the eastern side of the ossuary (*fig.* 96). First, individually these blocks are not equal in height, and they are propped up from below by rubble so that their tops are approximately level. Secondly, there are round holes drilled in the tops (and only the tops) of

[713] See *Mallia, Nécropoles*, I, *passim*; *Guide*, pp. 76-78, plan fig. 23. Platon told me that he believed that the enclosure wall, with which we are concerned here, was constructed in the EM III-MM IA period. Soles dates it somewhat later, in MM IB-II (Soles 1992, p. 168).

[714] The holes average 4 cm in diameter, and some 3 to 5 cm in depth. A longer, more detailed discussion of the following interpretation of the Chrysolakkos architecture is in J.W. Shaw 1973 b.

[715] *Mallia, Nécropoles*, I, p. 27; *Guide*, p. 77. The only person who, as far as I know, has questioned this interpretation is Graham (*P. of C.*, p. 154).

[716] See pp. 58-64 and figs. 85, 90, 91, 93.

some of these now weathered blocks, and the holes are in positions where they could have been used to stabilize timbering set on the top of the wall.

Most round mortises used in building construction, therefore, contained tenons that in turn fitted into sockets drilled in wooden beams set above them. There seem to be two types, the «saucer-shaped» and the drilled ones with parallel sides. The former occur occasionally in doorways, but most often on column bases. The latter occur in connection with corner piers, entrances, and orthostates. Most probably, the drilled krepidoma blocks at Chrysolakkos are reused in their present positions; some of them are really orthostate blocks now lying on their sides. These blocks may belong to an earlier phase of the Chrysolakkos ossuary, may have been designed for a different building but were never used in it, or may have been extracted in ancient times from a nearby, still undiscovered building for reuse in their present positions. Known examples of round mortises are so limited that the maximum time span suggested for their use, MM IB to LM III, from the time of the building of the ossuary of Chrysolakkos to the late architectural modifications of House E at Malia, is liable to revision.

3. Square Dowels

Unlike round mortises, which are limited in number and use, square and sometimes oblong mortises occur on early as well as on later sites, wherever orthostatic masonry or ashlar construction of gypsum or poros limestone was used. They are found at Hagia Triadha, Phaistos, Archanes, Tylissos, Knossos, Nirou Khani, Malia, Gournia, the Palace of Kato Zakro, and elsewhere as well. As was the case with round mortises, this type has never been studied comprehensively[717].

During the period of the First Palaces, their use in connection with stone may have been restricted to exterior façades and to a few pillar or pier bases in the interiors. Upon the building of the Second Palaces, however, the technique seems to have become more common on the interior than the exterior of the buildings, appearing consistently on free-standing pillars, piers of various types, windowsills, and occasionally on doorjambs. In almost all cases the wooden dowels fitting into them joined stone to wood[718].

Apparently the earliest use of square wooden dowels to bind timbers to cut stone blocks is to be found at Phaistos, along the top of orthostates belonging to the earliest southwestern façade of MM IB date (*figs.* 85-87), as well as on orthostates aligned with these further north and dated by the excavators to MM IIA (*figs.* 88-91)[719]. To judge from the mud and rubble construction used in the walls of the rooms behind the façade, mortising was not used there.

The number of dowel holes cut into the top of this façade course is exceptional, for nowhere else in Crete have I seen so many holes set so closely together on wall blocks in situ. Perhaps this technique is a distinguishing characteristic of early mortising, for at Phaistos itself mortising is used much more judiciously in later construction. Most of the mortises along the northern section of the early façade here (as in *fig.* 90) are set back from the edge of the blocks some 10 cm to 18 cm, a distance similar to that of the southern section (range

[717] See, however, Durm 1907, fig. 11, also his 1910, fig. 36; Orlandos 1958, pp. 189-190. figs. 141, 142; *P. of C.*, pp. 157, 174, and fig. 123; *Tylissos* (2), p. 50, figs. 6, 12, and *passim*; as well as other references given in the notes here.

[718] Possible instances where stone may have been joined to stone by dowels are rare. The only possibilities I am aware of are on the corner of a LM I building (unpublished) excavated by Alexiou at Amnisos, and also at Myrtos-Pyrgos.

[719] For more information about this monumental façade, see p. 59.

11 cm to 16 cm) and to that used later for mortising on windowsills. In a few instances mortises on this northern façade were placed behind (east of) the western line of north-south mortises, perhaps an indication of the very size and/or position of the beams set upon the wall. The holes themselves average 5 cm by 5 cm[720] and are about 6 cm deep[721]. The close spacing here is undoubtedly an indication that the masons were quite determined to keep a horizontal timber in place[722]. No doubt this beam received the lateral thrust of the thick mud and rubble walls above, stabilized vertical timbers mortised into it, and also may have been intended to bind the orthostate blocks together.

The only other example of mortising I know of in the area of the First Palace at Phaistos, although it has a somewhat different arrangement, is on a corner block which was reused in the foundations of the MM II A Palace (*fig.* 81)[723].

As far as I know, during later phases of architecture, mortises for dowels were usually cut only into the tops of blocks. I know of only one instance where beams were joined to a superincumbent block[724]; occasionally they appear on the sides of doorjambs and, in one case, on the side of a cist[725].

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[720] Those in the southern section may be somewhat smaller, to judge from the ones now visible. They range from 3 cm by 3 cm to 4 cm by 5 cm in size.

[721] The upper surfaces of some of the blocks have been restored with cement by the excavators, but on most of the blocks furthest to the north the holes are still clearly visible.

[722] See also *Festòs* I, pp. 184, 441-444.

[723] According to the excavators, this block is the missing corner block of the southernmost part of the Early Façade (fig. 87) (Levi 1957-1958, p. 206, fig. 20; Fiandra 1961-1962, p. 119, fig. AA'). This attribution seems unlikely because a bedding for a beam on the block in question does not recur on any of the blocks of either northern or southern section of the early façade at Phaistos. The origin of the block, therefore, remains unknown, but it could have originally belonged to a corner of a propylon or room to the east of Room lxiv.

For similar use of square mortises on reused blocks at Knossos, see *MA:MAT* 1, p. 168 and fig. 190, also Appendix G there.

[724] When the top parapet slabs of the staircase at Myrtos-Pyrgos (*fig.* 211b and cover illustration), were lifted for conservation, they were found to have dowel holes in the underside – so that the wooden beams below were secured from top and bottom.

[725] At Knossos, for instance, there are at least two blocks used as doorjambs with mortises along their sides. The first is in the southern part of the West Wing, west of the staircase leading up to the Piano Nobile, where some five mortises of standard shape are carved into the western side of a large gypsum block 1.35 m to 1.60 m by 1.16 m by 0.49 m. On the same face of the block are one horizontal and one vertical bedding cut for wooden beams. If the block is in situ, and not reused, the mortises may have retained part of a wooden door frame. A similar block is in the East Wing, north of the «Magazine of the Medallion Pithoi», where it may have performed a similar function. The block, 0.48 m by 0.95 m by 1.00 m, has about the half of one side cut back 0.25 m where four mortises of canonical size are visible.

Elsewhere, at Malia, at the end of Wall 1 in a series of storerooms in the East Wing (Area xi, 1) stands a block of poros sandstone, the end of which has been cut back to leave a central, squared vertical projection (*Mallia,* III, pp. 3-4, fig. 1). On each of the flanking surfaces there is a single mortise. These may, as the excavators suggest, have received bolts for double doors, but it seems more likely to me that they stabilized vertical wooden door frames. A somewhat similar block can be seen at Hagia Triadha, at a doorway opening from the south on to the Rampa Dal Mare. On the inner faces of the stone block are mortises, two on the east and one on the west. These blocks, along with the examples mentioned above, give some support to the theory that in rare instances vertical timber framing may have been attached to the sides of stone jamb blocks by means of square dowels.

To turn now to the cist: In the westernmost of the two deep repositories at Knossos is a series of four mortises cut into the inner sides of the blocks (for plan and section see *Knossos* I, p. 427, fig. 335 a & b). Apparently there are also mortises on the floor slabs as well (*Knossos* I, p. 468), although they are not shown on the published plan. According to the excavators, the mortises in this case «may point to a wooden framework, but it seems possible that there was also a metal casing» (*Knossos* I, p. 468).

A study of mortises on dressed pillar and pier blocks is especially informative[726]. There seem to have been three types of stone pillars built of cut blocks: the monolithic, the «multi-block», and what I call the «low-block» type. The monolithic (*fig.* 70) is composed of a single long, squared block set on end, rising from the floor to the ceiling. Occasionally the corners were beveled. The «multi-block» type (*fig.* 200) consists of a number of finely squared blocks, usually of differing heights but with the same widths. There is some evidence to show that the total height of such pillars was calculated in advance so that one block could be set above the other until a predetermined height was reached. The third pillar type, the «low-block» type (*figs.* 202-206), was made up of a single block which served as a base for wood and rubble construction that was carried up to ceiling level. All three types of pillar were usually set on large blocks, usually wider than the pillar blocks themselves, set into the floor and projecting up just above floor or pavement level[727]. Monolithic pillars appear only at Knossos, the best known ones being in the Monolithic Pillar Basement (*fig.* 70), the Temple Tomb, and the North Pillar Crypt. Of these, the first are of limestone while the second two examples are of gypsum (three pillars). The only example of mortising reported among these is that of two mortises on the top of the single pillar in the Sepulcher of the Temple Tomb, where the mortises found in two of the four corners of the top of the block[728] were probably once balanced by two others in the opposite corners, as in the pier base in *fig.* 208. These held a horizontal frame of wood on which the ceiling beams rested.

The multi-block type (*figs.* 200, 201) is much more common[729]. It seems that dowel mortises were cut only in the upper surface of the topmost block of such pillars. Usually one was placed in each corner of this block. The blocks themselves were joined only by a thin layer of clay mortar to give them stability, as is the custom in all coursed ashlar construction. This observation, also made by various scholars such as Evans[730], Banti[731], and Graham[732] is basic for determining whether a certain pillar is complete in its present state. Moreover, since the ceiling beams usually rested upon this uppermost block, the height of the pillar is crucial in determining the height of the ceiling.

A good example of a pillar with its topmost block preserved and in situ is in Room 2 of House C at Tylissos (*fig.* 200 [note mortises]). It rises 1.66 m above the top of the base upon which it is set, and 1.76 m above the floor. This type of pillar with mortise holes on its top also occurs in Rooms 1.1 and 1.2 of House B 2 at Mochlos, in the Unexplored Mansion at Knossos[733], and at Akrotiri on Thera[734]. The relationship can also be seen in the Unexplored Mansion at Knossos[735] where there are four dowel holes

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[726] By pillars I mean free-standing supports which, unlike wooden columns, are made up of one or more blocks of stone or, in rare cases, simply of clay packed between vertical beams set on end (*figs.* 175, 176). Occasionally pillars were made up of limestone slabs stacked one above the other (*figs.* 157, 158). By piers I mean square, rectangular, or, occasionally, triangular pillars engaged in a wall. The construction of pillars and piers is often quite similar if not the same. For more specific references to piers and pillars consult the Index.

[727] For an example at Malia (the Pillar Crypt [vii, 4]), see *P. of C.*, figs. 95, 98.

[728] As shown in *Knossos*, rear of Volume IV, in the plan «Temple-Tomb partly reconstructed showing constructional details».

[729] At Knossos, there are examples in the Pillar Crypts of the West Wing, in the Southeast House, in the Southwest Pillar Room, and also in the Rooms of Two and Three Pillars in the Little Palace (*fig.* 62c). They can also be seen at Tylissos in House A, Rooms 3 and 15 (*fig.* 201), and Room 2 of House C (*fig.* 195). There are two in Room vii, 4 at Malia, and one in Room 26 at Phaistos.

[730] *Knossos* I, p. 425 and n. 1.

[731] In Graham 1956, p. 157.

[732] *P. of C.*, p. 157.

[733] *MUM*, pl. 29b and foldout plan there.

[734] Palyvou 2005, fig. 99 and p. 131.

[735] *MUM*, Plan and pl. 29b, c, d, f.

in the top block of each of the two completely preserved southern pillars, but none in the top of the northeastern pillar of which only the first block is preserved.

There is no doubt that the wooden structure of the ceiling at Tylissos rested on the top of this pillar. It is not possible now to determine the exact nature of that structure, but I think that it must have been very similar to that of the Pillar Crypt of the Royal Villa which, as we have seen (p. 108), was deduced from beam-cuttings discovered in the walls. The comparison is an apt one, I think, for the buildings are contemporary, and the rooms in question, both basements with a central pillar, are similar in size[736]. In each case, the pillar presumably served to support a column in the room above.

In the «Crypt» at Knossos, the pillar rises about 1.80 m above the floor[737], a height close to that already noted from Tylissos (1.76 m). The floor-to-floor distance in the case of the former was about 3.06 m. The gap between the top of the pillar and the top of the floor above, therefore, was about 1.25 m. In Evans's reconstruction this space is taken up as follows: 1) ca. 0.20 m, for a wooden frame upon which the main ceiling beam was laid. In the case of the pillar from Tylissos, a similar frame must have been stabilized by means of dowels set in the mortises visible in *fig.* 200; 2) 0.65 m, the thickness of the main beam at its center; 3) 0.20 m, half the thickness of the crossbeams set on and into the main beam; and 4) 0.15 m to 0.25 m, the thickness of the actual flooring. I propose, therefore, that the floor-to-floor distance of this room at Tylissos was 3.06 m ± 20 cm[738].

The third, «low-block» type of pillar, is probably more common than has been realized in the past. Having seen a completely preserved multi-block pillar, it is natural for one to assume that other pillars, with only one block, were originally carried up with more blocks. However, mortises cut into the top surfaces of the single, «low» pillar blocks set on floors in many sites, make it clear that wooden, not stone, construction was mounted upon them (at Kommos and elsewhere I have seen masons' guidelines for the positioning and cutting of mortise holes in the form of two parallel lines incised at right angles to the side of the block nearest to where mortises are to be placed). That wood continued up to the ceiling in such cases is shown by the fact that no stone blocks similar to the pillar base (hence belonging to it) are found fallen nearby during excavation. In some cases actual remains of the wood that surmounted the pillar bases have been found. For example, in House A at Zakro, Hogarth found a single, squared block on a plinth, and felt certain that its continuation upward was «represented by a quantity of burned straight-grained wood found standing upright upon it»[739]. Perhaps the best examples of such pillar bases, with mortises clearly visible, are those in the so-called «Hypostyle Hall» (Room ix, 2) at Malia. Here, of six bases, five have a mortise in each corner (*fig.* 202)[740].

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[736] That at Tylissos is about 5.20 m by 4.70 m, as scaled from the plan; that at Knossos is about 4.00 m by 4.20 m.

[737] Most of the following measurements are scaled from the section in *Knossos* II, p. 396, fig. 226.

[738] Hazzidakis's calculations (*Tylissos* (2), fig. 10) about the estimated height of the ceiling in Room 15 of the same house led to a very similar result. Similar calculations could be made on the basis of other pillar blocks at Tylissos, a site which is especially well preserved and where little has been restored. There is one mortise in a corner of the seventh (top) course of the pillar in Room 3, House A, 1.98 m above the floor; and one in the second (top) block of the northernmost pillar in Room 15 of the same house, 1.77 m above the paving of the court (*fig.* 200). For additional discussion of ceiling, floor, and story heights, see *P. of C.*, p. 187f.

[739] Hogarth 1900-1901, p. 130. Hogarth does not report square mortises on this block, no doubt because he did not look for them. Similar blocks, all with mortises, have been found to the south, in the area of the Palace, e.g. in Room lviii (*figs.* 210a, 210b).

[740] Hue and Pelon (1991, pp. 14-15) have suggested, however, that blocks rather than wooden construction were set upon the Malia bases in *fig.* 202. This is based on blocks found near the pillars by the first exca-

No doubt a number of pillars of this type will remain unrecognized, either because the top of the base block has been weathered so that mortises that may once have been there are no longer visible, as (I suspect) along the stylobates of Central Courts, or because modern restoration has in some cases covered over the tops of blocks now visible at floor level. In some cases, as at Knossos, it is clear that pillars now rebuilt in the form of the «multi-block» type with cement were of the «low-block» type originally, for the actual-state plans indicate the mortises discovered on top of the base block by the excavators (as *fig.* 206 at C). Such a pillar should have been restored like a pier block from Phaistos (*fig.* 205).

Exceptions to the normal arrangement of wooden supports above the «low-block» pier or pillar base occur at two points in the same wall at the east end of the North Stoa at Kommos. There a number of D-shaped blocks separated by horizontal wooden members were set in, sandwich-like, above a single, high base block, the arrangement being carried up to ceiling level[741]. Two restorations have been suggested, the first (*fig.* 203) featuring only horizontal wooden members[742]. A second suggests the use of vertical beams at pier corners[743].

Piers consist most often of a low block with mortises cut in its upper surface and, like the low-block type of pillar, must have been built on up to ceiling level with vertical timbers in the same way as the low-block type of pillar. Piers are far commoner than free-standing pillars, partly, I am sure, because they did not interfere with the interior covered space of a room as pillars did, but performed their structural function from within, or next to the wall. They occur on all major sites of the Second Palace period. For example, their various functions can best be seen in the Residential Quarter at Knossos (*figs.* 181, 182b)[744], where they served to reinforce wall-ends (*fig.* 206A), to support the corner of a pier-and-door partition (*fig.* 206B), to form a support for the architrave alongside a light-well (*fig.* 206D), to serve as a base upon which part of a stairway structure could rest (*fig.* 206E), to strengthen the corner of a wall (*fig.* 206F), and to terminate the wall of a balustrade while at the same time providing support for the horizontal ceiling beam above it (*fig.* 206G). In this building, piers of this type were sometimes actually continued upwards to succeeding floors, making possible the repetition of floor plans on succeeding

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vators but unfortunately no longer available for inspection. To accept the observation, we must assume that the bottoms of the now missing blocks also had mortise holes to receive the tenons certainly set into the tops of the blocks seen in *fig.* 202, even though we know that the bottoms of Minoan blocks were hardly ever mortised. An arrangement such as Hue and Pelon propose might be possible if the blocks discovered had replaced an earlier wooden structure set upon the blocks visible today. Or, perhaps, similar construction was carried up into a similarly built hall on the second floor, such as the banquet hall proposed there by Walter Graham (*P. of C.*, p. 125; Graham 1961, p. 169, figs. 7, 8).

Usually single block pillar bases had four mortise cuttings, but one at Hagia Triadha has six mortises, which probably indicates that six or more vertical timbers were set on edge to form the exterior of the pillar. Three mortises can be seen on another such block at Gournia, along the western side of the Central Hall (Room 21).

[741] There is no other Neopalatial arrangement for the structure, but a similar, well preserved pier is in the Postpalatial «Mercato» or Agora at nearby Hagia Triadha. The style has not been reported outside of the Mesara in south-central Crete, so this may be a local technique which carried on there into LM III. For the date of the Mercato see La Rosa 1977.

[742] M.C. Shaw 1999. She also suggests there that the arrangement led to the pi-shaped patterns seen on building antae in Minoan pictorial representations.

[743] J.W. Shaw 1987, pp. 103, 105 and figs. 10-11, written before the northern pier was discerned. The construction of that pier, where the horizontal wooden members between the D-shaped blocks were actually socketed into the adjoining wall, obviates the use of a vertical timber on that side. For a photo of that arrangement as found, see M.C. Shaw 1999, pl. CLXXII c.

[744] For their use at Phaistos, see *Festòs* II, p. 434 ff. and fig. 273.

levels and maintaining constant structural support within the walls from the bottom floor upwards. *Fig.* 216 (A) and *fig.* 207 (A) show plans of pier bases on two succeeding floor levels next to a window in the west light-well of the Hall of the Double Axes.

The base block for such piers was generally squarish, ranging from about 0.50 m to 0.80 m high and 0.40 m to 1.30 m on a side. There were often four square mortises of the standard size set about 7 cm to 20 cm from the edges, although this number depended upon the location and function of the support. According to the most common restoration made by archaeologists, horizontal timbers were first keyed onto the bases by means of the dowels. Upon this were set the vertical timbers, one on each exposed corner of the block, and sometimes one in between, in the manner also known from the construction of door-jambs and window frames. It is quite possible that the dowels used may have been as long as 30 cm, which would enable the builders to secure both horizontal board and vertical timber at the same time. This seems likely in certain cases, for sometimes an extra mortise, which would otherwise appear unnecessary, is set between the two corner mortises (as *fig.* 206B, E). When the pier bases were almost hidden in a wall (as *fig.* 206E), or were strongly supported from the side (*fig.* 206B), wooden supports of this type were probably placed only along the wall faces, as is suggested by the pattern of the mortises from Knossos and in certain examples from Tylissos as well[745].

Mortises also appear on a peculiar «hollow» pier type apparently used only in association with stairways (*figs.* 206A, 209). To my knowledge, this type occurs exclusively at Knossos, and there only in the East Wing, at a turn of the Northeast Stairs (*fig.* 209), at a stairway north of the Eastern Light Area (*fig.* 206A) and as the upper landing block at the turn of the Grand Staircase[746]. These pier bases are less remarkable for the number or placement of the mortises cut into their upper surfaces than for the curious rectangular hollows cut out from the back of the block. The only explanation of these hollows that I can give is that they may have contained a vertical shaft of wood which helped to stabilize the central wooden and stone structure of the stairway. This is suggested by three things: the position in which they appear at the turn of stairways; the fact that the slot for the shaft passes completely through the length of the block; and the indication by Evans's architect in one case that wood is to be restored in the hollow (*fig.* 206A).

The «hollow pier» type used at the turns of stairways seems to have been used only at Knossos. Most likely during early MM III (the beginning of the Neopalatial period), Minoans developed a simpler form which soon spread as far as Chania in Western Crete[747] and Kato Zakros at the eastern end of the island[748]. It is especially noticeable at Akrotiri on Thera where architect Palyvou has recorded and studied the form in detail[749]. As shown in our Cretan example of the type in *fig.* 204a, a stairway in Building T at Kommos[750], an ashlar block, often slightly trapezoidal when seen in plan, was first set at the beginning of the central wall («spine») of a U-shaped stairway, usually at the ground floor level. This process

[745] Cf. *Tylissos*, (2), p. 50, fig. 12.

[746] For the latter, see *Knossos* III, pp. 483-484, figs. 336, 337. A similar block may have been used in connection with a nearby drainage system (*Knossos* I, p. 381, fig. 276 [= III, p. 493, fig. 341J]).

[747] Hallager 1990, pp. 283-284, fig. 1 (Room O).

[748] Platon 1971, p. 211 for the location between Spaces XLVIa and XLVIb. The two dowel holes in the top of the ashlar block set at the eastern end of the central wall of the stairway are not shown. For more details about this type of stairway support and its possible development, see J.W. Shaw 1999.

[749] Palyvou 1999b, pp. 243-282, especially figs. 132 and 134 (the West House) and fig. 133 (Xeste 3), where the ashlar wall-end pier blocks concerned are still in situ.

[750] For this northwestern part of Building T at Kommos, see *Kommos* V, pp. 23-25.

was carried out again at the other end of the same spine wall at the first landing, and was repeated during construction at each subsequent landing. In the meantime dowels set into the two (usually) square mortise holes cut into the tops of the blocks, and just back of their leading edges, stabilized vertical wooden piers constructed upon them. The timber pier structure was carried up to the base of the corresponding block above, just as was done with the «hollow pier» arrangement discussed earlier but without the extra continuous wooden shaft that probably began on the ground floor and continued up to the final landing on that end of the «spine» wall. Two of the three mortised blocks in the Kommos stairway (*fig.* 204b) were not found in situ but were scattered in the general stairway area; but they could be restored with assurance, as in *fig.* 204a, because the form is so predictable. Mortised ashlar blocks of the same shape found loose on excavations, therefore, may very well belong to a nearby stairway of Neopalatial date[751].

In some cases great triangular blocks such as that already discussed from the «Agora» at Malia (*fig.* 196C) strengthened wall corners. An example from Knossos, with blunted ends (*figs.* 196B), shows three square mortises on its upper surface. No doubt the mortises stabilized horizontal beams upon which, in turn, were set the vertical timbers. The blunted ends of this example preserve cuttings, probably pry-holes used by the builders when positioning the block[752]. Somewhat similar blocks formed high wall corners (*figs.* 212a, 212b), the one illustrated being the topmost block of the northeast corner of Room 2 at Hagia Triadha.

Dowels also stabilized the wooden members of piers set at the ends of parapets of lustral basins (*figs.* 210a, 210b). An example from the Palace of Kato Zakro (Room lviii) is especially interesting, for it shows the rubble packing which filled the wooden frame set upon the base block still in situ, while the wood itself has disintegrated (*fig.* 210b)[753]. An analogous state of preservation can be seen in a pier base next to a wall in Room 23 at Phaistos (*fig.* 211a). Very rarely was more than one cut block used as the base for piers in lustral basins, although one fine exception, in which two blocks were used, can be seen in a lustral basin at Tylissos (House A, Room 11).

A structural solution somewhat similar to that of the parapet/column arrangement in the northern Lustral Basin at Zakros (*fig.* 210b) appears in the parapet alongside the elegant gypsum stairway at Myrtos-Pyrgos (*fig.* 211b and cover illustration). There dowel-stabilized timbers underlay the parapet slabs, at least two of which served, unusually, as column bases.

A major function of square wooden dowels was to stabilize wooden window frames set on sills of cut stone blocks. Indeed, with the exception of the early walls lined by orthostates, dowels were hardly ever used on the upper surfaces of the lower courses of walls unless they performed this function. Let us first consider well-preserved examples of windows and then, with these as a guide, attempt to apply the above principle.

One window which is especially informative, since it is so carefully built and largely intact, is in a well-5preserved section of Hagia Triadha, at the bottom of a flight of stairs and

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[751] They are also known at Phaistos; cf. *Festòs* II, p. 435, figs. 169, 211, 212.

[752] The block was once lying in a sheltered area near the ground floor light-well of the Grand Staircase.

[753] In *fig.* 210b the restoration of the upper section is hypothetical, being based on the proportions of the wall and the preserved remains as compared with similar parapets found at Knossos and Hagia Triadha.

[754] For this window, see Halbherr, Stefani and Banti 1980 p. 160, figs. 101-102, also Paribeni 1903, p. 337; Mosso 1907, fig. 35; *Guida*, p. 34. For detailed studies of the types of windows at Akrotiri on Thera, see Palyvou 1990, also 2005, pp. 145-152. An example of an early, MM II window at Malia can be seen in our *fig.* 183. For vent-like and other windows in contemporary Quartier Mu see Schmid 1996, pp. 79-81 and fig. 42.

bordering a light-well east of Room 2 (*figs.* 212a, 212b)[754]. This window is of moderate size and in most of its features is typical of windows discovered elsewhere, so it is very useful for study purposes. On the top of the sill are three mortises, 4 cm by 4 cm wide. Two are 5 cm deep, the third, central one is only 1.5 cm deep, and all are set back about 11 cm from the outer edge of the sill. Two of these mortises are set toward the ends of the sill; the other falls near, but not at the center.

In the restored drawings (*fig.* 212b) I have given the dowels a length of about 18 cm, equal to the depth of the deeper mortises (5 cm) plus the height of the horizontal wooden sill beam (13 cm), the latter being estimated as the distance from the stone sill up to the horizontal under-face of the strip of plaster along the southern side of the window (note section in *fig.* 212a). Most likely the space behind the sill timber was filled with mud or clay, and then plastered over[755]. Probably, the builders first cut out the mortises in the wooden beam with a bronze chisel and wooden mallet, and next cut the top of the stone sill to match (note bedding for beam cut in the central block), and then set the beam in place with the dowels. Most likely, a procedure similar to this was followed in the case of other sills to be discussed below. As in the case of many windows built near interior wall angles (as *figs.* 216A, 218, 219 [right]), extra stability was added to the sill timber by extending it into the adjacent wall. Why the middle mortise was placed exactly where we see it now remains unknown. Perhaps it was by chance, perhaps because two shorter, separate beams were employed for the sill.

North of the same sill, and three courses of stone above it, is a corner block which may be unique, and to which we have referred already. This block is cut down along its top, on both faces, and in the center of each of the two shallow cuttings is a mortise intended to key in a horizontal wooden beam. One of the two beams must have extended to the south and formed the top of the window frame. This provides an unusual instance in which the height of a window can be estimated on the basis of preserved cuttings rather than by means of collapsed upper courses of masonry (as at Knossos), by the levels of upper floors (as in the restored window in House C at Tylissos), or from secondary evidence such as wall paintings or miniature house façades. In this case, the height of the window must have been about 1.18 m, that is, the difference in level between the bottom of the bedding cut in the high corner block, and the top of the sill (1.32 m), minus the estimated height of the wooden sill timber itself (0.13 m).

There is a double-window, also facing onto a light-well, in Room xxviii in the Palace of Kato Zakro (*fig.* 213). Here only four dowels were set into the ashlar sill that is about 4.71 m long. To judge by the height of the packing discovered on top of the sill[756] the timbers here were about 18 cm high. Along the sill were four vertical wooden supports, two at the ends, the other two toward the center, flanking a wall abutting the window on the west. The dowel mortises do not correspond with these vertical supports, except in the case of the second from the south. It is probable that each pair of dowels secured one horizontal beam.

[755] At Knossos, for instance, such a window sill with the mud preserved was found, topped by gypsum slabs, within the Queen's Megaron (*fig.* 217A), (*Knossos* III, p. 367, figs. 244, 245) and also in the South House (*Knossos* II, pp. 376-377, n. 2), although there were no slabs in the latter case. More examples of such earth fillings are known at Archanes, on a sill about 30 cm wide, at Tylissos (*Tylissos*, (2), fig. 10, p. 45 and pl. X, 2), and at the Palace of Kato Zakro, alongside the light-well in Room xxviii (*fig.* 213). Such intermediate fillings were most practical, for they are even in texture and provide adequate support for a thin layer of plaster or gypsum covering the sill.

[756] The packing fitted between the beams laid on the front and back of the sill.

A number of windows, which also deserve mention, were discovered by Evans at Knossos (*figs.* 214-216, 217). Unfortunately, separate state plans of the sills, with which we are primarily concerned here, were never published at a readable scale. I have, therefore, endeavored to make such plans on the basis of Supplementary Plan E in *The Palace of Minos*, by Christian C.T. Doll and Theodore Fyfe. Details abstracted from this plan form the basis for the drawings.

In the Court of the Distaffs (*figs.* 214, 217B), actually a light-well near the toilet of the Queen's Megaron, there were once two windows on two sides of an interior wall corner. Their existence is proved by the gaps in the walls as well as by the shape of the fallen masonry, which had collapsed when the window frames disintegrated and has since been replaced[757]. The sill to the south has two mortises, presumably one at each end of the single beam that was set there, while that on the east has three mortises, two similarly placed on the ends, with the third falling approximately in the center between the two, though not at the center of the wall (and hence window) opening.

Another sill faces onto the western light-well of the Hall of the Double Axes (*figs.* 215, 216A)[758]. This sill is quite unusual, for it provides cut beddings along both its sides for horizontal beams. The only other sill providing cut beddings on sides of the window may be one along the southern side of the monumental building at Archanes[759]. In the former, to the east of the window, there is a stone pier base at sill level, also with beddings cut for the reception of wooden beams secured by wooden dowels, of which only four mortises were apparently preserved. The wooden sill beams of the window were apparently held in place not only by the dowels but by the pier construction to the east, onto which they extended[760]. The sill beams also penetrated into the wall at the western side.

Along the southern side of this sill there are three mortises, which are not placed in relationship to the position of the frame but rather at stable points of the blocks, far from their edges so as to avoid splitting the stone. This tendency can be noticed on sills already discussed, although not as clearly at Zakro because of the numerous blocks used and the limited number of mortises present. Curiously, on the central ridge of the sill of the window in the light-well of the Hall of the Double Axes there are two mortises which seem to bear some relationship to other mortises on each side, but not to the basic dimensions of the window frame. Along the northern side of the sill are two more mortises, which are symmetrically placed within the length of the sill.

Another window overlooks a light-well located directly east of the Queen's Megaron (*fig.* 216B, 1). The single block here used for the sill, our first example of a monolithic sill block, has a bedding cut along its southern side, containing one dowel hole off-center. Comparable to this is that of a nearby window in the south wall of the Hall of Colonnades (*fig.* 216B, 2), also monolithic and with a single mortise placed off-center.

Within the Queen's Megaron itself is a series of combination benches and windows (*fig.* 217A)[761]. On the eastern side of the sill there is only one mortise reported. No doubt more exist below the gypsum and plaster which remains undisturbed on the surface of the blocks. During excavation, the preservation of this plaster was probably rightly considered more important than the detection of the mortises beneath. On the second sill, that to the south, Evans restored a similar arrangement, even though the gypsum slabs were apparently missing. Three mortises are visible on the plan and, as was the case with most of the

[757] *Knossos* I, p. 334, fig. 243; III, fig. 265.

[758] *Knossos* I, fig. 253 a (before restoration), 253 b (after restoration); 254.

[759] Between Room 10 and the court to its south.

[760] A similar arrangement, although not as neatly executed, can be seen on a pier base adjoining a window sill next to the large southern court at Hagia Triadha.

[761] *Knossos* I, fig. 242; II, p. 367 ff., figs. 244-246.

examples that we have discussed, they bear less relationship to transverse timbers restored as window partitions than they do to the sizes of the individual blocks used and, perhaps, to the length of the beams laid along the southern part of the sill.

By far the longest sill known is that along the southern side of the Central Court at Malia (*figs.* 218-219). Here we have our first example of a sill cut down along one side of its length and with transverse cuttings, at intervals, for the reception of longitudinal and transverse beams. The latter must indicate the partitions for the separations between windows[762]. Apart from its size and the peculiarities of beddings cut into it, this sill has many of the same features we have noted in others. Once again the builders avoided cutting mortises near the ends of blocks and, instead, placed them in more central positions, perhaps with some relationship to the length of the beams available. This observation is supported further by the lack of fixed intervals between mortises[763]. The position of the set-backs may have also affected the positioning of the dowel mortises. It is significant that there is no instance, among seven examples, in which a mortise coincides with the cutting for a transverse beam.

A number of conclusions can be deduced from the preceding evidence. First of all, a series of square mortises on top of an ashlar wall, with or without a cut bedding, indicates the presence of a horizontal wooden beam secured by wooden dowels set in the mortises. The presence of this beam, especially when it is not far above floor level, suggests that it may have functioned as the lower part of a window frame. The placement of mortises, to judge from the well-preserved sills, depended upon the length of the sill, the fortuitous sequence of blocks, the size of available timber, and even simply on chance. Transverse timbers and mortises are not aligned in examples of sills where the positions of such timbers are known.

Evans, however, makes the statement that «[w]here the woodwork had disappeared or been disintegrated [South Wall of the Hall of Colonnades, East Light Area of the Queen's Megaron], the dowel-holes were visible in the masonry below by which it had been attached. From the position of these it appears that there had always been a central dividing shaft»[764]. If, however, the actual state plan made by Doll and Fyfe is correct, the mortises indicated for the two examples Evans mentions do not support this view, for they are not placed centrally within the window frame, which they would probably have to be if they were to suggest a central shaft. Nor does evidence from other sites support his hypothesis. Better evidence for vertical window divisions at Knossos can be supplied by the arrangement of gypsum plaques on the sill of the eastern wall of the Queen's Megaron (*fig.* 182B, 217A). In between these plaques were found carbonized wood remains, which may indicate the presence of such vertical partitions before they were burned. Evans's theory could be supported by arguments based on the very length of the sills, or from the evidence of representations of windows on frescoes, or in the Town Mosaic, but not from the position of the mortises themselves[765].

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[762] See also *Mallia*, II, pp. 10-11; partial plan, pl. III; *Guide*, p. 16, fig. 5 (later, revised version); *P. of C.*, fig. 58, which restores fence-like partitions.

[763] These have intervals, east to west, of 2.05, 2.42, 2.13, 2.28, 1.87, 1.05, 1.55, 1.90, 0.80, 1.70 m, ranging 0.80 to 2.42 m, average interval 1.78 m.

[764] *Knossos* I, p. 355 (quotation). The brackets are mine. See also Evans 1901-1902, p. 63; *Knossos* I, p. 334, n. 1. It was generally on the basis of Evans's statement, quoted above, that such a central dividing shaft was restored by the excavators of the Hypostyle Crypt at Malia (*Mallia, Centre Politique*, II, p. 23, n. 1. See also notes 2 and 3 on the same page for a discussion of other windows examined). The remains of the well-preserved window at Malia are fully illustrated with photographs (pl. XV, 1; XVII, 1-3; XVIII, 1, 3) and a series of state and restored drawings (pl. II).

[765] At Tylissos, north of Room 14 in House C, is a series of uniquely placed mortises on each side of a sill about 2.72 m long, now covered by modern restoration (*P. of C.*, fig. 77) but partly visible on a restored plan and on the plan made by the excavators of the site. No

With the facts now at our disposal we can not only reconsider older reconstructions critically but also identify windowsills that have gone unnoticed in the past. In this way one can detect some 20 new windows in various areas of major sites, at Gournia, Malia, Nirou Khani, Knossos, and Hagia Triadha[766]. To take a few examples, some windows there remain unnoticed simply because collapsed rubble or fill within the window frame is left unexcavated. Such must have been the case with a window at Hagia Triadha, in the north wall of the light-well in Room 21 (*fig.* 220). Conclusive evidence for the presence of a window here is given by a mortise (arrow in *fig.* 220) used for fastening down the sill timber. The same is true of two of three windows that border the Rampa Dal Mare, just to the north (*fig.* 216F, 2, & 3) where, once more, proof that there were windows here is provided by mortises. No doubt when excavated these window openings would appear as does another window actually found by the excavators in the same wall (*fig.* 216F, 1)[767]. At the moment, however, they give the impression from the back (south) of being an extension of a single rubble wall, although the wall is faced by blocks along the north.

By far the most common, however, are instances where the mortises have simply gone unnoticed on the upper surface of an exposed wall in which the blocks on the sill course (if they existed at all) have now simply disappeared, usually having fallen to the side and then having been removed along with the excavated fill. Often mortises show up clearly only after excavation has terminated, and after the autumn rains have swept clean the upper surfaces of the blocks, so that the mortises appear as small pockets of dirt on the blocks' surface. This happened, for instance, at Malia, on the top of the wall that separated what have been called storerooms (Rooms xxvii, 2 and 3) from the North Court (*fig.* 216D). At Gournia the mortises were noticed by Hawes, the excavator, along the top of a very similar wall just north of Hall 20 (*fig.* 216C). The window(s) looked out onto the Hall from Room 23. However, she apparently interpreted the mortises as an indication of transverse beams set within a solid wall, as shown on the plan of the site[768]. As we have seen in examples of sills from Malia, Zakro, Tylissos, and elsewhere, on the other hand, the mortises themselves (as in *figs.* 218-219) do not indicate the position of transverse beams. This has its disadvantage for the study of Minoan windows, for without stone jambs limiting the window on its sides (as in *figs.* 212a, 214, 216A, 216B, 1 & 2, 216F, 1 & 2, 217B, 220), or without actual beddings for the transverse beams (as *fig.* 217A), we cannot restore the length of window openings and separations with any certainty.

Finally, we should consider mortises that occur on walls that are preserved to some height above the floor or ground level. Mortises can be seen, for instance, on the top of one of the monolithic gypsum doorjambs in the Temple Tomb at Knossos (*fig.* 222). In the same room mortises were cut into the tops of curious gypsum piers, the sides of which had

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detailed plan exists, but see *Tylissos* (2), fig. 10 at delta, pl. XI (plan) and X, 2 (photograph). This is the only instance I know of where the physical evidence could theoretically support Evans's theory of a central partition in the middle of the window, for there are three pairs of mortises symmetrically arranged on either side of the sill, with the central pair set very close to if not at the center of the sill's length. However, Platon, who supervised the restoration of the window which is restored with two separate partitions (making three windows), assured me that there were beddings on the sills showing the original positions of the four transverse beams for the window framework. One such bedding (at the extreme end of the window, where they usually appear) shows in fig. 10 at delta, in *Tylissos* (2).

766 For these windows, see Appendix H in MA: MAT 1.

767 See the description in *Guida*, p. 34, also Halbherr, Stefani and Banti 1980, fig. 97.

768 Another misinterpretation was that she believed that stone was joined to stone by means of such dowels, as can be read in *Gournia* (p. 25) in connection with a «low-block» pillar base in the Palace.

been cut with vertical slots into each of which was fitted the vertical edge of a single large gypsum slab[769]. In these cases, the mortises on the tops of the piers held the wooden framework of the ceiling, while that on top of the monolithic jamb block held the lintel in place.

Mortises also appear on the top blocks of monumental door- or pier-jambs at Knossos, where they most often occur at the entrances to the storerooms of the West Wing, and appear as well at the entrances to the storerooms of the Magazine Block of the Second Palace at Phaistos (*figs.* 110, 223, left and right)[770]. In both cases the ashlar masonry of the pier-jambs was preserved to a uniform height, which strongly suggests that ashlar construction stopped at this level. The presence of mortises confirms this hypothesis, suggesting further that above this point construction of wood and rubble, analogous to that already described for jamb, pillar, and pier construction, carried up the rest of the way to ceiling level[771].

Lastly, to judge from mortises visible on top of the northern section of the wide wall bordering the north part of the Central Court at Phaistos (*figs.* 62b, 216G, 221)[772], it appears that this wall was also topped by wooden construction, most likely by a single beam which was topped by a thick, high rubble wall[773], perhaps similar to the wall set upon the top of the fourth course of the West Façade of the Second Palace, where mortises were also found by the excavator[774].

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[769] The «triglyph» benches so common at Phaistos and Hagia Triadha are constructed in the same way, with slabs fitting into the slots of each «triglyph» (Cf. *Festòs* II, fig. 89). The form occurred in wood as well, as between the gypsum dado slabs in Room 4 at Hagia Triadha (our Pl. 180, and Halbherr, Stefani and Banti 1980, p. 70, fig. 40) and, at Akrotiri, where they retained the slabs lining the Lustral Basin in Xeste 3 (Palyvou 2005, p. 116).

[770] *Festòs* II, p. 80. The mortise cuttings appear in the general plan of the Palace, but not in Festòs II, fig. 41, a detail of the top of the pier-jamb shown here in *fig.* 223, right.

[771] Evans, however, has restored a third block in the case of the pier-jambs at Knossos. The Italian excavators correctly restored wood.

[772] *Guida*, p. 50; also *Festòs* II, p. 35.

[773] As in *Festòs* II, p. 56.

[774] *Guida*, p. 50; also *Festòs* II, p. 35.

CHAPTER THREE

SUN-DRIED MUD BRICK AND TERRACOTTA

As we have seen, mud (or, in its refined form, clay) was used throughout the Minoan period for a multitude of purposes. Its most basic use was as a mortar binding together the stones of rubble walls, though it also bonded ashlar masonry and mud brick. It was used to form the mud bricks themselves, and entered into floor, ceiling, and roof construction as well. It coated and filled the interstices between vertical timbers, «glued» gypsum revetment slabs to rubble walls. It filled the spaces between horizontal timbers set on windowsills. Occasionally, after having been shaped and baked in kilns, it was made into terracotta drain sections, pipes and tiles. There were many other seemingly humble but important functions which it performed.

A) Sun-dried Mud Brick (*figs.* 223-236)

1. Composition and Technique

We have no remains of brick-making establishments, which must have been of a humble nature. Most bricks (*fig.* 225) are regular enough in their dimensions, and even enough along their sides, however, to suggest that they were made in molds[775]. The molds themselves were probably wooden frames, open at top and bottom, and perhaps provided with handles by the extension of one side. Into this mold mud, previously mixed with water and a binding element of straw[776], or perhaps seaweed[777] or even leaves[778] was placed. Straw of course could be gathered in neighboring fields, while seaweed could be collected on nearby beaches when it had washed up after a storm. I have noticed that sometimes small stones and potsherds were added to the mixture, no doubt to give it greater strength.

It is possible to infer the Minoan technique for making mud brick by comparison with that used in Classical Greece[779] and in modern times. I have watched farmers making mud brick near the ancient Phrygian capital of Gordion, in Turkey (*fig.* 224).When the bricks had partly dried, the mold was lifted up so that the bricks could dry completely in the sun.

The suggestion has been made in the past that the Minoans used fired bricks[780], but there is no evidence that this was ever a common practice[781]. The peculiar reddish color of

[775] Guest-Papamanoli (1978, p. 8) has suggested that some bricks were simply made by hand.

[776] *Festòs* I, p. 228; *Gournia*, p. 28; Seager 1904-1905 p. 209 (Vasiliki); *Knossos*, II, p. 105.

[777] Charbonneaux 1928, p. 354; (Malia); Xanthoudides 1922, p. 9 (Nirou Khani). Jan Driessen (personal correspondence) informs me that at Palaikastro mud brick tends to contain marine weed, whereas plasters usually contain straw.

[778] Fiandra 1961-1962 p. 120 (Phaistos). For the more exact petrographic character of the earthen materials used at three sites in Eastern Crete, see Nodarou et al. 2008.

[779] As in Orlandos 1955, p. 65f; Martin 1965, p. 46f.

[780] Durm 1907, p. 41; *Festòs*, I, p. 228 (but cf. *Festòs* I, p. 443).

[781] See, for instance, *P. of C.*, p. 148; Bosanquet 1901-1902, p. 315 (Palaikastro); *Gournia*, p. 28 (Hawes having changed her mind [from Boyd 1904, p. 37ff]).

mud bricks, as they often appear in walls or fallen in rooms is due to the color of the earth used for making the bricks in the first place[782] and, secondly, to their accidental baking in the holocausts which destroyed many Minoan establishments.

When the bricks had dried sufficiently and were ready to be used for building, a second batch of mud or clay, sometimes of a whitish color and sometimes laced with bonding straw (*fig.* 226)[783], was mixed up and then spread between brick courses as they were laid (*fig.* 227). (A similar mixture was used for plastering the walls [*figs.* 252, 253]). This bonding layer, clearly visible in *figs.* 231 and 256, averaged one-fifth (M 7) to two-thirds (Z 6) of the thickness of the bricks themselves. (See explanatory note below for the key to references to bricks, and Appendix D, p. 183 for a list of the sites and the sizes of mud bricks found on them)[784]. Usually bricks of one course overlapped those set below them (*fig.* 231), as in modern practice, and in some cases the faces of the walls were plastered over, first with a thin layer of mud similar to the bonding mortar, and then with a fine, thin layer of white lime plaster (*fig.* 256). In most cases the brick walls were set upon a socle of stone to protect them from dampness, a further indication that they were unbaked. Usually the brick was set with its longer sides parallel to the wall faces, so that unless additional packing was used along the faces (as in *fig.* 227A), the wall remained thin and weak. As a remedy for its weakness, vertical wooden supports occasionally carried some of the weight of the ceiling and superstructure. Since extremely thick walls of mud brick were never built in Minoan Crete (as they were in many buildings in the Near East, for instance), mud brick could never have played an important role in instances in which great weight was to be transferred down from upper stories. Consequently, mud brick construction appears in areas of the ground floor where minimum weight was to be placed upon it; there it was usually used for minor alterations and renovations. In the Little Palace at Knossos a stack of bricks was found in one of the ground floor rooms, where it was probably stored for such occasions[785].

2. Evidence on Sites[786]

At Malia perhaps five percent of the visible Palace structure is composed of mud brick set on a socle of small stones. This is a very high percentage compared to what can be seen at other sites. No doubt much of the upper walls and stories consisted of mud brick as well, to judge from estimations made here and on other sites. Now only the brickwork in the East Wing of the Palace is obvious, especially that in the series of storerooms, the walls of which consisted of brick laid on a rubble socle perhaps 0.15 m high. To the south, in Area xiii, 1-3, all but the exterior walls were of brick. The interior walls here (*fig.* 227B) (M 1) are only about 0.40 m thick, the width of a brick plus the plaster coating on each face. Along the southern side of the corridor leading from the Southeast Entrance into the Central Court from the east, however, the wall contained a core of brick with rubble packing on each face (*fig.* 227A). At three points this wall is

[782] Vitruvius, De Arch., II, 3, 1 especially recommends red earth.

[783] As Seager 1904-1905, p. 200 (Vasiliki).

[784] References in the text to mud bricks are keyed to the name of the site (usually the first letter) and the number of a wall or area where the bricks are used. Thus M 7 = Malia, Sample 7. For location and other information about each group, see the catalogue in Appendix D (pp. 183-188).

[785] *Knossos*, II, p. 519. Hatzaki (2005, p. 71), however, interprets these bricks as part of an LM III A wall.

[786] See a review of the use of mud brick on Aegean sites, by Guest-Papamanoli 1978. For Eastern Crete, see especially now the interdisciplinary study by Nodarou *et al.* 2008. For mud brick use on the Mycenaean mainland, see also Darcque 2005, pp. 98-100.

interrupted by vertical gaps ranging 0.17 m to at least 0.40 m in width, which were originally occupied by wooden posts supporting the ceiling structure above[787].

In the North Wing of the Palace the only significant use of brick is in the southern wall of the Hypostyle Hall (Room ix, 2, Sample M 2). The side of the wall which faced the Central Court (*fig.* 227C) was built with brick, the rear face being filled out with rubble construction and, like the other face, plastered over[788].

In the West Wing of the same Palace there is an early mud brick wall, perhaps belonging to the First Palace, which was incorporated into the later rubble construction of immense storerooms (Area I, 1; Samples M 6, 7)[789]. Near this wall, a late doorway has been blocked with bricks (*fig.* 256) (M 8). To the east of here, along the Central Court, a long flimsy wall was built of bricks, with occasional traces of vertical timbers in its sides, that probably supported a makeshift shelter west of it. North of here, in Areas IV and VI, brickwork was used for minor partition and blocking walls (*fig.* 229) and formed part of a pillar in Room VI, 4. Occasionally bricks were set on edge here, as if along the back of a niche (*fig.* 229)[790]. The excavators have suggested that some of these partition walls were pierced by windows or bays[791].

At the Palace of Kato Zakro perhaps three percent of the area excavated through 1973 is built of brick (*figs.* 230-232). Some partitions of clay there may have brick cores (*figs.* 233-234). Most of the remainder consists of rubble construction, the exterior façades being mainly of megalithic construction (*fig.* 75), while the façades preserved about the Central Court are mostly of coursed ashlar blocks (*figs.* 120, 121). Brick at Zakro is restricted to sheltered walls on the interior of the building, and is usually set on a socle of small stones, both wall faces being plastered. In the East Wing, which was so damaged by cultivation before excavations began, construction above floor level is mostly destroyed. In the South, West, and North Wings, however, fallen mud brick was often discovered within rooms being excavated and was welcomed by the excavators as promise of undisturbed finds below, so there is no doubt that these bricks are the collapsed remains of upper walls that fell when the Palace was destroyed.

One of the difficulties in studying the brick remains at Zakro is that in some places the unbaked, pebbly bricks have coalesced with each other and with the strips of bonding clay with which they were joined, with the result that individual bricks are not distinguishable. The only proof that some walls were once composed of separate bricks rests on the alternation between reddish brick material and greyish bonding clay that is sometimes discernable along the faces of the walls. In the lowest parts of the Palace, accumulated ground water sped up this process of dissolution even before excavation took place, disintegrating wall plasters and dissolving mud brick that had tumbled down about the stumps of the lower walls. Only with the greatest care were certain walls discovered and then cleared by Professor Platon, as for instance in the South Wing where the walls of Room xlii had become simply hard masses of red earth defined primarily by the edges of the plastered floor[792].

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[787] Similar chases for vertical wooden supports can be seen in the eastern storerooms of the early Hypostyle Crypt northwest of the Palace.

[788] Upon re-examination, the wall suggested another possibility, namely since most of the wall is covered by plaster, perhaps the mud brick visible in the one small section mentioned is really a blocking of an opening, such as a window, into Room IX, 2.

[789] This wall is the oldest among a series of neighboring walls which Charbonneaux would include as part of the First Palace (1928, p. 357). Pelon, who re-examined the area, calls parts of this group Prepalatial (Daux 1966, p. 1011), later dating it to EM II (Pelon 1980, p. 41).

[790] See also van Effenterre 1980, p. 119, note 108.

[791] Charbonneaux 1928, p. 354.

[792] See also Platon 1965a, p. 194.

In the West Wing, one can see well-preserved bricks (Z 2) laid in line along the top of a rubble wall bordering Corridor xiv, and they also form a wall corner near Room xi. Within Stairwell x, bricks were laid in line along the top of a thin rubble wall; this wall serving as the back wall of a small closet and at the same time as the base upon which supports for the wooden stairway could rest (Z 3). Groundwater does not accumulate in the North Wing, which is higher than other parts of the Palace, so that water falling or flowing into these areas eventually accumulates in the Central Court to the south. Consequently, the brickwork is fairly well preserved, especially in Room L (*fig.* 230). Here socles are low since bricks were less exposed to dampness. Especially along the south wall of Room L (*fig.* 231) (Z 6) the bricks can be measured easily. The very thick (6 cm) clay layer between brick courses is quite conspicuous. In the same room there is an unusually well-preserved section of a brick wall that split up into separate brick and mud layers when it collapsed (*fig.* 230 at B)[793].

In the Palace, bricks were occasionally set on edge to form partitions in narrow passageways (Room xi, Sample Z 10), to close off an opening as in the Lustral Basin (Room xxiv, Sample Z 9), and in one case, they probably formed the core of mud partitions in a toilet room (Room xxii) (*fig.* 233) that was subdivided into separate areas for bathing and other uses. They were also used for forming the «Archives» (Room xvi), where the structure was stabilized by the use of vertical posts (*fig.* 234)[794]. At Knossos, partitions of this type consisted simply of clay, plastered on the exterior[795].

On sites other than Zakro and Malia, visible remains of mud brick are so few that they can be considered together. At Vasiliki, in the House on the Hilltop, there is a layer of brick on top of a rubble wall (V 1), reminding one of Room x in the Palace of Kato Zakro. There is another similar wall in Storeroom 7 of the Palace of Gournia (G 1). In Room 16 of House Ac at Gournia and in House A at Zakro, mud brick forms part of the basement walls designed to support the wooden floor above (*fig.* 235)[796]. In the Villa of Nirou Khani a number of minor walls are formed of mud brick[797], and bricks set on edge were used as partitions within Room 7 and formed bins for the storage of grain within rooms 26-30[798]. At Phaistos mud brick had a limited use. It was probably part of the packing within piers in the Second Palace[799], it was set along the sides of a stairway[800], and it appeared on a windowsill[801]. Usually, however, brick was set on edge at Phaistos, as within the «Archives» (Room xl, Sample P 2) (*fig.* 236)[802], or forming an enclosure for a toilet near Room lxxxii, as well as a curious revetment on the wall leading down to the Lustral Basin within Room 63[803]. At Hagia Triadha, bricks appear only in Room 14, where they were set on edge to form a partition[804]. At Sklavokambos

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[793] See also Platon 1965b, p. 129, fig. 162.

[794] For mud bricks set on edge in a MM III house nearby, see Platon 1962a, pp. 149; *Archaeology*, XVI, 1963, p. 275, plan p. 271.

[795] The partitions were found in the Southeast Quarter. See *Knossos* I, p. 581, fig. 425; II, fig. 186; Heaton, p. 701, fig. 8; Fyfe, p. 108.

[796] Sample G 2. See also *Gournia*, p. 22, fig. 8; Hogarth 1900-1901, p. 130 ff. Of some interest, and possibly connected with mason's marks (see pp. 76-79 here), are mud bricks from Gournia which had crosses either incised or in relief on them (Fotou 1993, p. 33, notes 91-93). At this point these mud bricks are unique on Crete, but a mud brick with a T on it has been reported from Mikro Vouni on Samothrace (Fotou 1993, note 94, from Matsas 1991, p. 164 and fig. 9).

[797] As in Xanthoudides 1922, p. 9.

[798] As *Knossos* II, fig. 167.

[799] *Festòs* II, pp. 265, 437.

[800] *Festòs* II, p. 412, note 168.

[801] *Festòs* II, p. 445.

[802] *Festòs* I, p. 443.

[803] Sample P 1. See also *Festòs*, II, pp. 171, 179, 265, 303, 421.

[804] *Guida*, p. 31. Vincenzo La Rosa has confirmed (letter of 2/11/06) that mud brick was used only in partitions at Hagia Triadha. No mud brick was discovered at the nearby harbor town of Kommos.

bricks set on edge divided the space behind a doorway. This is perhaps the only instance in which bricks set on edge were found in situ with one set upon the other[805]. Mud brick partitions were used for some interior walls at Pseira as well as for partitions[806]. An unusual use of mud brick for pillars set on foundations of small, irregular flat slabs has been reported at Makrygialos and Palaikastro[807].

As we have seen, the use of mud brick on the ground floor of Minoan buildings is limited; on the other hand, its importance in the construction of the upper stories cannot be underestimated. It is ironic in a way that mud brick in what must have been its most commonly used form is no longer observable on Minoan sites. One can understand, nevertheless, why such an economical, light, adaptable material was reserved for walls where there was no heavy superstructure to carry, especially walls on the upper floors, which may have resembled those on the ground floor of Area xiii at Malia (*fig.* 227). In order to emphasize the point, it is worthwhile to quote from the reports of the archaeologists who patiently traced the mud brick remains that they found collapsed within the rooms of the ground floor. For instance, Seager records what is one of our earliest post-Neolithic instances, at Vasiliki, «It is plain that the building must have possessed several stories ... in the best part of the house there are sometimes two meters of solid plaster..., amid which lie bricks from the upper walls»[808]. At the MM III houses at Zakro the same thick deposit of fallen mud brick was found[809], and this is generally true throughout the Palace of Kato Zakro as well[810]. Of House B at Palaikastro, Bosanquet states, «All the rooms hitherto described were full of the peculiar crisp red soil formed by the disintegration of the brick-built upper story - on the south-west it lay 1.25 m deep»[811]. In Building 5 there, all interior walls were constructed with mud brick on a stone socle[812]. At least the first steps of a staircase were of mud brick in Building 1 at the same site[813].

If we move further west to Gournia, we note that Hawes makes comparable observations: «The upper walls of most, if not all, of the houses were built of bricks, laid in mortar of the same substance»[814]. At EM II Myrtos-Phournou Korifi to the south, Warren states «Walls not built entirely of stone had their upper parts in mud brick»[815]. Of Malia, Charbonneaux believed «l'étage ou les étages, bâtis en briques et en bois, n'exerçaient qu'une faible pesée sur l'infrastructure»[816]. Charbonneaux was referring, of course, to the later Malia Palace. As to the earlier, Protopalatial custom at the Malia site, Schmid has noted, «On peut admettre que, comme partout au Quartier Mu, la superstructure était en brique»[817]. At the villa of Nirou Khani, Xanthoudides thought that, «Most likely the walls, especially those of the upper rooms, were built mainly of brick»[818]. Finally, we might quote Evans, who, referring to the South House at Knossos, says that «From the amount of clay deposit in the

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805 Marinatos 1939-1941, p. 72.

806 *Pseira V*, p. 31. At Akrotiri on the island of Thera, mud bricks were not used for load-bearing walls, but exclusively for partitions such as those just described (Palyvou 2005, p. 114). Partitions were also used there in upper floor rooms.

807 Davaras 1985, p. 79 and 1977, p. 120 note 14.

808 Seager 1904-1905, p. 210.

809 Hogarth 1900-1901, pp. 130, 132 (House A); 135 (House D); 136 (House F); 140 (House I).

810 See Platon 1962a, pp. 150, 161; 1964, pp. 146, 149; 1963b, p. 165 and 1971, p. 83, where he emphasizes the use of mud brick on upper floors at the Palace.

811 Bosanquet 1901-1902, p. 315.

812 Driessen 2000, p. 43.

813 Driessen 2005, p. 87.

814 *Gournia*, p. 28.

815 Letter dated 3 March 1969.

816 Charbonneaux 1928, p. 349. See also *Mallia*, I, p. 7; *Mallia, Maisons* I, p. 76.

817 Schmid 1996, p. 77.

818 Xanthoudides 1922, p. 9.

lower rooms and basements it may be inferred that the upper part of the house walls was largely composed of sun-dried bricks of the kind found in the 'Little Palace'»[819].

At Phaistos, which is an exception to the rule, rubble instead of mud brick seems to have been used for the upper stories of both Early and Second Palaces[820].

Tsakanika-Theohari has wondered[821], however, to what extent, outside of the Mesara, mud brick played a role in the upper floors of Minoan palatial buildings in Central Crete. Her argument is, briefly, that the use of vertical wooden supports in the stone walls of the ground floors does not necessarily denote the use of mud brick on the floor above. Also, scholars have been led to the belief of mud brick walls there by their proven use in upper stories in Asia Minor and Palestine, as well as on the Greek Mainland (Tiryns, Mycenae). She notes that the chief reason for the current belief is the discovery of mud brick in Minoan destruction levels; but that such bricks were also in use on ground floor levels, or might be later additions, also that burned clay plaster might be confused with disintegrated brick. As to the Knossos Palace, she concludes that Evans's belief that the upper parts of the Residential Quarter were built with mud brick is not tenable at least up to and including the third story at Central Court level, although a story above that may have been of brick.

This prompts reexamination of evidence from past excavations as well as closer examination during ongoing discovery. Outside of Central Crete, at Kato Zakros, for instance, tumbled mud brick, partially baked by the fire that destroyed the Palace, characterized the levels above and within Rooms lvii (the Lustral Basin in the North Wing) and Room xxxvi (just east of the Queen's Apartment). But did the brick, which certainly «fell from above», fall from a ground or from an upper story wall? Also, while a sizable portion of a mud brick wall (our *figs.* 230-232) was found fallen on its side in Room L there, the brick mass may have tumbled sideways from the neighboring wall.

A confident resolution of the question is made difficult by the possible confusion of reddish earth which could come from either burned mud brick or mud plaster, referred to above. Also, separate mud bricks found fallen from an upper story could simply come from partitions, which were common throughout Crete. We must also allow for regional variety within Crete, for as noted by Palyvou, «the choice of materials is connected with the natural resources of an area»[822]. Moreover, local customs can differ within areas that are otherwise similar from the point of view of natural resources.

3. Brick Sizes

Although sizes of individual mud bricks have been reported by excavators in the past, only Graham has studied the general range of sizes, which he gives as 46 cm to 61 cm long, 35 cm to 40 cm wide, by 10 cm to 13 cm thick[823]. On the basis of the present study this range can be extended from 42 cm to 64 cm long by 26 cm to 42 cm wide by 9 cm to 12 cm thick, although there are still occasional departures from the norm[824].

At Malia, a number of brick sizes are represented in different constructions. Generally speaking, bricks are of the same sizes in one continuous wall. This suggests the use of the

[819] *Knossos* II, p. 390, see also p. 519; II, pp. 105-107 (Caravanserai); I, p. 327 (Residential Quarter) and Evans 1904-1905, p. 4, fig. 1 (Northeast Magazines).

[820] *Festòs* II, p. 421; Banti 1960, p. 630; *Festòs* 1976-1988, II (Part 2), p. 298, fig. 116.

[821] Tsakanika-Theohari 2006, pp. 237-241.

[822] Palyvou 1999b, p. 112.

[823] *P. of C.*, p. 148.

[824] This range is based on over 100 bricks from about 40 places on 12 Minoan sites. Most of these can be found listed in Appendix D. As might be expected, measurements from Malia and Zakro are especially numerous.

same wooden mold and, by inference, implies that the same group of workers was involved in the construction. Guest-Papamanoli infers that since a few bricks were often made in a single batch with differing molds, that one should not imagine large-scale mud brick manufacturing in Crete, especially the preparation of large quantities of bricks for possible future use[825]. A somewhat similar situation arises at Akrotiri on Thera where the mud bricks used for partitions remain a standard size within the same building but differ between one house and the next. Palyvou believes that this suggests that each worksite was more or less autonomous, possibly with different architects using different measurement units, and even that itinerant masons may have been employed[826]. Charbonneaux has pointed out that this phenomenon occurs elsewhere at Malia as well[827]. Average sizes of bricks at Malia, from small to large, can be listed in the following groups, in which the lengths do not overlap with one another: 45-46 × 33-37 × 8-10 cm (M 2, 4, 8); 56 × 40 × 10 cm (M 17); 49-52 × 28-39 × 8-14 cm (M 1, 5, 11, 16); 59-64 × 34-43 × 8-10 cm (M 6A, 7, 9, 10, 15); 54 × 29 × 10 cm (M6B, 12, 15B). The basic sizes, averaged out, might be expressed as follows: 1) 45 × 36 × 9 cm; 2) 50 × 36 × 9 cm; 3) 54 × 29 × 10 cm; 4) 56 × 40 × 10 cm; 5) 62 × 41 × 10 cm.

There is no doubt that the thickness of the bricks of all classes, and probably for all periods represented, remains roughly the same; this was the most convenient size in which the bricks could be handled and dried.

At the Palace of Kato Zakro, the large bricks which were laid on their sides fall within the range 60 to 64 by 35 to 42 by 9 to 10 cm (Z 1, 6, 7), a range similar to that of size 5 from Malia (above). They average 62 by 40 by 9 cm, very similar to the large bricks reported by Hogarth from House A (ZH 1A). The two larger bricks set on edge (Z 9, 10) belong to the same group. With one exception (Z 8), the remainder of the bricks in the Palace have a range of 40 to 43 by 31 to 38 by 5 to 14 cm (Z 2, 3, 4, 5, 11), the average being 42 by 35 by 10 cm, a size smaller than those present at Malia. Still, two separate sizes seem to be present at Zakro.

At Phaistos, due to a scarcity of evidence, our information on the sizes of bricks is generally limited to those set on edge and others found fallen from place. Bearing this in mind, we can still state that the range of bricks preserved (P 1, 6, 7) is 42 to 43 by 26 to 35 by 10 to 12 cm, with an average of about 42 by 28 by 10 cm. The existence of a larger size is suggested by Sample P 2 (48 by 34 by 12 cm), of which the lengths given are the maximum preserved[828].

At other sites measurable examples are limited. At Knossos a small size, 45 by 34 by 12 cm (K 3) is known. A small variety, 30 by 9 by 9 cm (K 2) of MM IA date, might be compared with bricks of EM II date found at Myrtos-Phournou Korifi, of which some are 15 by 15 by 10 cm[829].

At Nirou Khani bricks in the walls (N 1) range 40 to 50 by 34 by 9 to 12 cm, most averaging 42 by 34 by 10 cm. At Gournia there are samples of a small size, ranging 45 to 50 by 30 to 36 by 9 to 10 cm (G 2, 3A, 4), and there is one sample of a large size, namely 60 by 30 by 9 cm (G 2B). From Vasiliki a small size is suggested by an inadequate sample, while at Palaikastro there definitely seems to be a small size, 40 by 30 by 10 cm (PA IB) and perhaps a large size (PA 1A). The bricks from the houses at Zakro indicate a larger size, 61 by 44 by 10 cm (ZH 1A), also an unusually small size, 34 by 31 by 10 cm (ZH 1B) as well as a square type (ZH 2), 38 by 38 by 10 cm, apparently used as a base.

In summary, brick sizes found on various Minoan sites appear somewhat as follows:

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[825] Guest-Papamanoli 1978, p. 17.

[826] Palyvou 2005, p. 156. In one wall (M 6, 7), however, they appear to be different.

[827] Charbonneaux 1928, p. 354; M 14, 15 here.

[828] *Festòs*, I, p. 354.

[829] Warren 1972, p. 59, note 1.

Malia (M) MM III-LM I
45 × 36 × 9 cm
50 × 36 × 9 cm
54 × 29 × 10 cm
56 × 40 × 10 cm
62 × 41 × 10 cm

Palace of Kato Zakro (Z) LM I
45 × 35 × 10 cm
62 × 40 × 9 cm

Zakro Houses (ZH) (A and I) MM III
61 × 44 × 10 cm
34 × 31 × 9 cm
38 × 38 × 10 cm

Phaistos (P)
42 × 28 × 10 cm

Knossos (K)
30 × 9 × 9 cm (MM IB)
45 × 34 × 12 cm (MM III-LM I)
45 × 45 × 12 cm

Sklavokambos (S) LM I
52 × 36 × 10 cm

Nirou Khani (N) LM I
42 × 34 × 10 cm
50 × 35 × 11 cm

Gournia (G) LM I
45 × 30 × 9 cm
60 × 30 × 9 cm
50 × 35 × 9 cm

Vasiliki (V) EM II
45 × 40+ × 10 cm

Palaikastro (PA) LM I
40 × 30 × 10 cm
56? × 42 × 14 cm

Mochlos (Mo) LM I
30 × 42 × 8.5 cm

The sites at which a variety of mud brick measurements is represented thus show that different sizes were preferred locally. It is important to note that the separate categories recorded from Malia and Zakro are justified by the fact that the bricks in each category have distinct lengths. The sizes of bricks, on the other hand, do not seem to correspond to specific uses. Further study will show whether the variations are fortuitous or a deliberate choice on the part of the local builder, and whether there is any relationship between bricks of early and later periods, although I see no clear change or development.

Therefore, with the exception of Phaistos and probably Hagia Triadha as well, mud brick was used chiefly in the construction of upper walls and floors (as at Malia, Zakro, Knossos, Nirou Khani, Gournia, Vasiliki, and Palaikastro). Only at a few sites, such as the Palaces of Malia and Zakro, was brick used to any extent for building on the ground floor. There it usually served to patch walls and block wall openings, and, set on edge, to form room partitions and the sides of storage compartments. As to the shape of the bricks, it clearly contrasts with that at Classical sites, where square bricks were the rule[830]. Minoans preferred oblong bricks. Although the thickness of the bricks remained about the same, no doubt for purely practical reasons, there were one or more preferred length and width combinations on different sites.

B) Terracotta (*figs.* 237-241)

In Minoan architecture, terracotta is used for making water channels, pipes, catch-basins, and occasionally tiles for paving floors. As far as I know, terracotta roof tiles, which enjoyed popularity and assumed a variety of shapes during later periods, did not exist in Crete during the Minoan period[831]. The water channels are of two types: sealed pipes probably used for transferring fresh water, and channels commonly used for carrying away overflow and waste water. Terracotta tiles, used for decorative effect on floors, seem to have been used only at Malia and in easternmost Crete.

1. Pipes

We possess a fair but often tantalizingly inadequate amount of information about the purpose of round terracotta conduits that appear at various sites. We know most about those discovered at Knossos in deep levels below the South Porch and in the Draught-Board Area in the Eastern Wing (*fig.* 237)[832]. These are at the same time the earliest (MM IA - MM III) and, along with the later examples from Tylissos, the most carefully made examples reported from Minoan Crete. At Knossos their lengths vary from 76 cm to 82 cm, and they taper; their exterior diameters averaging about 8.5 cm to 9.3 cm at the smaller end and 15 cm to 17 cm at the thicker end. The thickness of the pipe is about 1 cm to 2 cm. The dimensions of the former group are slightly larger than the latter[833]. In each case the tapered end fitted into the butt-end of the adjoining pipe section, and was provided with a ridge of clay, or stop-ridge, to prevent penetration. Apparently the narrow ends (or spigots) were wave-surfaced to guarantee adhesion of the plaster which sealed the joints[834]. Some of the pipes in the area of the South Porch were provided with four handles each, two on either side. Such handles were laid parallel to the surface on which they rested[835]. Evans believed that these handles were tie-ons for ropes used to bind one section to another[836].

[830] Martin 1965, p. 57.

[831] For Mycenaean roof tiles on the mainland, see Iakovides 1990, Küpper 1996, pp. 134-136, and Darcque 2005, p. 80.

[832] For a listing of these and similar pipes, see the catalogue in Appendix E, p. 189.

[833] *Knossos* I, p. 141, n. 4.

[834] *Knossos* I, p. 141, n. 4.

[835] *Knossos* IV, fig. 113

[836] *Knossos* IV, p. 146 ff., and fig. 114.

Most likely the narrow ends of the pipes pointed in the direction of flow[837]. The taper has been interpreted in the past as a means of preventing clogging[838], but it also ensures better joining of the sections. The five pipe sections in the Draught Board Area, some of which are still visible below a modern steel grating, carried water off to the north[839]. No plan is available of the group below the South Porch, as far as I know. Evans states that the pipes had an «upward slope, 1 in 18.90 meters», which suggested to him that a closed water system existed, although possible ground settlement in the area made this uncertain[840].

The long conduit found near the houses at Tylissos (*fig.* 238A) is similar to the line of plain, tapered pipes with stop-ridges from Knossos. Many long sections of this pipe were discovered in situ to the west of the site. They follow an eastward slope from a spring down toward the settlement, and for this reason most probably brought fresh water to it. At one point the bedrock was cut away for the passage of the conduit, which was probably covered over by stone slabs[841]. Although they are dated by the excavator to as late as LM III, it is more likely that they are somewhat earlier.

Elsewhere, only occasional sections of pipe have been reported. At Phaistos, for instance, a number of coarsely made, untapered sections were found in Room 38. The sections reported were 8 cm to 9 cm in diameter, and one was as long as 82 cm. These may have been joined by means of a kind of collar since they could not fit into each other[842]. They were apparently connected with a curious round collection basin, also of terracotta, discussed below. Two tapered pipes like those from Tylissos or Knossos may also have been found at Phaistos, but they are now hidden below floor level in Room 74. While visible on the plan of the area[843], they do not seem to be mentioned in the excavation report. A group of tapered pipes was found at Gournia, stacked in a cellar, where they appear to have been placed in reserve[844]. These are smaller, cruder versions of the Knossian variety, with stop-ridges formed simply by reducing the diameter of the pipe at one end and without the collar that is visible on the pipes from Knossos. From Eastern Crete there are only two examples reported, one from Palaikastro (*fig.* 238C), reused in an LM III drain[845], the other from House B at Zakro, excavated by Platon[846]. Finally, concerning joined terracotta drains, is an ingenious series of hollow rectangular terracotta channels with removable tile lids, decorated with finely painted flowers, found in connection with the Neopalatial establishment at Pyrgos. These unique conduits functioned to carry storm water down to the cistern in the open courtyard[847].

Such pipes were usually set horizontally, but one of those already described in Room 38 at Phaistos was apparently set vertically although its position is not indicated in the publication[848]. A vertical pipe is also surely suggested by the receptacle in our *fig.* 238 (C) from Palaikastro. Also pertinent, since Minoan materials and their uses can be so similar, are the arrangements for a toilet facility in the West House at Akrotiri on Thera where a series of vertical terracotta pipes drained down into a sump connected

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837 See *Knossos* I, p. 141, n. 4, for use of word «spigot»; *Tylissos* (2), Plate xiii, 1.

838 *Knossos* III, pp. 252-253.

839 See *Knossos*, Plan B, showing the orientation of the pipe sections; also *Knossos*, I, p. 141, «layed to a fall North».

840 *Knossos* I, p. 141; A. of C., p. 101.

841 *Tylissos* (2), pp. 62-63, fig. 14 and Plate xiii, 1.

842 *Festòs* II, p. 103, fig. 52.

843 *Festòs* II, Plate VI, north of the collection basin, along the eastern side of the peristyle.

844 *Gournia*, p. 28, pl. I, no. 22.

845 Dawkins 1904-1905, p. 290, fig. 16 b, pl. XIII (*fig.* 238 [C] here).

846 Platon 1962a, pp. 148-149.

847 Cadogan 1978, p. 83, fig. 39.

848 *Festòs* II, p. 103.

with the town's drainage and/or sewer system. The pipes were shaped at each end to fit into one another, with the joints sealed with hard lime plaster[849].

2. Channels and Catch-Basins

U-shaped conduits of terracotta (*figs.* 164, bottom row; 239a, b; Type 1 in Appendix E), set with the straight ends of each section abutting those of other sections, were much commoner than the round, enclosed type. They are especially common on sites in Eastern Crete, not appearing as far as I know at Phaistos[850]. At nearby Kommos only fragments of such drains were discovered, those probably often from channels that drained rainwater from house roofs[851]. Similarly, only a few such drains were found at Pseira[852]. Such conduits, which have a U in cross-section, are handmade with coarse, pebbly clay, which is reddened by the fire that baked them. In some cases, as at Kato Zakro, the clay matrix was strengthened with the addition of small fragments of reddish schist, a potter's technique also used in the manufacture of many of the coarse pots found there. While all the surfaces are smoothed, the edges and interior corners are left somewhat rounded rather than being carefully squared. To judge from the examples from Kato Zakro, their lengths are arbitrary, but they do seem to observe a ratio of height to width of about 6:9 or 6:10, a proportion no doubt adopted in order to minimize blockage.

At the Palace of Kato Zakro, conduits of this type seem to be confined to the West Wing, while in the East Wing all the drains were constructed of poros sandstone. They were invariably buried below floor level, the only drain in the West Wing which was partly visible when the building was in use being one formed by finely cut sections in Room xxviii (*figs.* 165, 166). Once the line of the terracotta drains (*fig.* 164, bottom row) had been set across corridors and below or through walls, but apparently avoiding the main Room xxviii, the abutting ends of the conduits were waterproofed by a layer of fine plaster. Then they were spanned by hard-packed clay, which at the same time formed the floor above, or by small slabs topped by clay. In one instance, in Room xxv, a rectangular tile covered the drain.

It is clear at Zakro that these drains channeled off waste water. At least two of them emptied outside the Palace walls[853]. Well-preserved, fine plaster floors prevented a complete tracing of any one series of these drains. The longest single stretch known here (Appendix E, Zakros no. 1A-1C) is about 10 m long, and slopes down gently from north to south. From its beginning to its end, the size, hence capacity, of this drain doubles, which suggests that either there are tributary drains still hidden or that the widening was intended to reduce clogging.

This type of drainage channel was also common at Palaikastro, according to Dawkins. Among the examples enumerated by him is a channel of which four sections are preserved, the first and highest section, which is unique, being equipped with a receptacle for overhead

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[849] Palyvou 2005, pp 40-43, 51-53, *figs.* 41, 44, 58-61. Two extra pipes were found lying on the floor near a corner of Basement Room 4 in the same building. A similar arrangement with vertical pipes at Akrotiri, although not as well preserved, was found in connection with Rooms Delta 7 and Gamma 7.

[850] The line visible along the southern edge of the Central Court at Phaistos is probably Hellenistic. For an LM III conduit, see Levi 1965-66, p. 387.

[851] J.W. Shaw 2004, pp. 180-182. See also Chapter IV, under «Ceilings and Roofs», below.

[852] *Pseira V*, pp. 34, 83-84, fig. 28.

[853] See Zakros Palace nos. 3, 4 in Appendix E. Probably no. 1 did as well, but the outside of the wall at the point where the drain seems to be heading had not been cleared when I inspected it.

drainage from the roof (*fig.* 238C)[854]. According to Hawes, U-shaped conduits of terracotta were found on all parts of the site of Gournia, where they served both for draining streets and as house gutters; an extra supply of them was found stacked against the wall of a Palace storeroom (G 24)[855]. At the flat site of Malia they were used in the houses, but there is less indication of them in the Palace[856].

At Knossos, where various types of drainage systems were installed in many of the houses and in the Palace, such U-shaped drains of terracotta are by far outnumbered by drains formed of lengths of poros limestone blocks, described elsewhere (p. 86f.). Two long stretches of such terracotta channels are traceable, however. The first winds about in the area between the Central Court and the staircase leading up to the Piano Nobile, in the West Wing of the Palace. The second is in the Southeast Quarter (*fig.* 239b). This type of channel also seems to have led water away from a stone drain-head or collection basin in the East Wing[857], carried water below the floor of the Caravanserai to a footbath intended to be used by visitors[858], and was probably also used under the pavement in the northwest corner of the Central Court[859].

A variation of the ordinary U-shaped terracotta channel is one which is splayed open at one end, such as that at Malia, northeast of the Palace, where six sections of drain overlap one another (*fig.* 238B «plan», Type 2 in Appendix E). The piece illustrated is shaped so that the adjoining piece of conduit can be set into it. A curious curving, elbow-like conduit connects these with an open stone drain[860]. A conduit with partly overlapping sections at Palaikastro (*fig.* 238C) is made up of three types of terracotta drains[861]. All are probably reused from nearby houses[862]. A similar type (Type 3 in Appendix E) with shovel-like ends, as in our *fig.* 238C, was often used in connection with vats in houses – the flattened end collected liquid and prevented spilling[863].

Still another purpose was served by both the U-shaped channel and its splayed or flattened variant. Namely, they (and their cousins, the U-shaped channels of stone) were set as spouts along the edges of roofs to prevent damage to roof and wall structures[864].

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[854] Dawkins 1904-1905, p. 290. A drain from Palaikastro, incised with a double axe sign, was reported by C. Davaras (1977, pp. 65-69).

[855] *Gournia*, p. 28, pl. I, no. 5.

[856] E.g. *Mallia, Maisons* II, Pls. xxii, 1 and xxxviii, 5. A terracotta drain 0.79 m long, with a splayed end, has also been reported from MM II Quartier Mu (*Malia, Mu Artisans*, pl. 75 no. 392, from Building F), and is not unlike that from the same site in our fig. 238b.

[857] There is some confusion in Evans's description of this basin: at one point he states that the drain head was stone, and that a «section ... of... terracotta conduit ... stood in connection with this drain head» (*Knossos* I, p. 379), while the accompanying illustration (*Knossos* I, fig. 276) labels the same basin as «terracotta head and channel». At another point he repeats that both basin and «pipe» were of terracotta (*Knossos* III, p. 492, n. 2, figs. 338, 341). However the confusion may have arisen, the basin is definitely of limestone; the channel itself is no longer visible.

[858] *Knossos* II, p. 119, figs. 48, 57.

[859] *Knossos* I, p. 230, n. 1. Evans states here that the conduit is «square» in section. I assume he means the type of U-shaped drain we are discussing.

[860] *Mallia, Maisons* I, p. 13, fig. 2.

[861] Dawkins 1904-1905, p. 290, fig. 16 a-c.

[862] At Burial Building 3 in the Fourni cemetery at Archanes a number of U-shaped terracotta water channels, some splayed, were found fallen into the adjoining corridor (*Archanes* pp. 205, 241 and fig. 273 on p. 316 there).

[863] Cf. *Gournia*, p. 28, pl. I, no. 4. The excavators at the Artisan's Quarters at nearby Mochlos had a similar experience, finding fragments of conduits with flattened ends to be associated with vats discovered within the buildings (Soles and Davaras 2003, pp. 19-20). Another is reported from the Malia palace (Appendix E, Malia no. 4).

[864] See Chapter IV, below, under «Ceilings and Upper Floors», p. 152 f., also J.W. Shaw 2004.

At Phaistos special terracotta catch- or collection basins have been found in situ next to open areas in two of the most elegant rooms of the Second Palace, the Peristyle (Room 74) and the Propylon (Room 69). In each case coarse pots, quite similar to those which have been identified as ovens in the past[865], were sunk into the floor bordering the light-well. In the Peristyle the outer edge of the round catch-basins must have been approximately tangent to the line of the horizontal cornice of the roof far above[866]. Most likely the entire floor sloped down slightly, as was a tendency in Minoan light-wells[867], directing runoff rainwater into the pot, which was probably set just below floor level[868]. Water within the pot, which had a diameter of 35 cm, escaped through a triangular cut in its side and ran down a plastered, stone-lined conduit to the east. In the Propylon (Room 69) the catch-basin is similar, though slightly smaller and with two handles (*fig.* 240). It fed into a similar stone-lined channel to the west[869]. A third basin was found in Room 38. It differs from the two described in that instead of having an opening cut in the side, it had a pipe-like orifice which was joined to coarse terracotta pipes, sections of which were found nearby. Moreover, the catch-basin, which is 23 cm in diameter and handleless, was not found set into the floor, unlike the others[870].

At nearby Hagia Triadha a small pitharaki-shaped stone vase was set neatly into the floor of a light-well (Room 54) in the northwestern part of the major living complex there (*figs.* 241a, b)[871]. The vase's mouth was 0.24 m in diameter; its interior depth was 0.44 m. An opening in its side channeled away collected water. To judge from where they have been found, such stone or terracotta collection basins may have been used only in the Mesara.

3. Flooring Tiles

Minoan tiles are thin, rectangular terracotta plaques, which were set side-by-side and end-to-end to form attractive rectangular floor patterns. They were set into pavements and floors of interior rooms at ground level, and seem to have been used on upper floors as well. They are not common, but a number of examples have been found at the Palace of Kato Zakro, where they were made of reddish-orange clay with small fragments of reddish schist and whitish pebbles, this texture being very similar to that of coarse pithoi found within the Palace. In Room ix the pattern (*fig.* 242) was composed of 30 tiles, each about 30 cm by 34 cm, which were the central decoration for a room paved with *tarazza*, a mixture of pebbles and lime (see below). The second room where these tiles occur (Room xlii) is also paved with *tarazza*. The pattern of tiles in this case is made up of 12 tiles, each about 30 cm by 37 cm wide and about 4 cm thick. Elsewhere at Zakro, tiles 21 cm by 24 cm, and 4 cm thick, cover the drain running below the floor of the Treasury (Room xxv) (*fig.* 164, third from left). In a nearby MM III house excavated by Hogarth, tiles were used as a paving in the basement[872], and at Palaikastro to the north tiles «0.4 m thick and at least 0.30 m square» may have been used as a paving for an upper floor[873]. To the west, the only other examples I am familiar with have been found at Malia, where they also were used to form rectangular, paved areas on floors. In the Malia Palace a series of regularly set

[865] Cf. *P. of C.*, fig. 141, B.
[866] See *Festòs*, pl. VI.
[867] As in Dawkins 1904-1905, p. 193 ff.
[868] *Festòs* II, pp. 347, 349, figs. 217, 218, 221.
[869] *Festòs* II, p. 323, figs. 201, 202.
[870] *Festòs* II, p. 103, fig. 52.
[871] Halbherr, Stefani and Banti 1980, pp. 102-103, figs. 69, 70a (from which come our illustrations).
[872] Hogarth 1900-1901, fig. B, p. 131.
[873] Bosanquet 1901-1902, p. 315.

tiles was found in Room xvi[874], and I measured one such tile in Room xviii, 1, which was 50 cm long and 37 cm wide. A number have been found in houses as well, for instance in the Maison de la Cave au Pilier (MM IIIB) bordering the Agora near the large court discovered northwest of the Palace. There were 15 tiles, set in three rows of five each, and their dimensions are 31.5 by 27.5 by 6 cm[875]. Four were found in House ZB: these were of about the same size as the lone one reported above: 50 by 35 by 4 cm[876].

It seems, therefore, that such tiles were used mainly at Malia and further east, and then during the MM IIIB-LM IB period. Perhaps they were introduced there in imitation of the floors of gypsum flagging at Knossos and Phaistos, gypsum being a material that was either not readily available or else little exploited in the east[877], other than at Myrtos-Pyrgos.

[874] *Mallia* IV, p. 7. Dimensions are not given.
[875] *Mallia, Centre Politique*, I, p. 119, pl. LXII, 3.
[876] *Mallia, Maisons* II, p. 12f.
[877] At Akrotiri a few terracotta tiles were found collapsed within a room, possibly from the floor of an upper story (Palyvou 2005, p. 127, fig. 180).

CHAPTER FOUR

LIME AND CLAY PLASTERS

In Minoan architecture the two types of plaster used, lime and clay, performed a number of functions. The former served to seal the exterior joints of ashlar façades[878], the joints of masonry on the interiors of springhouses and cisterns[879], and sometimes the interior, bottom corners of stone drains, as well as the joints of terracotta pipes. In a few cases the drain itself was formed of plaster (*fig.* 257). Either alone or in combination with other materials, lime plaster was also used for paving lower and upper floors and probably roofs as well. Sometimes it covered steps made either of slabs or of rubble and earth, such as those in Room xviii at the Palace of Kato Zakro, or in the basement stairway leading down into the Hypostyle Crypt at Malia[880]. It coated benches, niches, compartments and the like. Its chief function, however, during all periods, consisted of providing a surfacing for interior rubble walls. In such cases lime was almost always used along with mud plaster, the latter serving as a thick undercoat that evened off the otherwise rough surface before the final coating could be applied. In some cases (*fig.* 253), especially in poorly lit areas, only this undercoat seems to have been applied.

A) Composition and Early Uses

Since the time of Heaton's meticulous and thorough studies of Minoan plasters[881], there has been no doubt that the base of Minoan plaster is burnt calcium carbonate or burnt limestone. Before Heaton's analyses, both Fyfe and Hawes wrongly assumed that gypsum served as the base material[882]. The present study has confirmed Heaton's basic conclusion about the development and composition of Minoan plaster, and it covers a greater geographical and chronological range of examples[883].

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[878] See also p. 75 f.

[879] As in Room lxii at Zakro.

[880] For production of plaster, see also *Crafts*, pp. 472-484. Dandreau (1999) has published a typology of Minoan wall plaster, including the ingredients and preparation, with a focus on Malia.

[881] N. Heaton 1910. Durm had found previously that the base for plaster found on mud bricks was lime (1907, pp. 41-42 [note]).

[882] Fyfe 1902, p. 108; *Gournia*, pp. 21, 25. Eibner claimed that equal amounts of gypsum and lime were used in at least one case at Knossos (1926, p. 59 ff.). Dr. Skalos, who helped in the preparation of the present chapter, originally added the following cautionary remark: «The constituents of the samples, as analyzed, do not suggest the presence of gypsum in the plasters. However, a long-term leaching process could possibly bring about an ion exchange which might result in the removal of the sulphuric ions in the form of water soluble salts whose presence was not detected». In retrospect, Skalos's cautionary remarks proved to be unnecessary, for analyses made since he wrote have confirmed that lime was the basic material. The only evidence I am aware of for Minoan use of gypsum plaster is the material, published by Mark Cameron, shown in *fig.* 248. Cameron's conclusion is that such gypsum, «which would likely harden quickly, probably served strictly non-decorative constructional purposes» (Cameron 1977, p. 170).

[883] For a table of the analyses made, see Appendix F, p. 193. The analyses listed there, with the excep-

The EM II settlement of Vasiliki provides many examples of the early use of plaster, which then consisted of a very hard, thick coating of light brownish-orange clay mixed with lime and straw (*fig.* 243). This coating, to which pebbles and potsherds were added, was as thick as 5 cm, and was smeared over the faces of the rubble walls in order to strengthen and protect them[884]. Then a second coat[885] of finer clay of a somewhat darker color was spread over this before it had dried. This second layer, as measured on the site, ranges 4 mm to 9 mm thick. While this was still damp, an even finer layer of clay, no doubt slaked, and averaging a few millimeters thick, was applied, and in turn it was painted a reddish-orange[886]. Next, to judge from the polishing marks still visible on the walls, the already fine surface was further smoothed and hardened until in some cases it literally shone.

In the analyses made for this study, Dr. Skalos detected small seashells in the backing plaster (layer 2), suggesting that perhaps the earth used as part of the plaster makeup had been gathered from the seashore not far from the site. The shells may also have been added to add consistency. In both Heaton's analyses and in the present one[887] there is a low (about 40 percent) percentage of carbonate of lime in the plaster of both layers, and a relatively high percentage of silica (32 to 39 percent) by comparison to the plasters of the period of the Second Palaces[888], apparently an illusory difference that is likely the result of EM II regionalism, as suggested by the contemporary plasters from Myrtos-Phournou Korifi, for which see below. The high percentage of silica and alumina, according to Heaton, suggests a plaster made by mixing lime with clay of the type known to mineralogists as zeolite (hydrous aluminum silicate). He identified a similar plaster from the earliest phases of the Knossos Palace[889]. Since Skalos's analyses, which still pertain[890], and as interest in Minoan plaster composition and techniques have been paced by methodological sophistication, numerous new analyses have been published. The first were by Cameron, in his 1972 study of the plasters from Myrtos-Phournou Korifi, and in his group's 1977 work focusing specifically on fresco fragments from Knossos. More recently, R.E. Jones (1999) published a broad survey of technical studies of plasters, especially painted ones, and plastering, and D. Evely reviewed[891], as we do here, evidence for plastering and the tools used in the craft[892].

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tion of no. 9, were made by Dr. George Skalos, chemist and Epimelete at the National Technical University of Athens. He was aided in his work by K. Makris. The work was partly financed by a Grant-in-Aid given to the author in 1968 by the American Council of Learned Societies. For permission to select the small samples necessary for analysis at various archaeological sites in Crete, I would like to thank the relevant archaeological authorities, as well as those archaeologists who gave me samples directly from their own collections.

[884] See also Heaton 1911, p. 698; Seager 1904-1905, p. 209; *Knossos* I, p. 533 ff.

[885] Sample I B in Appendix F, p. 193.

[886] Samples I A in Appendix F, p. 193. The similar red color at Myrtos-Phournou Korifi was made up of iron earth pigments (Cameron 1972, p. 306).

[887] Heaton apparently combined outer and inner plaster layers (layers 2 and 3) in the analyses published (Heaton 1911, p. 698, bottom).

[888] The approximate amount of carbonate of lime, or limestone, used for making the plaster can be determined by adding the amount of CaO (calcium oxide or lime) to the amount of «Burnt Remainder» in Appendix F. The burnt remainder is mainly carbon dioxide released when the carbonate of lime is burnt.

[889] Heaton 1911, p. 698.

[890] Jones 2005, p. 203.

[891] *Crafts*, pp. 471-484.

[892] For recent studies of pigments used in Minoan fresco work, see in particular Cameron 1977, Jones 2005 with an appendix by E. Photos-Jones; also Evely (*Crafts*) pp. 478-479 and M.C. Shaw 1996, especially her 2005 along with Appendix 2.2 on fabrics and pigments by A. Dandrau and S. Dubernet (pp. 236-248). Also Militello 1998 (Hagia Triadha), pp. 379-381, and his 2001 (Phaistos), pp. 196-198, as well as Dandreau 1999 (mainly pigments from Malia). For grids and other drafting devices used in Minoan painting, see M.C. Shaw 2003.

At Fournou Korifi near Myrtos, contemporary with EM II Vasiliki, lime plaster was used to cover walls and provide upper surfaces for ceilings and roofs. For the former, a method similar to that described here already for Vasiliki was used[893]. Tubular voids show that fine straw or some other organic material, chaff or hair, was mixed up with the plaster, some of which has a light brown color. In a number of instances the plaster was painted red, as at Vasiliki. What has been identified as plasters from roofs or ceilings is of two types: A) plasters consisting of a single layer about 8 cm to 11 cm thick, and B) those with two layers, together not less than 17 cm in thickness[894]. The latter may actually represent a resurfacing operation postdating original construction. The roofing/ceiling plaster was a thick, cream-colored coarse mixture of lime, large chaff or hair particles, a few beach pebbles and some small fragments of pottery which, where areas had burned, hardened into a compact mass that does not break up easily. Roof plasters with reed impressions were also reported[895].

In the First Palace of Phaistos a similar plastering technique was used. A thick layer of clay and straw, 2 cm to 3 cm thick, was first applied to the rubble walls; a final coating of monochrome grayish-yellow plaster was smoothed on over it[896]. Probably the yellow and earlier red coloring of the exterior plaster coating at EM II Vasiliki and Myrtos-Phournou Korifi had gone out of style here by this time[897]. The same technique appears in the southern section of the same Palace, excavated by Levi. Although the details of a series of analyses of plaster made there have not yet been published, it seems that the clay mortar used was similar to that we have already discussed from Vasiliki[898]. Once more, a generous amount of straw was used in the clay backing plaster.

The peculiar hardness of the early plaster has been variously explained. For instance, aside from lime, which was always present in varying amounts, Heaton thought that the hardness was due to the use of a special clay (zeolite). Seager may be thinking of the same ingredient when he refers to the peculiar quality of the soil in the neighborhood of Vasiliki. The recent excavators at Phaistos describe the composition of the plaster as of lime, earth, and potsherds, and there seems little doubt that the materials used in every case were of local origin[899]. Fiandra has pointed out[900] that the plaster used during this early phase of Minoan architecture is much like that used in coating Roman and Byzantine cisterns. It is also similar in content to that used during Classical Greek times on Crete[901] and on the Greek Mainland[902]. There is the same high percentage of hard silicates (over 35 percent), while the amount of carbonate of lime averages 45 percent. Roman building mortar[903] is different, with its carbonate of lime content dropping to about 25 percent and the silicate content ris-

[893] Cameron 1972, p. 307. At Myrtos-Phournou Korifi the percentage of lime in the plaster (60 percent) was much higher than that at Vasiliki (40 percent). Cameron (1972, pp. 312-313) attributes that difference between the two sites to regional variation. Of interest is that at the same time at Knossos in Central Crete, plastering seems to have been of less concern. At the otherwise well constructed EM II building found below the West Court there neither exterior nor interior wall faces were plastered (J. Evans 1972, p. 118; Wilson 1985, p. 288). In Cameron's study of plastering at the site, of the three sure EM samples cited, only mud-plasters are reported (Cameron 1977, pp. 174-175, nos. 1-3).

[894] Cameron 1972, p. 309; see the analyses for them (nos. 7, 8) on p. 312 there.

[895] Cameron 1972, p. 309 and pl. 82B, D.

[896] *Festòs* I, pp. 443-444.

[897] Heaton 1911, pp. 698-699; *Knossos* I, p. 533, and n. 3; *Festòs* I, n. 65.

[898] Fiandra 1961-1962, p. 126.

[899] There is no evidence, for instance, that Santorini earth, a local form of volcanic pozzuolana from the nearby island of Santorini (Thera), was used by the Minoans. It is reported in *Gournia* (pp. 21, 25), but no doubt incorrectly, as is the mention of gypsum plaster, which was hardly ever used by the Minoans. On Santorini earth, see *MA:MAT* 1, p. 210, n. 1.

[900] Fiandra 1961-1962, p. 126.

[901] Appendix F, nos. 7 A, 7 B.

[902] Appendix F, no. 9.

[903] Appendix F, no. 8.

ing to almost 70 percent. The difference is certainly due to the use of an aggregate of sand, but it could also be partially caused by the addition of fragments of volcanic stone to the mortar. The latter seems likely, for as I noted when gathering the sample from the Roman circuit wall at Polyrrhenia, the mixture was quite full of small fragments of purplish stone, which looked like the volcanic stone used to strengthen the hydraulic mortar of the Roman buildings at Kenchreai, the eastern port of Ancient Corinth[904].

B) Later Uses of Lime Plaster and its Preparation

An indication of the Knossian builders' priorities, after the initial stages of plaster development in Crete, is that the first pure lime plasters there belonged to floors, not walls[905]. Concerning the walls, Heaton remarked, «as long as the chief function of the plaster was structural – the facing of the walls to reduce decay – color and texture were immaterial; but as the practice of painting on the walls developed, more and more attention would be paid to producing a surface suitable for decorative treatment. For this purpose, fineness of grain, in order to prepare a perfectly smooth surface for painting, and brilliant whiteness in order to enable the designs to tell to the utmost, were desirable, and what the Minoan craftsmen were evidently striving after as their skill in decoration increased»[906]. Cameron also noted that «[b]y MM IIIA a lime plaster of high purity and quality was regularly being produced, whose recipe evidently remained in good stead until the end of the Bronze Age, c. 1200 B.C.»[907].

Their statements, however, would apply only to the finest plaster prepared, which had no aggregate of any type, for although the carbonate of lime content remains consistently high for exterior plaster coatings during the Neopalatial period, I have noticed pieces of pulverized terracotta used to strengthen the plaster of a number of walls on sites other than Knossos. These plasters as a result are generally much harder than the Knossian ones. A typical sample of fine Knossian plaster of this period can be seen in *fig.* 244, where a piece of plaster consisting of only one thick coat is shown. In this case the plaster has been painted red, and one can see (*fig.* 244, left) how the red paint has penetrated some distance into the body of the plaster[908]. Analysis of such fine, white plaster from Knossos has shown that neither an aggregate such as sand nor a fibrous organic binder was used[909].

To mix this fine plaster, the normal procedure must have been similar to that used today, namely to gather the limestone necessary, to break it into small chunks before firing, then to burn it with a wood fire in a kiln at a temperature of about 900° C, and then to crush it into powder form, or quicklime. No Minoan lime kilns, however, have yet been discovered, as far as I know[910]. Next, water was added, and the mass stirred with sticks, since the mixing process generates a great amount of heat and hands cannot be used. This

904 This should not be confused with Santorini earth, which is also of volcanic origin. In the case of Kenchreai, the material proved to be definitely of volcanic origin, perhaps having been brought from the neighboring region of Kalamaki.

905 Cameron 1977, p. 170.

906 Heaton 1911, p. 699.

907 Cameron 1977, p. 170.

908 The piece illustrated is probably of MM IIIB date, and is from the excavations near the Royal Road, conducted by Sinclair Hood (Trench JK Extension, Level 231).

909 Heaton 1911, *passim*; Duell and Gettens 1942, pp. 196, 215-216, 218.

910 Both Jones (1999, pp. 216-217) and Evely (2000, p. 474) agree that lime found in channel kilns was only being readied or stored there, rather than actually being baked.

heat disappears upon setting. The mixture produced is called «slaked lime» and, as long as it is kept wet, can be stored and used for a long period of time[911].

Heaton believed that limestone for the plaster found at Knossos must have been brought from the quarries of Hagia Irini (*figs.* 31a-c), a few kilometers south of the Palace, because of the close similarities between the plaster from the Palace and the limestone from the quarry revealed in the respective analyses[912]. Jones's later analyses indicated that a source west of Gypsades Hill, southwest of the Palace, was the more important[913], although he thinks that more samples must still be analysed to be sure[914]. Heaton also suspected that the shallow pits or cists in the galleries at Knossos may have been used for storage of lime[915], but the only indication of which I know first hand for the semi-permanent storage of lime is a number of pithoi partially filled with lime, which were discovered in the ruins of a destroyed house to the northeast of the Palace of Kato Zakro in 1969[916]. The pithoi contained solid quantities of lime which in hardening had assumed the shape of the bottom of the pots' interiors. In this case, there is a good chance that the lime was in a slaked condition at the time the house was destroyed.

Plaster may have been applied and smoothed down with wooden, stone, or metal tools. In at least one case an unmistakable finger mark on the joint of a pillar (*fig.* 127) shows that hands were used as well. Also, finger impressions in a lump of plaster from Knossos show how the plaster was scooped out by hand (*fig.* 248)[917]. No doubt the plaster was placed in bowls such as that which formed the lump in *fig.* 250 or, as shown in another example from Knossos, an LM IIIA bowl still half-filled with plaster (*fig.* 249)[918].

As far as tools are concerned, at least six oblong plaster «floats» of stone have been discovered on Minoan sites[919]. Probably the oldest is from Phaistos, of the Protopalatial period. It is about 23 cm long, and of a reddish stone[920]. One of the other two, both of which belong to the LM I period, is from Gournia (*fig.* 245). It is 40.9 cm long, 5.6 cm high and 7.2 cm wide. Like that from Malia (below), it was carved from steatite and has a handle that could be grasped by the workman[921]. It was probably used for polishing and smoothing floors, because it is quite large and heavy, weighing 4.064 kg (about 8.96 lb.). Curving striations, similar to those still visible on many plaster floors, can still be seen on its lower surface. A

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[911] For more details about the preparation of the plaster and its use, see Evely 2000, pp. 471-474.

[912] Heaton 1911, p. 700. It is interesting in this respect that Vitruvius (*De Arch.*, II, 5, i) recommends specifically poros limestone, rather than the denser limestone types, for making plaster.

[913] Cameron 1977, pp. 152, 170.

[914] Jones 2005, p. 203.

[915] Heaton 1911, p. 700, note. The impressions in *figs.* 248, 249 came from these pits.

[916] Apparently two LM IA jars containing lime were also found by Evans in the Queen's Megaron at Knossos (*Knossos* III, p. 356). In the course of his description of the Palace, Palmer (1969, p. 85) puts quotation marks around the word «lime» and explains by inference later that the «lime» must be gypsum turned to plaster of Paris by the heat of the fire that destroyed the Palace. He fails to explain, however, how burnt gypsum, apparently fallen from above, could accumulate so neatly within jars; so at least for the moment I prefer Evans's explanation that the jars, like the one reported here from the Palace of Kato Zakro, were indeed for storage of lime, most likely for plastering. For other evidence for storage, see now Evely 2000, p. 474.

[917] The late Mark Cameron, who kindly furnished me with the photographs, also provided me with the present location of this lump as well as its provenience: Knossos Stratigraphic Museum, Box 527, D IV 9, K. '03, Long Corridor-Cist 11; B. 27, '03=H. 0.08 m.

[918] Knossos Stratigraphic Museum, Box 521, D. IV 6, K '03, Long Corridor-Cist 5, '03; B. 27 = H. 0.08 m. One handle is missing.

[919] *Crafts*, p. 477, nos. 12-16.

[920] Levi 1952-1954, p. 414, fig. 37 (bottom row, middle).

[921] For the example from Gournia, see *Gournia*, p. 32, pl. III, no. 35; also Orlandos 1958, pp. 366-367, fig. 399, and Zervos 1956, fig. 607.

third example of a «float» is a fragmentary one from Malia. When complete it must have been about half the size of that from Gournia[922]. Perhaps this example and that from Phaistos could have been used for smoothing wall surfaces, for they are of a handier, lighter size. However, light wooden floats of the same shape, now used in Greece for work on walls, were probably used to smooth Minoan walls as well. At Kommos a number of hand-sized cobbles recovered with remnants of plaster and chaff on them (e.g. those in *fig.* 247) were also probably used for smoothing down plastered walls of the MM II-LM I houses[923]. Another tool type, which has been variously interpreted as a dagger and a spatula in the past, may actually be a small trowel used to point the joints between wall blocks. It is a triangular, flattened piece of worn bronze, perhaps 7 cm long, with an up-curving tang of metal at the end where it was held (*fig.* 246); that illustrated is from House X at Kommos[924]. A number of examples were found at Gournia, and single examples are reported from Malia as well as from Palaikastro[925].

The basic technique for applying the plaster did not change from the First to the Second Palace period. The chief role of a plasterer was to cover interior rubble walls, and to do this he first evened off the rough surface by applying a thick layer or two of mud, in some cases mixed with lime and organic binding material, and then he spread the final coat of white plaster over it which, before it dried, was smoothed with polishers such as we have described. At Knossos, where the final coat of white plaster was often exceedingly thick, it was noticed that the backing plaster was sometimes scored to provide a key for the final coat, a technique that was also used between plaster layers of high modeled relief stucco[926]. In some cases at Knossos the plaster was so thick that wooden dowels, driven into the walls and left projecting from them a certain distance, were probably used to keep the heavy plaster from falling down of its own weight (*fig.* 251). At Nirou Khani, Xanthoudides reported three plaster layers on some walls, the first of mud about 1 cm thick, the second, also of mud, about 2 cm thick, and the third a thin layer of lime plaster 7 mm to 8 mm thick[927], the last being the same thickness as that reported from Tylissos, and slightly thicker than that from Phaistos (0.5 cm)[928] and Malia (0.5 cm)[929]. At a number of sites straw was used as a binder, as can be seen at Phaistos, Tylissos (*fig.* 252, 253)[930], and Malia (*fig.* 256) as well as at Kato Zakro[931]. Occasionally wall plaster was renewed, which left a series of fine layers, one upon the other[932]. The same could occur on floors when plaster surfaces were renewed[933]. The renewal illustrated here, from Malia, is composed of at least seven coats, 0.5 cm to 1 cm thick (*fig.* 255 a).

The only instance of which I know when the immediate backing for fine white lime wall plaster was not composed of mud is to be found at Malia, where a mosaic-like backing

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[922] *Mallia* III, p. 68, fig. 44.

[923] H. Blitzer in *Kommos* I (1), especially pp. 456-458, pl. 8,26 and 8.93-8.94. See also Tylissos (2), p. 53. For similar hand stones from Phaistos, see Militello 2001, pl. XV 1-3.

[924] From Room 9, Trench 97G, Pail 80.

[925] *Gournia*, p. 34, pl. IV, no. 27; Bosanquet and Dawkins (eds.) 1923, pl. xxiv B. The date of the example from Gournia may be LM I. They are very similar in shape to those of later times (Cf. Orlandos 1958, p. 57, fig. 20). Evely (2000, p. 475, no. 3) notes another from Malia, House E, Room 38 (*Mallia, Maisons* II, p. 145, pl. 51.2; LM). For the method of their use, see a wall painting from Pompeii illustrated in Orlandos 1958, fig. 17.

[926] *Knossos* I, p. 531, fig. 387.

[927] Xanthoudides 1922, p. 10.

[928] *Festòs* II, p. 422.

[929] Charbonneaux 1928, p. 358.

[930] See also *Tylissos* (2), p. 51.

[931] As in Hogarth 1900-1901, p. 130.

[932] As *Festòs* II, p. 422; Charbonneaux 1928, p. 358.

[933] As at Kommos in Building T, Room F (*Kommos* V (2006), pl. 1.105; 2.20, lower right; 2.21, top). There are some six plaster layers there. The first, thickest, was white, as was the final; the four between were blue.

of small fragments of stone, 1.5 cm to 6 cm in size, and curiously modern in appearance, was occasionally used (*fig.* 254). In the Palace this technique was apparently used only in the north and west walls of Room vi, 2, and on the floor of the same room[934]. It also appears in Rooms 3 and 4 of the Hypostyle Crypt to the north of the Palace. Here a rubble wall of large stones and mud was first built. Next a layer of finer mud plaster, mixed with a few sherds, was applied. Into this mud was added a single layer of thickly packed small fragments of rock, 0.01 m to 0.04 m in size. These were hidden later by a layer of lime plaster about 6 mm thick. Upon such plaster surfaces, backed by rubble, the Minoans executed their wall painting. Unlike the Egyptians, it is unlikely that they ever painted on stone, although traces of color have been found on stone relief decoration and stone furniture[935], and red wash was found on some of the orthostates at Knossos[936].

Aside from forming the surface for the painting of important pictorial scenes and architectural representations, of which the subjects and techniques are beyond the scope of this study, plaster was sometimes incised or painted to imitate other building materials. For instance, at Malia, on the exterior face of the northern wall of Room III, 8, the plaster was incised to imitate the joints between courses of ashlar masonry[937]. At Knossos, in Room H of the House of the Frescoes, the wall was painted in a manner imitating a dado course of stone topped by a wooden beam, the beam being about 5 cm thick and with red graining on an ocherous ground[938]. The Marbled Fresco from Knossos and that from the Chania Splantzia Lustral Basin imitate variegated stone in painted plaster[939]. In both the anteroom to the Throne Room and to the Portico of the West Court at Knossos, panels were decorated to imitate slabs of veined stone[940]. No doubt this marbling technique imitates the natural veining of gypsum slabs (*fig.* 14). On the southern wall of the Painted Pavilion of the Caravanserai was painted a full-scale reddish, wooden pillar set upon a red base, which rose 13 cm above the floor and was apparently topped by a painted architrave, 23 cm high, which represented the wooden beam forming the continuation of the lintel over the door[941]. At one site, plaster was even used to serve as the channel for a drain (*fig.* 257).

C) Floors

Minoan floors varied[942]. The simplest were of packed earth or clay, sometimes with the addition of small stones, pebbles, pottery or seashell fragments to increase durability[943].

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[934] Charbonneaux 1928, p. 358; Daux 1966, p. 1001, fig. 7. It was also used for floor and wall covering in MM Quartier Mu.

[935] Fyfe 1902, pp. 111, 112 and note; *Knossos* IV, p. 904, fig. 877.

[936] *Knossos* IV, note on fig. 877.

[937] Charbonneaux 1928, p. 357.

[938] *Knossos* II, p. 444, fig. 260.

[939] *Knossos* I, pp. 356, 531, fig. 255; IV, p. 896, fig. 874; Andreadaki-Vlasaki 1988, fig. 3.

[940] Heaton 1911, p. 707, fig. 10; Fyfe 1902, fig. 25, also p. 110, fig. 13 for another example.

[941] *Knossos* II, p. 109, fig. 49. For imitations of variegated stone in the North Stoa at Kommos, see *Kommos* V, pp. 221-224 and pl. 237-238. For the imitation of a horizontal wooden beam in plaster, see that in a small light-well at Hagia Triadha in our *fig.* 241 a. For similar effects at Akrotiri see Palyvou 2005, p. 166 and, elsewhere, see Palyvou 2000, pp. 425-429.

[942] For the variety of Aegean decorated floors, see Hirsch 1977. Occasionally, floors were painted with pictorial depictions, for instance the LM III marinescape in Shrine H at Hágia Triadha (Militello 1998, pp. 321-335, pl. 13) or, also of LM III date, a presently unique geometric mosaic of lozenges and spirals made up of gray, blue, and white pebbles found in Quartier Nu at Malia (Driessen and Farnoux 1994, pl. III, 3, and Driessen 1994, p. 78).

[943] Apparently pumice was used as insulation in an LM I house roof at Chania, where it «kept the house warm in winter and cool in summer» (V. Hankey in

Other, «special» floors were made up of locally quarried «earths», often with distinctive colors and particularly gritty. Such earths were sometimes used in exterior courts or in dense layers on roofs. One pebbly-to-sandy variety is locally called «white earth», or asprochoma (ασπρόχωμα), and is still used nowadays in a few rural areas to waterproof roofs. When used it can be mixed with water and lime. It is composed at least partly of soft limestone, somewhat similar to but much softer than the type of limestone called *kouskouras* that normally occurs as bedrock in the regions of Knossos and Phaistos. At Zakro it was used for the hard-packed floor of an exterior court northwest of Room i of the Palace as well as a thick early court floor partially exposed below the level of the Central Court in 1971. At the Northeast Entrance of the Palace, the slab pavement was set upon a layer of this material, and in Room lxviii, a nearby walled enclosure, probably unroofed in ancient times, there were found thick chunks of the same material. No doubt this room was a temporary storage area for white earth, for nothing else was found within it. I assume that this earth was excavated from the hillside near the Church of Ayios Antonios southwest of the Palace, for this is probably the nearest source. The deep pits still visible there (Hogarth's «repositories») may originally have been quarries furnishing flooring material for an early phase of the Palace.

Outside of Zakros, «white earth» was also used for a 25 cm-thick layer of the Central Court at Malia[944]. At Kommos in the Mesara, it was used in open areas, and probably on roofs[945]. Actually, «white earth» is only one of a number of local earths used by the Minoans. «Red earth» was used in some cases at Knossos[946], and «Sissi clay» was used as a waterproofing material for a water conduit at Malia[947]. The excavators of MM II Quartier Mu report a greenish water-resistant clay that was used for upper floors and, in quantity, for terraces and roofs[948].

Aside from revetting and strengthening walls, a chief function of plaster was to cover earth floors. At EM II Myrtos-Phournou Korifi, however, lime plastering was used less for floor or bench plastering than for walls and ceilings where, by assuring structural consolidation and protection, plaster might assure longevity and thus comfort[949]. Later, at MM II Quartier Mu, with the exception of rooms below ground floor which were left with irregular surfaces, the floors usually consisted of small pebbles mixed with earth, often covered with plaster. Floors in porticoes and vestibules, however, were paved with stone slabs, with plaster in the interstices between them. Plasters varied from whitish-yellow to beige-brown; also there was a bluish-green hue known as well at Phaistos. Red, also the predominant color at EM II Vasiliki and Myrtos-Phournou Korifi, characterized upper floor plasters[950].

At Knossos investigators noted that the first, pure white lime plaster (in MM IIA) belonged to floors rather than walls[951]. Some five types of floor plaster were identified, including two with lime mixed with small sea pebbles (*tarazza*, for which see below), another with sherd fragments and stone, one of pure lime plaster, and a last, either left unpainted or treated with a red or ochre wash[952]. At Kommos, where a thorough examination of Minoan plasters over a large area was conducted, M.C. Shaw noted that plaster floors during

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Doumas [ed.] 1980, Volume II, p. 340); Jan Driessen has also informed me that the same material was used as floor and roof packing in the LM III Building in Quartier Nu at Malia (personal correspondence of 7 July 2006).

944 *Mallia* V, p. 20. See also Pelon 1989, p. 773.

945 *Kommos* I (2), pp. 125, 350, 354. For its use in the roofs of house tombs, see Soles 1992, pp. 213-216.

946 See p. 150.

947 *Mallia, Centre Politique* II, p. 20, n. 3.

948 Schmid 1996, pp. 89-90.

949 Cameron 1972, p. 305.

950 Schmid 1996, p. 77.

951 Cameron, Jones and Philippakis p. 170.

952 Cameron, Jones and Philippakis p. 170. The relevant analyses are on pp. 183-184.

the MM period were simple, usually a thin layer of plaster laid over compacted earth[953]. For the LM I-III period in the Southern Area there she proposed six types (and variants), the more simply defined consisting of thin layers of fine white or blue-painted plaster applied upon each other during renewals. Others were combinations of layers of plaster with various inclusions (sand, fragments of stone, reused plaster fragments). One type that she believes was used in an upper story had an upper plaster layer 0.2 cm to 0.4 cm thick, with a flat but unpolished surface set on a thin layer of small pebbles or sand, laid in turn upon a plaster layer incorporating small stones and old plaster fragments[954].

1. *Tarazza*

A particularly hard, durable mixture of lime and small rounded beach pebbles of uniform size, *tarazza* often formed particularly attractive floors and pavements (*figs.* 258-260). It was dubbed «*tarazza*» by Evans, after local usage, the more formal name being χαλικάσβεστος. This flooring material is characteristic of the Second Palace period. As far as I know, it does not appear at the EM II sites of Vasiliki and Myrtos-Phournou Korifi, but it was used at Knossos as early as MM IB[955]. Occasionally it was used in the pavements of light-wells, as in that of the Hall of the Double Axes at Knossos (*fig.* 97)[956]. At the point where the floor met the wall, it was beveled up to keep dampness away from the lower parts of the walls. The floor sloped down toward a catch-basin («gulley») from where the water would drop down into a drain passing below the floor[957]. It was used in the South Propylaeum at Knossos as well[958]. At Phaistos this durable flooring material was common[959], as it was at Kommos[960]. It was used to pave upper-floor rooms at Archanes[961].

At the Palace of Kato Zakro (on the ground floor), it was usually used to pave roofed areas (Rooms ix, xxi, xxx). In Room ix (*fig.* 242), which had in addition a central floor design of terracotta tiles, the floor was paved with an especially fine mixture (*fig.* 258). Along part of the edges of this room, on the north and east sides, a clearly defined, later addition of *tarazza* of a whiter composition suggests that there were originally benches here which were later removed. The gaps in the floor were then evened off with a different batch of *tarazza*. No doubt the *tarazza* was used at Zakro where water would be most likely to muddy the floor. It probably covered the entire floor in Room lxii, for substantial amounts are still visible around the circular cistern or well-house («pool») there. The mixture in such cases was about 5 cm thick (*fig.* 259) and in some cases contained fragments of crushed terracotta. Some of the pebbles are inside the mixture, which shows that they were mixed along with the lime. It seems, however, that a layer of additional pebbles was spread upon the surface when it had partly dried, and was then pushed down, being evened off with a plaster float such as that in *fig.* 245. When partially dry, the floor was polished.

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[953] M.C. Shaw 2006, p. 212.

[954] M.C. Shaw 2006, pp. 208-210.

[955] Letter from Mark Cameron, dated 26 January 1970. In his study of Knossian floor plasters, Cameron included *tarazza*, cataloguing four Late Minoan examples from various areas (Cameron, Jones and Philippakis 1977, pp. 156-157, and nos. 108-111 on pp. 183-184, with pl. 15b).

[956] *Knossos* III, p. 330.

[957] Mackenzie 1904-1905, p. 194.

[958] *Knossos* II, pp. 688, 689, 696.

[959] *Festòs* II, p. 422. Our sample from Hagia Triadha (Appendix F, no. 6) showed upon analysis pure lime plaster mixed with pebbles. See also Heaton 1911, p. 703, fig. 13; *P. of C.*, p. 208.

[960] It was used in open spaces such as courts in the houses as well as in the Central Court of Building T (*Kommos* I [2], pp. 350-351; *Kommos* V, pp. 60, 387 [sample 12]).

[961] *Archanes*, pp. 142-143.

There is no doubt that the same material also paved floors of upper stories. At Zakro, for instance, large thick fragments of such floors were found in a number of the ground floor rooms, for instance in Rooms iii, xix, xxx, xlvii[962]. Since they were found in high positions in the fill, they had definitely fallen from above. The pieces I have seen show no impressions of beams, boards, or reeds on their lower surfaces, and the pavements therefore were probably laid upon a smoothed surface of plain earth or mud first spread out upon the ceiling structure. Since there definitely was a second story in these areas, one cannot say if the fragments belong to a floor or to a flat roof. My impression, however, is that they belong to the former, for pieces of this pavement have not been found in all the rooms of the Palace, which one would expect if the original roofing was uniformly of the same material.

At Knossos Evans distinguished two types of *tarazza* pavement (*fig.* 260). The first, for ordinary pavements (*fig.* 260A) was composed of a thin top layer of lime plaster and pebbles of the kind that we have described, set upon a thicker layer of red earth[963]. The second type, much thicker (*fig.* 260B) had a similar upper layer, then a thin layer of red earth, and below this a layer about 2 cm thick of blue-black clay which Evans identified as lepidha (actually decomposed schist) that occurs in many of the Cretan hillsides (*fig.* 16). Its name is derived from its frequent occurrence in the form of small crumbly flakes, or scales (λεπίδες). It was often used as a covering for roofs in Cretan villages, and in the past has been thought by a number of scholars to be the material most likely used for waterproofing Minoan roofs[964]. The best evidence for its use in Minoan times is in the examples quoted above and, also from Knossos, its appearance in the interstices between blocks in a cist near the Early Propylon[965]. It has also been reported from the roof of the palatial building at Archanes[966] and as a bedding for plaster at Kommos[967]. The second type of pavement presumably formed a roof terrace over the second story of the Caravanserai[968] and the pavement of the Long Corridor near the Southern Propylon, which Evans claimed was open to the sky[969].

2. Slab Pavements

The most elaborate Minoan floors were paved with slabs, often with their interstices filled with plaster painted red. The slabs themselves could vary considerably, being of irregular or squared gray or white limestone, or of gypsum, or uncut local schists that occur in green, bluish-green, and purplish-red[970]. Slab floors were also used to pave upper stories[971]. In the light-well of the West Wing at the Palace of Kato Zakro (*fig.* 213), for instance, as well as on many other sites in Crete, plaster filled the interstices between slabs of stone. One of the most typical procedures, especially during the Second Palace period, was first to lay down cream-colored gypsum slabs, about 5 cm thick, in rows parallel to the walls, then fill

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962 Platon 1962a, p. 159; 1964a, p. 146; 1965a, pp. 189, 200.

963 *Knossos* II, p. 327, fig. 185. I was not able to find out what exactly is meant by «red earth», but it was apparently excavated from the hillside near the southwest angle of the Palace (*Knossos*, II, pp. 294, 296) and was in use in foundations, the interstices of wall blocks, and for the backing of cists in the West Wing (*Knossos* I, p. 451, fig. 325) as well as for floors during the Neolithic period (*Knossos* II, p. 18).

964 As in *Tylissos* (2), p. 54; *P. of C.*, p. 161.

965 *Knossos* II, pp. 699-700.

966 *Archanes* pp. 108, 111, 138, 144.

967 *Kommos* V, p. 208.

968 *Knossos* II, p. 107.

969 *Knossos* II, p. 716.

970 For the arrangement of slabs on floors, see also Hirsch 1977.

971 There are numerous instances where slabs from upper floors have been found collapsed down into ground floor rooms, as at palatial Archanes (*Archanes*, pp. 85, fig. 64, drawing 8, pp. 142-143). At Kommos

in the remainder of the floor surface with slabs separated only by plaster infill. Sometimes the slabs bordering the walls enclosed a central pattern of slabs of dark limestone (*fig.* 12). A rhomboidal arrangement of such gypsum slabs has been discovered in Room 93 at Phaistos[972]. In most cases the strips of plaster between slabs were painted red. Sometimes actual stone slabs were not used but were imitated in plaster, as in an MM II plaster floor at Malia, which was subdivided into slab-like panels painted red and each outlined by white plaster strips[973].

3. Plaster «Strip Designs»

An unusual and still incompletely understood way of completing Neopalatial Minoan floors was to decorate them with thin, flat strips of plaster laid down carefully in deliberate patterns[974]. For instance, at the palatial building in Archanes (*fig.* 123c), long thin plaster strips, painted red, were laid in patterns on the floors in what probably formed the building's north wing. There four adjacent rectangles were set at its entrance (Space 2), with a larger rectangle split into four equal spaces in Lobby 3, beyond which adjacent smaller rectangles lined the length of at least one corridor. On the basis of evidence for burning on the floors, the excavator has suggested that wooden boards filled the spaces between the strips[975], a hypothesis similar to that proposed for the decorative strip designs found in the North Wing of the Palace at Galatas[976]. Also at Archanes, such strips, unpainted, were found in destruction debris fallen into ground floor rooms from an upper story, showing that plaster strip decoration was used on the upper floors. Strip decoration from an upper floor is also reported from the town on the island of Pseira, where red-painted strips were found fallen onto the ground floor level of a house in Block AF[977].

At Palaikastro bands of plaster set on the floor formed a rectangle subdivided into nine rectangles by crisscrossing strips of plaster[978]. There is a similar example at Zakro, where a number of patterns, the plaster strips painted red, appear to have been set directly on the earth floor. In the southeastern part of Room xxviii, for instance, there is a rough square, 2.59 m by 2.46 m, which was divided into four sections by plaster bands crossing at the center[979]. North of these is a series of meanders bordering the stylobate of the light-well on the east and south. Similar designs decorate the eastern half of the same space. In Room xxix to the south, two parallel rectangles each are subdivided into four smaller rectangles by short plaster bands.

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there was a slab floor (roof?) above the ground floor room of the House of the Press (*Kommos* I (1), pp. 106, 254, 369); another, with at least 7.5 m² of slabs, was above Storeroom 25 on the Central Hillside (*Kommos* I (1), p. 182). For the similar custom at Akrotiri on Thera, where entire slab floors on upper floors can be seen in almost the same relative positions as when the Cycladic town was overcome by the volcanic eruption, see Palyvou 2005, pp. 126-127, also Michailidou 2001, pp. 200-212 and 363-370.

972 As *P. of C.*, p. 207 ff., fig. 126.

973 Daux 1965, pp. 1000-1001, figs. 1, 2; Deltion, XX, 1965, pl. 722 B, and Hirsch 1977, pl. 2 fig. 4.

974 This type of floor decoration has appeared in Neopalatial contexts now in north-central and eastern Crete, but not so far in the Mesara area. Also, although Minoan style affected floor planning at Akrotiri on the island of Thera, no examples of «strip» floor design are reported from there.

975 *Archanes*, pp. 503-504, figs. 64, 78-79, drawings 8, 9, and 5, also p. 143 where wicker-work is suggested; Sakellarakis and Sakellaraki 1999, p. 271.

976 Whitley (after Rethemiotakis) in *AR* 2001, p. 127 and 2003, p. 79.

977 M.C. Shaw and P. Betancourt, *forthcoming*.

978 Dawkins 1904-1905, p. 278, fig. 9: Hirsch 1977, pl. 3, fig. 7. The excavator does not suggest any prototype in wood or stone from which this pattern is probably derived.

979 Platon 1971, p. 119 (top), plan on p. 150 (top).

These plaster strips at Zakro are 5 cm to 7 cm wide, and 0.2 cm to 0.4 cm thick, and in all cases are extremely fragile, so fragile that one wonders how such designs could survive the everyday wear of people walking over them. This becomes especially pertinent when one notes that adjoining rectangles formed by such strips lined corridors at Zakros (e.g. around Space xxxvi in the East Wing), at Archanes (Area 5; *fig.* 123c), and in the North Wing at Galatas. Since there is no indication, at least at Zakros, that boards or slabs were used in combination with these strips, one tends to think that the spaces between strips there may have been filled with a perishable material that has disappeared entirely. Platon has suggested that a mixture of wax and resin may have been used[980], although I think that a less exotic solution may be that the designs were never meant to be stepped on, functioning instead as an outline that would guide the occupants in the placement of colored mats or rugs[981]. There is no physical evidence for either theory, however, and if the strips were intended only to guide the placement of rugs or mats, it does seem strange that a similar plaster band should always outline the edges of the rooms as well.

D) Ceilings and Upper Floors

Ample stairways leading upward, and artifacts found significantly above ground floor level, thus «fallen from above», begin to inform us about a Minoan upper story or stories. To learn more can be difficult in Crete, for unless a building is built into a hillside, little may be left of the upper walls. In some cases, however, fallen floor features such as paving slabs, plaster strip decoration, or fragments of *tarazza* (see above) indicate that an upper story had more than simply earthen floors. Pier-and-door partition bases such as those found fallen into the lower levels of the Residential Quarter at Knossos (*fig.* 181) may also be recovered. Also, in fortuitous circumstances ceiling beam sockets can still be preserved in upper walls (as in *figs.* 72, 117, 181, 182a, 191)[982]. Those chases can give us roughly the size, shape and spacing of the primary rafters. The size and sometimes the positioning, as well as the spacing, can also sometimes be determined from beam impressions in baked clays from buildings destroyed by conflagration (*fig.* 192c). Similar impressions can result when lime plaster has been packed around beams (*figs.* 192b, c; also see Chapter 2 on wood). Round chases (the equivalent of the beams themselves, ca. 20 cm in diameter) appear in an exquisite series of architectural drawings of Quartier Mu (*figs.* 261, 262) by Martin Schmid. On and between them were laid lengths of branches 6 to 7 cm in diameter, which then were covered over by earth that was later plastered. As can be seen in the section detail, parts of the floor could, with the addition of earth, be made to curve up to form a bench-like contour, in this case with the addition of mud brick[983].

While branches or poles could be used to keep covering earth from sifting down into a room, the Minoans commonly arranged a layering of reeds cut from local streambeds crosswise upon a room's rafters[984]. As exemplified in *fig.* 192a, this is attested by reed impressions

[980] Platon 1964a, p. 148. At one time it seemed that lead sheets might have been used (Platon 1963b, p. 172).

[981] Also argued on new grounds in M.C. Shaw and P. Betancourt, *forthcoming*.

[982] Actual cut sockets are preserved in the upper wall of the Temple Tomb at Knossos in *fig.* 191.

[983] The Quartier Mu ceiling is ca. 1.90 high in our *fig.* 261. For some comparative room heights at Akrotiri on Thera, with ground floor rooms ranging from 1.90 to 3.00 m high, and the upper floor rooms ranging from 1.95 to 2.70 m high, see Palyvou 2005, p. 128, table 1. Similar sections of Protopalatial upper floors at Phaistos can be seen in Tomasello 2001, fig. 2.

[984] The practice of using reeds for the lower part of ceilings (roofs) in houses of only one story, and for intermediate floors and roofs of houses with more than

in clay and plaster found on numerous Cretan sites, showing that the custom continued from the Neolithic through the Late Minoan period[985]. At Myrtos-Phournou Korifi, botanist Oliver Rackham examined clay imprints of the reeds, noting that the «leaf-sheaths and occasionally the leaf blades are visible, but not the stems or ligules», and suggested that the type of reeds used were probably *Phragmitis communis Trin.*, rather than another, stronger type, *Arundo donax L.*, that may have been introduced later[986]. At Akrotiri on Thera, Palyvou notes that even the strings binding the reeds to thin branches (poles or oleander stems?) set parallel to the rafters can actually be seen in the impressions[987].

E) Roofs and Parapets

Minoan buildings have always been thought of as being flat, a perception reinforced by faience plaques from Knossos and more recently by a terracotta building model found at Archanes (*fig.* 264)[988]. Unfortunately, much Minoan roof structure has simply disappeared. From this point of view the architecture of Akrotiri on Thera is particularly important for our consideration of Minoan construction, for it is contemporary with the second main phase of developed Minoan architecture (Neopalatial) and there is general agreement that, aside from innovations usually found only on Thera[989] and some details of Minoan Neopalatial design that have not yet been found on Thera[990], much of Theran design is derived directly from Minoan prototypes[991]. But even at Akrotiri, well preserved as it is, little still remains of roofs, but that little is precious for providing details of construction.

For instance, our view of roof composition is enhanced by actual fragments recovered fallen within the second story of the West House at Akrotiri. As seen in *fig.* 265, the roof there was first formed, as are most upper story floors, by a thick layer of earth and branches packed above ceiling beams already set in place[992]. Upon this, in turn, were spread layers of waterproofing clay, which were then smoothed and polished, perhaps with heavy

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one story, was perpetuated until recently in many village houses. The preferred roofing material is now reinforced concrete, which requires less renewal and care. The reeds can be gathered from neighboring streambeds, especially in marshy lowlands near the sea. In section the mature reeds average 0.5 cm to 1.0 cm, or more, and can be over 2 m high. The same reeds are used for windbreaks now in the areas of Chania (Kydonia) and Hierapetra. Modern practice was to harvest the reeds during the winter months, when, botanist Rackham informs me, they are harder and more difficult to cut, but more durable.

985 Knossos, Early Neolithic I (Strata IX, VIII, and VII): J. Evans 1964, p. 146 and pl. 59 (1), pp. 149 and 153 (from Cameron 1972, n. 2); Vasiliki, EM II (Seager 1904-1905, p. 209 f.); Gournia, LM I (*Gournia*, p. 49); Nirou Khani (Xanthoudides 1922, p. 10); Palaikastro (Dawkins 1903-1904, p. 205; Sackett, Popham, Warren and Engstrand 1965, pp. 255-256 n. 23).

986 Rackham 1972, p. 304. This is the only species identification I am familiar with. See also Cameron 1972, pp. 309-314, in the same Myrtos-Phournou Korifi volume for his descriptions of ceiling and roofing plasters which were spread over the reeds which had been laid upon thin tree-trunks 3-5 cm in diameter.

987 Palyvou 2005, p. 127. In her restoration of a ceiling structure of squared rafters over which canes were set (*fig.* 181) she shows that the canes showing on the undersides of the ceilings were plastered as well.

988 By contrast, at least some Mainland Mycenaean roofs were tiled and, therefore, gabled (Iakovides 1990).

989 Palyvou (2005, pp. 115-116) describes, for instance, the ashlar framing around wall openings and the ashlar and timber reinforcements for building corners that seem to be Theran «specialties».

990 E.g. the «plaster strip» floor designs discussed above.

991 Palyvou 2005, p. 180; 1999c, *passim*, and J.W. Shaw 1978b.

992 J.W. Shaw 1977, also Palyvou 2005, pp. 128-129. The ceiling beams had been covered earlier by seaweed, for which see the example from the Palaikastro excavations mentioned below.

stone floats such as that shown in *fig.* 245. New layers were probably applied every year or so – there are at least eight layers of white and brown waterproofing earth in this example. Thick chunks of plaster roof fragments were recovered from another Theran building[993].

A pertinent piece of comparative information can be provided by a discovery at a Late Minoan house at Palaikastro on Crete. To quote the description of the excavator, R.M. Dawkins, «The staircase by the entrance that was cleared last year ... showed that this house had an upper story. This year's work gave interesting evidence as to the structure of the roofs of these houses, showing that they were practically the same as the clay roofs of modern Cretan cottages. The fire which destroyed the house had baked this clay hard and a good deal of it was found. First a lump of burned clay appeared, furrowed on one side with the marks of reeds. This was pronounced by the men to be a piece of the first layer of clay (πηλοδόρομα or ρόδομα) that is applied immediately to the reeds that form the ceiling. Presently a lump was found that showed markings, as if strap-shaped leaves had been mixed with clay. These were recognized as traces of the seaweed (φύκια) that today is often mixed with the upper layers of clay (λεπίδα) to help to make the roof watertight»[994].

Also of note at Akrotiri are parapets around roofs or verandas, already suggested by Theran wall painting where people obviously standing on roofs are depicted only from the waist up[995]. Of actual parapets, one is partially preserved in the outer wall of Building D 16, where it is at least 0.85 m high and 0.70 m wide[996]. Another, a low parapet 0.50 m high and 0.80 m wide, can be seen in *fig.* 263, where the clay-covered roof in a building near the South House slopes down to where a terracotta spout was set in a gap in the parapet. The runoff rainwater could collect there and then arch out beyond the building onto the street below[997].

The spout just mentioned is splayed in order to collect and then carry the rainwater. While its form is unusual at Thera, other spouts performing the same function are known as well, both simple U-shaped terracotta and stone shapes, those of terracotta predominating[998], thus filling out our knowledge of roof drainage on that island. Some of these were set in gaps in parapets, others were set, with their channels free, below the parapets themselves and projecting out beyond the side walls of the buildings. All these are, perhaps not surprisingly, similar to channels known from Minoan Crete (*fig.* 164) where they performed various household and industrial functions[999].

With this new knowledge gained from Thera, excavators in Crete, in particular those at Kommos, Mochlos, and Palaikastro[1000], have begun to identify sections of U-shaped drainage channels found loose, usually only fragments found broken at ground floor levels, as roof drains. Those discovered around the periphery of the building are most likely to have been along the edges of the roof. More than likely, as suggested by a model from Archanes (*fig.*

[993] Palyvou 2005, fig. 186 (from Xeste 3).

[994] Dawkins 1903-1904, p. 205. The seaweed being referred to is probably eel-grass, long, narrow, and thin, which grows in thick masses just beyond the point of normal wave turbulence, and which often can pile up on shore after a winter storm. I should also point out that one may not be able to distinguish between the clay and reed structure of the floor of the second story and the lower part of the roof over that.

[995] J.W. Shaw 2004, pl. 13a.

[996] J.W. Shaw 2004, pl. 11b, and see that text for other Theran parapets.

[997] Palyvou 2005, pp. 39-40 and 129, figs. 41(a) and 185.

[998] J.W. Shaw 2004, *passim*; Palyvou 2005, pp. 39-40.

[999] For the stone channels, see Chapter 1, p. 86 f. For those of terracotta see Chapter 3 and J.W. Shaw 2004, *passim*.

[1000] For Kommos see J.W. Shaw 2004, p. 181 and n. 29 (House X). For Mochlos see Soles and Davaras 2004, p. 184 and n. 34 (at Chalinomouri), and for Palaikastro, MacGillivray, Driessen and Sackett 2000 and fig. 2.5 (House 5).

264) which has a parapet along the perimeter of its roof[1001], such drainage channels also projected out from below Cretan parapets, in the same manner as those on Akrotiri, and not unlike those in Greek villages today, even in houses constructed of reinforced concrete.

F) Calcestruzzo

At this point we should consider an unusual kind of cement, called *calcestruzzo* or *astraki*, terms applied by the Italian excavators to a very hard, amorphous material that they had to dig through when they were clearing the northwestern and southwestern sections of the First Palace.

This material, composed of stones, clay, lime, crushed potsherds, and sometimes entire vases[1002], partially filled many of the rooms of the Palace. It also provided a solid platform covering the early remains west of the Second Palace to the north[1003], and in the southern section of the First Palace it has been interpreted as a filling material used for leveling after each of three phases of rebuilding[1004]. La Rosa has calculated the amount of labor entailed[1005]. According to Fiandra this *calcestruzzo* was slightly hydraulic[1006] and its composition changed from one period of the First Palace to another, as is indicated clearly in the analyses made[1007]. Platon, however, prefers to assign the filling material to one period, attributing the difference in composition of the various layers to the process of its preparation, namely that it had to be made up in separate batches, each of which would have by chance a different composition[1008].

A question occasionally raised is also whether the *calcestruzzo* at Phaistos is in reality fallen wall material, evened off by later builders and consolidated either by moisture or by heat. Evely prefers to think of it as a «natural product of the weathering of debris following a destruction/collapse»[1009]. At the moment, however, we should certainly accept the opinions of Pernier, Banti, Levi, and Platon, who have firsthand experience with these hard layers and are convinced that they are not fortuitous. It is still worthwhile, however, to note that although perhaps no similar masses of «concrete» have been found elsewhere in Minoan Crete, hard masses found on the island have normally been interpreted as solidified material formed by the coalescence of fallen wall debris.

Seager, for instance, found many of the rooms at Vasiliki filled with extremely hard deposits that could be removed only with great difficulty. He described these deposits and how they came about as follows: «When the [ceiling] beams gave way, the ceiling sank into the rooms below, making a layer of debris about fifty centimeters and sometimes more in thickness. This debris, owing to the action of fire and water, has become an almost petrified

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[1001] For a thorough description and interpretation of the Archanes model, see A. Lebessi 1976, and for some later commentary concerning the model see J.W. Shaw 2004, n. 24.

[1002] Levi 1964, p. 3; Levi 1960, p. 113.

[1003] *Festòs* II, pp. 10, 422, fig. 3; *P. of C.*, p. 147.

[1004] Levi 1964, p. 4; Levi 1957-1958, p. 195 ff. See also *Festòs* 1976-1988, II (Part 1), pp. 24-25.

[1005] La Rosa 2002, p. 81 and n. 59.

[1006] Fiandra 1961-1962, p. 126. The term «hydraulic» means that the cement can set under water.

[1007] Fiandra 1961-1962, pp. 123, 125-126; Levi 1960, p. 113.

[1008] Platon 1968a, p. 34, n. 4.

[1009] *Crafts*, p. 208. Evely notes that that A. Kanta gave a lecture 1988 in which she identified such material at Monastiraki, which was deserted after a MM II/III destruction (Evely 1993, p. 208, n. 34). Since the site was abandoned at that time, it appears that the changes to the material occurred naturally.

mass on which the picks of the men made slight progress. Certain rooms had to be abandoned on this account, as little short of actual blasting would have been required to clear them»[1010].

At Gournia, Hawes had a similar experience, which prompted her to write: «Strangest of all was the effect [of fire on plaster, which reconverted it to] unslaked lime, and this, under the first rain, again formed plaster, encasing vases, or anything else on which it fell, in an airtight, almost petrified mass. ... In time, we looked to rooms where the destruction had been most complete, and where the pick struck such solid opposition [for finds]»[1011].

A hard, thick layer, some 3 m deep in some places, was discovered by Evans in the Residential Quarter of the Palace of Knossos, in the Hall of the Double Axes and the Queen's Megaron. He interpreted this, which was associated with a thick lime deposit, as the remainder of a comprehensive scheme of restoration of this part of the Palace[1012]. Later, when the Caravanserai was being excavated, a similarly hard layer, composed of clay and fallen mud brick, was removed with difficulty. Evans thought that this fill, certainly of material from the collapsed walls, floors, and ceilings had been consolidated by the deposit of gypsum-bearing groundwater, and that this provided an explanation for the deposits found earlier, mentioned above, in the Residential Quarter[1013]. Similarly hard masses of material were also found during the excavations at Malia, in Area I[1014].

At Kato Zakro I have not noticed any filling or wall material that resembles *calcestruzzo*. Nor would one expect to find any there, for a number of reasons. One reason is that the major buildings now visible at Kato Zakro are confined to a small valley and the surrounding hillsides, where large artificial terraces, such as those built at Phaistos, were not necessary. Most of the terraces built at Zakro were at least partly excavated from the side of the hill. Another reason is that *calcestruzzo*, at least in great quantities, is certainly confined to Phaistos, and there to the Palace itself.

Two new analyses, the first by Fornaceri and Fornaceri[1015], another by Ciliberto[1016], add perspective. Both agree (contra Fiandra, above) that the *calcestruzzo* from the three phases of the Old Palace at Phaistos is similar. Only Ciliberto takes a position, however, concerning the intentionality in the material's placement. There is no doubt in his mind that the astraki (*calcestruzzo*) «represents a material purposefully and specifically created for particular uses ... and was the first hydraulic cement in history»[1017]. There the matter can rest, at least for the moment. Perhaps similar phenomena seen at different Minoan sites simply came about in different ways, the first quite intentional (at Phaistos), and the other, associated with collapse, brought about through natural chemical processes.

[1010] Seager 1904-1905, p. 210. In a later report, he thought that the hardening may have been due to «some peculiar quality of the soil of the Kephala» (Seager 1906-1907, p. 125). See also Zois 1976, p. 41 f.

[1011] *Gournia*, p. 21. The brackets are mine.

[1012] *Knossos* III, pp. 319-321, also p. 356; see also *Festòs*, II, p. 422.

[1013] *Knossos* III, p. 287. For those who would connect the solidified lime deposit in the Residential Quarter at Knosso's with burned plaster revetment, Cameron notes that plaster does not change in composition under normal circumstances (Cameron 1977, p. 157 and n. 60).

[1014] *Mallia* I, p. 7. Driessen (personal communication) informs me that in the LM IIIA2 Postpalatial Quartier Nu at Malia, *calcestruzzo* was intentionally used to cover earlier remains and to provide hard surfaces in open areas.

[1015] Fornaceri and Fornaceri 1976-1978.

[1016] Ciliberto 2001.

[1017] Ciliberto 2001, p. 474. For the intentional use of the cement, see Fiandra 1997 pp. 69-73 (with analyses).

CHAPTER FIVE

CONSPECTUS AND BEYOND

A) Development and Change

From the beginning in Crete, while some people lived in caves, others constructed permanent shelters to protect themselves from excessive moisture (rain), heat (during the summer) and cold (during the winter). Their walls, in their simplest form, were usually composed of earth and field stones. But at Knossos, even during the Neolithic aceramic period in the 6th Millennium B.C., walls were being built of unfired mud brick[1018], an ambitious experiment that was, however, to degenerate into a less time-consuming custom of first building a simple stone foundation, then layering mud and stone that, once the mud had dried, could be preserved as long as roofs minimized rain water run-off[1019].

During the Early Minoan period (see Table 1), agricultural techniques developed, also surplus products accumulated. Storing products, and providing for more living space combined to create settlements with separate dwellings grouped together, as at Myrtos-Phournou Korifi[1020]. The development of bronze tools, beginning with the double-axe, adze, pick, and chisel (Table 2, *figs.* 37a-47) to some extent replaced the use of stone tools for agriculture, but simplified the felling and butchering of trees to be used in building, especially for roof construction and, with time, upper floors. At EM II Myrtos-Phournou Korifi a thick plaster, mixed with lime, was used to coat walls and in general protect its moderate-sized structures from the weather. A similar technique was used at Vasiliki (*fig.* 243) to the north, also bordering the Isthmus of Hierapetra. Its walls were thickly plastered with a durable lime-enriched coating painted red. Also a new technique was being developed, with the builders placing lengths of rough-cut tree branches horizontally within the walls (*fig.* 66) to give them strength and flexibility. These techniques may have been practiced there in Eastern Crete before they were in the central part of the island, for a well-built EM II building excavated below the West Court of the later Knossos Palace was not plastered, nor were non-spanning timbers included within its wall construction[1021]. Rather, its builders used stones set in well-laid courses on both sides of walls, a technique that was to continue in Crete through historic periods until, relatively recently, reinforced concrete was resorted to as a less expensive, but usually less durable, alternative.

At the same time people began to build more houses near each other, to form settlements. Those would, with time, often become towns. Thus a class of landowners, still

[1018] J. Evans 1971, pp. 101-103, 115, Stratum IX and VIII.

[1019] J. Evans refers to this as the pisé method which, however, normally requires a form along the sides of a wall, the form being removed after the wall mixture has dried. See also Chapter 3, p. 127 f. here.

[1020] *Myrtos, passim.* Also, for the interpretation of separate family rather than communal living areas, see Whitelaw 1983.

[1021] Wilson 1985.

3500-1900 B.C.	Late Neolithic-Early Minoan I – III periods through Middle Minoan IA
1900-1700 B.C.	Middle Minoan IB – II (A, B) periods or «Protopalatial» period
1700-1425 B.C.	Middle Minoan III (A, B) – Late Minoan I periods or «Neopalatial» period
1425-1200 B.C.	Late Minoan II – III (A, B, C) periods or «Postpalatial» periods

TABLE 1: SIMPLIFIED CHRONOLOGICAL CHART. IN THE TEXT, MINOAN PALACES (MM IB - MM II) AND THEIR RENEVALS (MM III - LM I) ARE REFERRED TO AS PROTOPALATIAL (OR FIRST PALACES) AND NEOPALATIAL (OR SECOND PALACES), RESPECTIVELY. FOR DETAILED INFORMATION ABOUT RELATIVE AND ABSOLUTE DATING, SEE WARREN AND HANKEY 1989.

Tool Type	Prepalatial EM through MM IA	Protopalatial MM IB = MM II	Neopalatial MM III = MM II	Postpalatial LM II = MM II
Double Axes	======	==========	==========	==========
Adze and Pick	========	==========	==========	==========
Hammer and Mallet	==========	==========	==========	==========
Saw		== =======	==========	= ==== ==
Drill Solid Tubular		========== ==========	========== ==========	=== ===
Chisel	======	==========	==========	======
Punch and Point	======	==========	==========	= ==== ==
Abrasives		==========	==========	===

TABLE 2: CHRONOLOGY OF THE MOST COMMON BUILDER'S TOOLS (PARTLY AFTER EVELY 1993, 217, FIG. 88).

undefined but probably with an accumulating agricultural surplus which required storage, began to have influence. They, along with others, probably formed a governing elite no doubt connected by social and religious practices, orchestrated the beginning of large-scale structures that would be termed «palaces» by us, a misnomer that is still without accurate substitute («court-centered building», «central building», «court building») in the light of our lack of defining written records.

The best early glimpses that we have of such large buildings[1022] is presently at the Malia site, where excavators found massive EM II walls, made of solid clay and rubble, along with mud brick, built in stages (*figs.* 68-69), encased within a later Neopalatial storeroom area of the Malia Palace[1023]. Also, just north of the Central Court (a characteristic feature of all Palaces) and below the level of the Neopalatial remains is an impressive series of early rooms with rubble walls still partly preserved, along with stratified layers of the adjoining early Central Court made of chalky white earth, which was first laid down as early as EM II[1024].

[1022] For further discussion of the early phases of Minoan palatial building, see Schoep 2004, 2007.

[1023] See Pelon 1980, p. 41.

[1024] Pelon 1989, p. 773. See also Driessen 2007a, p. 85.

Material or Technique	Prepalatial EM through MM IA	Protopalatial MM IB = MM II	Neopalatial MM III = MM II	Postpalatial LM II = MM II
«Rubble Masonry»	===========	==========	==========	==========
Orthostate-style Ashlar		==========	==========	
Coursed Ashlar on Interior*		======	==========	
Coursed Ashlar on Exterior		======	==========	
Pier and Door Partition Form		======	==========	= =
Pier and Door Stone Bases			==========	= =
Wooden Frameworks	===========	===========	==========	=========
Wooden Reinforcing in Walls	=========	==========	==========	== = ====
Round Wooden Dowels Joining Beams to Masonry*		===		
Square Wooden Dowels Joining Beams to Masonry		==========	==========	== =====
Wooden Clamps Joining Ashlars*			====	
Stone Column Bases		=====	==========	== = =====
Stone Pillars		=====	==========	====
Mud brick	===========	==========	==========	== = =====
Lime Plaster	======	==========	==========	== = =====
Terracotta Drains		=====	==========	==
Cut Stone Drains		=====	==========	==========

TABLE 3: APPROXIMATE CHRONOLOGICAL RANGE OF MATERIAL AND TECHNIQUES IN MINOAN ARCHITECTURE (* = RARE).

Subsequently at Malia, a group of large buildings without central courts, which combined storage and artifact manufacture and perhaps residence on upper floors, were built and, later, burned during MM II. There, at what is dubbed «Quartier Mu», one can learn much about Middle Minoan architecture from the point of view of materials and techniques (see also Table 3)[1025]. For instance, the heavy plastering of interiors and exteriors seen in EM II Vasiliki, continues while, on the other hand, the use of vertical wooden supports within and at the ends of walls, hardly visible at Vasiliki, is the norm. Clear traces of such supports, but those grouped in line and at intervals to form the sides of multiple doorways, appear for the first time in Building A here. This arrangement of space separators, the «pier-and-door partition» or *polythyron* form, first had wooden bases (*fig.* 184). Later, especially shaped stone bases became common, and characterize many elite residences in both houses and palaces during the Neopalatial period (*fig.* 186). Also in this building are tooled column bases (*fig.* 139), among the earliest known from Crete, so finely made that one feels confident to infer progenitors. The remarkable state of the upper walls of the Mu buildings (*figs.* 261-262) often preserves the shape and position of many of the stair and upper flooring timber, whereas in most Minoan excavations we are fortunate even to recover a few fractured plaster forms that preserve the shape of ceiling timbers (*figs.* 192 b).

We also find along the west edge of House A an exterior façade of ashlar (squared) blocks, for the present among the earliest substantial sandstone blocks known to have been

[1025] *Malia, Mu Artisans;* Poursat and Schmid 1996.

quarried for a specific purpose at the Malia site[1026]. They, like the other walls in Mu, were covered over by plaster. These were probably surmounted by mud brick construction[1027]. The blocks formed a single, low first course, making them structurally analogous in use to the tall blocks of ironstone (sideropetra) that were used in MM IB/MM II[1028] at the largest Minoan burial building of Chrysolakkos, north of the Malia Palace near the sea. Those were trimmed by bronze saw and set in line, with round dowel holes drilled into their upper surfaces[1029]. Wooden tenons were placed in the holes, their projecting ends fixed into horizontal timbers running along the top of the wall. The timbers functioned to stabilize the wall of clay rubble, perhaps plastered, built above the course of ironstone blocks. The blocks can be called «orthostates» («set upright»), a term used by scholars after the Classical Greek tradition of using such blocks as a base for important walls in temples and other public buildings.

Dating to as early as Middle Minoan IB, the Chrysolakkos façade at Malia (*fig.* 96) may be roughly contemporary with the Early Palace façade at Phaistos, south of Knossos in the Mesara Plain. But the latter is surely better preserved and more impressive (*fig.* 88). There a long façade wall borders the First, or Protopalatial, Palace building along the west. The same wall was built on two levels, first the southern section, then the northern one. The former (*fig.* 85), excavated by Doro Levi[1030], flanks a formal entranceway leading into rooms where goods were stored in pithoi. The walls of these rooms, supporting at least one more story above, are among the most massive walls in Minoan Crete, some two meters thick, exemplifying a period before wooden superstructure began to allow builders to enlarge their rooms and thus reduce the size of walls. All of the walls here, aside from the façade blocks, were coated with thick layers of lime plaster painted a brownish red, reminiscent of the tradition of creating thick, structurally supporting coatings like those at earlier EM II Vasiliki. Some of the walls were decorated with thin sheets of gypsum, perhaps the first use of that stone in Minoan Crete; the technique of inserting branches horizontally into the fabric of the walls, also known from Vasiliki, continued in use.

The façade wall itself is composed of a line of carefully fitted poros limestone blocks set upon a low socle or krepidoma of cut limestone slabs, a reminder of the rubble socles that had been developed earlier to strengthen and protect the vulnerable lower part of exterior wall faces (*fig.* 65). The orthostate blocks themselves, set with their tops even, have a series of mortise holes along their entire length, a situation similar to that already pointed out at Chrysolakkos. At Phaistos, however, the mortise cuttings are square (the earliest examples in Crete) unlike at Chrysolakkos, the hard limestone of which required mortises to be drilled out with a hollow circular drill bit rather than be cut by a chisel, as in the softer poros. Probably for the sake of economy, after Chrysolakkos was built, softer stone was preferred for ashlar wall construction, but the tradition of attaching horizontal beams to the top of a single course of blocks was to continue.

A similar technique was followed in the northern, higher and later stretch of the First Palace at Phaistos (*fig.* 88), excavated by Luigi Pernier and others[1031] during the early part of the 20th century. Of particular interest is that where the orthostate wall there meets the rising bedrock of the hillside (*fig.* 89), a second block or course was added in order to prevent runoff

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[1026] Smaller, rougher blocks, but quarried nonetheless, were used in courses for EM II wall interiors in the Crypte Hypostyle not far away (*fig.* 117). Architect Schmid has noted (personal correspondence) that the walls were covered with plaster.

[1027] Martin Schmid (personal correspondence) has also noted that the blocks, although quite damaged by plow marks, had no traces of dowel mortises for attaching horizontal timbers.

[1028] Soles 1992, p. 168.

[1029] J.W. Shaw 1973b.

[1030] *Festòs 1976-1988, passim.*

[1031] *Festòs* I, *passim.*

water from eroding the wall's upper, rubble structure. This is the among the earliest clear examples of carefully squared, coursed ashlar in Crete, introducing us to the many examples of coursed ashlar walls that are to be built later, almost always on exteriors or as wall facings around interior courts. This early West Wing of the first Phaistos Palace, projecting beyond the later, New Palace that was superposed partly on its eastern extension, remains the best preserved, unambiguous MM I-II palatial architecture in Crete. No doubt further investigation within it and elsewhere will enable us to chart subtleties in the development of construction methods, as well as of the building and room types discussed by others[1032]. It would be useful to know more, for instance, about any gradual changes between the early, thick walls of the southwestern section of the First Phaistos Palace, already mentioned, and the later style with thinner walls featuring vertical wooden supports at their ends and along their sides, a tendency already manifested in MM II in the walls of Quartier Mu at Malia.

One factor affecting such a study is that Enzo La Rosa, reexamining the Phaistos palace, has proposed that while the First Palace was, indeed, destroyed at the end of the MM II period, much of the later one was not built over it until LM IB, well into the Neopalatial period[1033]. He believes, however, that there was still some building not long after the MM II destruction, during MM IIIA. Of particular interest is this regard is a so-called «Lustral Basin» (a room with a stepped descent leading down into a space used for ritual activity) found by Pernier below the remains of the New Palace[1034]. Of note from our point of view is that the neat squared room shape and general appointments are like those encountered in much later lustral basins, which implies that the development of this room type had already occurred by MM IIIA even though the major MM II palace destruction had taken place not long before[1035]. Masonry techniques can also serve as a criterion. The ashlar pillars at the beginning and end of the short stairway leading down in the lustral basin, for instance, have dowel holes for attachment of a wooden pier and a possible pillar, the latter quite similar to one, for instance, from Kato Zakros (*fig.* 210 b) which is thought to have been built considerably later, at the end of LM IA[1036].

Was there, therefore, a still unheralded development of room and structural style at Phaistos during late MM II, not long before part of the new palace was built? To what extent did what has come to be called the «Neopalatial Style» actually originate during MM II?[1037]

[1032] *P of C*; McEnroe, *forthcoming*.

[1033] La Rosa 2002, p. 94; 2007.

[1034] La Rosa 2002, p. 74; Fiandra 1995, pp. 329-339; *Festòs* I, pp. 327-331 and plan in fig. 191 on p. 328. Pernier thought that the lustral basin belonged to the Middle Minoan Palace.

[1035] Yet the earliest so-called «Lustral Basin» in Crete, in Room I4 in House A at Malia's MM II Quartier Mu, is deeper than later lustral basins, is very thickly coated with lime plaster, and lacks an ashlar-based parapet. What were the stages that the form went through in order to reach the «canonic» shape described from Phaistos? Or is the Mu example, perhaps, not generally representative of early «lustral basin» development?

[1036] L. Platon 2002, p. 145 (LM IA, late), a change from the MM IIIB/LM IA date proposed by the previous excavator (N. Platon 1971, p. 238 and chronological chart on p. 325).

[1037] In her detailed survey of the predecessors of the New (or Second) Minoan Palaces, Schoep (2004) correctly demonstrates that those predecessors were simpler and less pretentious in design and materials used than their successors. She also points out that while rooms separated by pier-and-door partitions (The «Minoan Hall») as well as the Lustral Basin, leitmotifs of Neopalatial design, have not been found in the predecessors of the Palaces, that both appear in MM II House A in Quartier Mu at the Malia site. This suggests that possibly the forms (along with their social and religious functions) were incorporated into the later palaces from outside their borders. Such architectural innovations, she thinks, could reflect a competition between rival elites, with the Neopalatial incorporation mentioned signifying the consolidation of palatial control by a specific elite, which replaced an earlier, more communal use of the building.

Or, if we search for another explanation for finding surprisingly well-developed architectural features at one site (Phaistos), is it possible that the style had first developed elsewhere and was «imported»? The obvious candidate here is Knossos to the north. After MM II, Knossos came to exert growing political and cultural influence over the Mesara[1038]. Therefore, architectural influence cannot be excluded here. A clear parallel to this suggestion can also be pointed out, namely the case of LM I Myrtos-Pyrgos (see *fig.* 211b and cover illustration) in Eastern Crete, where very developed architectural forms, which directly reflect Knossian style, were built on a site without a previous history of elite architecture[1039]. Of interest in this regard is that plaster strips, usually painted red, used to subdivide corridor and floor spaces at Galatas and Archanes in Northern Crete, at Pseira, and at Palaikastro and Kato Zakros in Eastern Crete, have not yet been reported from the Mesara[1040] nor, for that matter, from Knossos itself.

While details of the origin(s) and development of a Minoan «Neopalatial» style still remain to be clarified, what is abundantly clear is that many major architectural initiatives were carried out during that period. Driessen reasonably suggests that the proliferation of the style started from Central Crete; he also suggests that the leader in the process was Knossos, sometime in MM IIIB[1041]. These projects involved renovation but also replacement of destroyed buildings, at First Palace sites (Knossos, Malia, Phaistos, Petras, Kommos), as well as new palatial buildings (Zakros, Gournia, Kommos, Makrygialos). Also, in a break with past custom, and probably indicating a growing economy, impressive new buildings with palatial features, for instance new «villas» or «country houses» (e.g. Myrtos-Pyrgos, Pitsidia, Nirou Khani), and new town mansions (e.g. Knossos, Tylissos, Malia) were constructed from scratch.

The new, or one might say more cautiously, «further developed» style, included increased use of ashlar masonry, more porticos and stoas, lustral basins (until they went out of fashion), pier-and-door partitions, as well as frescoes and plaster relief[1042]. All these were set within buildings affected by design including an overall lightening of structure made possible chiefly by intensive, massive use of vertical wooden supports set within walls and at wall openings and wall-ends (*figs.* 179, 182b). Those transferred the weight of upper walls directly down to ground level. Part of the same support system were piers and pillars which sometimes made use of ashlar construction (*fig.* 206), but were also often constructed chiefly of wood, with some clay and rubble lending cohesion and stability (*figs.* 175-177). This new custom reduced the wall thickness seen in early structures in the southwestern section of the First Phaistos Palace (*fig.* 85) from some two meters to half (or less) of that, in later construction. A result was a major increase in the actual space available for use as compared with the structural mass. For instance, architect Fiandra has calculated the dramatic difference in space use in a section of the First Phaistos Palace as compared with another, but otherwise similar, section of the Second Palace:

[1038] Wiener 2007; Warren 2002, p. 204; La Rosa 1995, pp. 889-890; Driessen 1989-1990, p. 22.

[1039] Cadogan 1978.

[1040] For these plaster strips, see p. 151 here and *fig.* 123 c.

[1041] Driessen 1989-1990, p. 22. For Neopalatial architectural features in north-central Crete, see Adams 2006, fig. 5.

[1042] Driessen's 1989-1990 article, «The Proliferation of Minoan Palatial Architectural Style: (I) Crete», which deals with aspects of these subjects, and locates regional developments on maps of the island, remains an indispensable introduction to the nature, spread, and dates of the changes discussed in the text here. See also Driessen and Macdonald 1997, p. 41.

«For the Palace I block, the total surface was 226.80 m^2 of which 59.50 m^2 was used for rooms and 167.30 m^2 for external and internal walls. In other words, the rooms covered a useful area equal to 26.24% of the total, while the walls covered 73.7%».

«In Palace II, the surface examined measured 209.10 m^2 of which 115.97 m^2[was used for] rooms and 93.14 m^2 for the walls, making 55.46% for the rooms and 44.54% for the walls»[1043].

Another characteristic of the New Style was an increased use of squared ashlar blocks for certain interior uses (pillars, piers, occasional corridors and, more rarely, «special» rooms), and as facings, usually on only one side of a wall, in areas exposed to weathering, whether important exposed façades (*fig.* 98) the sides of light-wells (*fig.* 97) or, selectively, the surrounds of large interior courts not lined by colonnades. The use of gypsum, once relegated to thin sheets mounted on palace walls, increased with ashlar blocks and dados, as well as floor slabs, becoming common (*fig.* 180). Often the quality of masonry, such as that at Hagia Triadha (*fig.* 113), is superb and immediately recognizable as a Neopalatial product. Here is work made possible by stone masons with experience, probably with apprenticeships in their pasts, and with clear instructions from a supervisor or *architechnitis* carrying out agreements made with the building initiators. Some of the masons engraved «mason's marks» (e.g. *fig.* 128a) of differing types, about which opinion ranges from religious symbolism to marks left by groups of workmen representing a particular guild or community group[1044]. While there are clear examples of massive ashlar walls that rose eight or more courses high[1045], some orthostate walls, such as the West Façade at Knossos (*fig.* 92), were often probably surmounted by the conventional clay and rubble used earlier during the Protopalatial period. Some walls, such as the northern wall of the Central Court at Phaistos, rise up two very tall courses, with dowel holes in the top course (*fig.* 221) guaranteeing a transition to wood construction above that point, and as a result any continuation in coursed ashlar is brought into question[1046]. The same tradition of orthostates, which appears to be restricted to Central Crete, developed at Kommos into an unusually high wall of two courses (*fig.* 95), with occasional tall single blocks, which embellishes a long, broad avenue leading in from the Libyan Sea.

The tradition of columnar constructions already known from the First Palace period (e.g. at Malia[1047] and Phaistos[1048]) continued into Neopalatial construction (e.g. at the Kommos stoas in Building T (*fig.* 203), or along the north side of the Malia Palace Central Court (*fig.* 135), the stoa in the Petras Central Court[1049]) as well as in mansions such as that at Vathypetro (*fig.* 131) or Myrtos-Pyrgos (*fig.* 211b and cover illustration). Columns also became common in house architecture[1050], usually in connection with a side of a light-well but occasionally next to courts, along the center of an interior span[1051], and sometimes

[1043] Fiandra 1995, p. 338.

[1044] See p. 76 f.

[1045] E.g. the west wall of the light well in the Hall of the Double Axes at Knossos (*Knossos* III, Pocket Plan G).

[1046] Banti and Pernier realized the use of the dowel holes here (*Festòs* II, p. 56). Graham did too, and reasonably suggested plastered rubble above the level of the horizontal wooden beam set here (*P of C.*, fig. 50).

[1047] In Quartier Mu (our *fig.* 184). Also, excavation along the western side of the Central Court in the Palace (Pelon 1999, pp. 468-481), also described in a talk presented by architect Martin Schmid at the Institute for Aegean Prehistory in Eastern Crete.

[1048] Along the western side of the Phaistos Central Court (our *fig.* 154, and Di Vita and Rizzo (eds.) 1984, fig. 91).

[1049] Tsipopoulou 1999, 2007.

[1050] McEnroe 1982; see also Appendix B.

[1051] In the Palace of Kato Zakros, Room xxviii in the West Wing.

at the center of a main room used for a variety of living activities[1052]. Another addition, it appears, was the «Minoan» stylobate, a series of carefully laid slabs which were cut so as to fit above and/or around stone column bases set in line, usually on one side of a court (*fig.* 129). Sometimes the stylobate was stepped[1053]. Columns were also introduced to enhance stairways leading down into lustral basins (*fig.* 210 b) or leading up from the ground floor of light-wells.

The increased use of horizontal and vertical timbers in combination with ashlar construction can be traced by certain indicators, in particular by square dowel holes, sometimes set into shallow ledges where the horizontal beams were set. Such dowel holes can indicate the tops of blocks. This technique, seen for the first time in Crete in connection with First Palace orthostates (*fig.* 87), now became generalized, used almost invariably for anchoring wooden window frames to ashlar sills (*fig.* 219). It was also used in connection with various types of stone piers and pillars (*fig.* 200), and with few exceptions attached wood to stone construction, rather than stone to stone as in later Classical Greek masonry. As U-shaped stairways became more popular, for instance, the usual wooden uprights at each end of the shared «spine» wall between the flights were further stabilized (*fig.* 204a)[1054]. This was done by anchoring the uprights to single ashlar blocks by means of two mortises set in a simple pattern so characteristic that its original use can sometimes be identified even if the stairway has disappeared and only one block remains. Wooden dovetailed clamps (*fig.* 194) were also used, but only occasionally, and then horizontally, sometimes to bind opposite wall faces together, as in the orthostate façade bordering the West Court at the Palace of Knossos (*fig.* 93).

The practice of creating flexible use of space in interiors by means of *polythyra* (pier-and-door partitions) continued. It began as we have seen at least as early as MM II Quartier Mu at Malia. Its spread continued, along with the increased use of wood. At least as early as the MM IIIA period, not long after the MM II destructions of the First Palaces, we find it appearing in developed form at both Phaistos and Knossos[1055]. New partitions were provided there with cut stone bases of the Gamma, T, and I types illustrated in *fig.* 186, and soon became characteristic of New Palace construction and, *polythyra*, like coursed ashlar, were incorporated into new construction of many of the mansions and villas. Even abroad, on the island of Thera, the *polythyron* became a common architectural motive in the houses at Akrotiri. At the same site we also see the common use of a multiple window arrangement (*polyparathyra*) on exterior walls[1056] known on Crete only from the examples in the Queen's Megaron at Knossos (*fig.* 182b, left, lower center), no doubt on Crete the result of the poor preservation of upper floors[1057]. The wooden jambs set on the new bases, we know, had a sim-

[1052] Michailidou 1987.

[1053] Kato Zakros, along the northeastern side of the Central Court.

[1054] *Kommos* V, p. 24 and pls. 1.34-1.35; also J.W. Shaw 1999, dated to early MM III.

[1055] Fiandra 1995, in connection with the lustral basin in XLIV-389 and 70. Note that in her drawing of the area (Fig, 5) she includes the pier-and-door partition as part of the MM III construction, a change from the way it is shown in *Festòs* II, fig. 195 on p. 328. For the date see also La Rosa 2002, p. 74. At Knossos, Colin Macdonald finds a similar situation, with the already developed pier-and-door partition appearing there during «MM IIIA at least» (doorjambs on the east side of the Northwest Lustral Basin [personal correspondence]). Macdonald also suspects that the solid gypsum doorjambs of the West Magazines there may go back to MM II.

[1056] Palyvou 2005, *passim*, and 1999b, pp. 343-350, fig. 345.

[1057] To judge from Akrotiri, where the multiple windows usually occur only on upper floors, the arrangement provided for views, light, and air at the same time that the height above street and ground level created privacy. In the case of the Queen's Megaron at Knossos privacy was assured by a private court to the east and south. The *polyparathyra* arrangement there was probably carilar form, which allowed one to swing the door-leaves back into the reveal or set-back provided in the frame of the jamb. The door pivots were set into one of the interior corners of the stone base. The arrangement provided for large spaces that were self-supporting at the same time that the spaces could be subdivided into more private areas depending on the social situation or, simply, the weather since the *polythyron* was often directly associated with a light-well.

At some Minoan sites, either during house building or renovation, a few obviously deliberate selected features of Neopalatial style, like suggestive *leitmotifs*, were sometimes added without «the rest». For instance, in some of the otherwise very adequate houses of the LM I Kommos town, especially cut gamma-shaped bases supported ordinary single door frames[1058], perhaps as a gesture to the new style known by the builders to exist in Palatial Building T, located just south of the Kommos town, but especially at nearby elegantly appointed Hagia Triadha. There possibly was also a practical advantage to using the bases, for their short projections provided an interior angle that served as a secure socket within which the door pivot could rotate.

As an indication that time and circumstance also played roles in bringing about the inclusion of the innovative partition bases, it is worth reflecting that the earliest appearance of the pier-and-door partition base (along with the «Minoan Hall» form)[1059] is in Malia's Quartier Mu of MM II, or Protopalatial date, where it was wooden (*fig.* 184)[1060]. Much later at the same site, the pier-and-door bases in the LM IA[1061] Residential Quarter in its North Wing of the Palace, surprisingly, were also of wood[1062]. Perhaps ironically, and at some point(s) no doubt coexisting with the same Residential Quarter arrangements, a number of houses in the Malia town sported fine stone bases for interior doorways[1063]. Does this necessarily imply that the builders of the houses, aware of stylistic innovations elsewhere, procured fancy, permanent stone bases that even the palatial overseers could (or would) not afford, or that the conventional wooden bases in the Residential Quarter were set in before the style of stone jamb-bases had «caught on», introduced from elsewhere to Malia? Or both?

In the Protopalatial period builders at Knossos, Phaistos and Malia used mainly clay, fieldstones, branches and quantities of lime plaster to consolidate their walls, and quarried limestone blocks to provide for underpinnings and façade walls. Gypsum was used from an early period at Phaistos in the form of thin slabs for wall decoration, while at Knossos door-jambs were already being quarried from the rich nearby sources[1064]. At both sites gypsum was used extensively throughout the Neopalatial period, in combination with plastered and often frescoed walls, to adorn the interiors of buildings with high dados (*fig.* 180) and, especially at Phaistos and Hagia Triadha, to provide for steps, balustrades and interior pavements

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ried up into the upper stories here and no doubt in many other Minoan Neopalatial structures taking advantage of the new support system and plentiful supply of wood.

[1058] For partition bases at Kommos see *Kommos* V, p. 24; I(2) pp. 356, 364; also J.W. Shaw and M.C. Shaw 1993, fig. 4 (the bases can be seen on the plan between Rooms 4 and 5, and 5 and 7 in House X). At Kommos the T-shaped base type, always part of a multiple doorway or *polythyron*, was found in situ only in Building T, Room 5.

[1059] Driessen 1982.

[1060] Poursat and Schmid 1992, p. 37 and fig. 30 (our *fig.* 184), also Schmid 1983, figs. 18-19, where the bases are shown as rectangular, still without the door-enclosing projections that were to develop later (as in our *fig.* 186).

[1061] Excavator Olivier Pelon believes that the hall dates no earlier than LM IA (personal correspondence).

[1062] Schmid 1983.

[1063] For a discussion of these bases, see J.W. Shaw 1999, p. 766, note 38.

[1064] I owe this information to Colin Macdonald.

with slabs arranged in patterns (*fig.* 12). Gypsum, despite its somewhat erroneous perception as a «soft» stone, was often used interchangeably with limestone blocks for walls as well as pier and pillar supports. Throughout the Minoan period, especially in Northern and Eastern Crete, mud brick played a major role in construction, for instance on the ground floor at Malia, but also for relatively light walls of upper stories.

Elaborate pavements are known from the Protopalatial Period, for instance in the West Court of Phaistos. During the Second Palatial period special stones were actively sought after to provide variety, along with the tan limestone and bluish-black ironstone used in the past. Varieties of bluish green and red schist, and white limestone, which often can serve as identifiers of relative date, were used in combination with one another, for instance in light-wells, and at the North Entrance to the Malia Palace (*figs.* 4-6), or in the court in front of the Myrtos-Pyrgos country establishment, providing both residents and visitors with pleasing variety and contrast as they went about their activities.

The great Neopalatial building surge was during LM I[1065]. Yet there were times when the material ebullience seems to wane, as suggested by the abandonment of the palatial buildings at Galatas and Kommos and reduced construction at Phaistos in LM IA[1066]. But many structures continued in use through LM IB when, like the Palace at Kato Zakros in Eastern Crete, the Palace at Phaistos, and the Villa at Hagia Triadha, they were destroyed by fire. The most flourishing period of Minoan architectural prowess had passed. After that point there were few new architectural projects of any scale. At Knossos in LM IIIA1, for instance, only a few exterior «dancing floors» can be pointed out[1067]. In the Mesara, however, a new local initiative prompted impressive building at Kommos and Hagia Triadha, where some of the old, but also some new, techniques are reflected. Those are described elsewhere here[1068].

B) The Builders

Without adequate contemporary records, our understanding of the organization of the builders and their relationships to those in charge of the building, whether patrons, administrators or experienced supervisors, is limited to reasoned speculation. As Driessen has put it, «the study of Minoan societal organization is *still in its infancy*»[1069]. Still, from the Mycenaean Linear B records, which represent a period on Crete when building of the type discussed in this book was at a low ebb[1070], we can glean the titles of at least a few of those involved in construction. For instance, in a list of mixed tradesmen from Knossos, there are men of Aptera, 45 (or more) fief-holders and five builders or carpenters (te-ko-to-ne or [Greek] tektones)[1071]. From Pylos on the Greek Mainland we also hear of a mason (or wall-

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1065 For details, see Driessen and Macdonald 1997, pp. 41-45.

1066 Pelon 2002; La Rosa 2002, 2007.

1067 Warren 1982-1983, pp. 72-76. The Knossos Palace itself was being used, even renovated, but the basic architectural layout remained largely that of an earlier period (cf. McEnroe, *forthcoming*).

1068 See Chapter 1, pp. 74-75.

1069 Driessen, *forthcoming*. In *Crafts*, pp. 554-562, Evely has assembled available information, as well as possible comparative material from countries of the Near East (Egypt, Mesopotamia, the Levant, Anatolia, Assyria).

1070 The LM III revival at Hagia Triadha and Kommos in the Western Mesara (Chapter 1, p. 74) remains an exception. The relative date(s) of the Linear B tablets from that period continues to be debated.

1071 Ventris and Chadwick 1973, pp. 123, 179-180. KN Am(2) 826.2. I am indebted to Dimitri Nakassis for helping me with this brief summary, especially with the use of his unpublished «Architecture in the Pylos Tablets».

maker, a to-ko-do-mo or toikhodomos)[1072], as well as a wood-cutters (du-ru-to-mo or drutómos)[1073] furnishing saplings, and «sawyers» (pi-ri-e-te-re or *prietêres)[1074]. There is also an «all-builder», (pa-te-ko-to or *pantektôn)[1075] who may have been a foreman since he received some 3.2 liters of grain per day, more than twice the amount that «wall builders» and «sawyers» received (1.2 liters)[1076]. While it would be encouraging to know that the «mason's marks» common on building blocks on Palatial sites represent individual groups of masons leaving their marks as evidence of their contribution to the building project, or to aid delivery of blocks to the correct part of construction projects, such cannot yet be shown to have been the case (see Chapter 1).

There appear to have been two different artisan types among the Minoans, the «attached» artisans who worked for special patrons, and the «independent» artisans, often part-time, for whom farming was also a major activity[1077]. Builders, whose work was usually seasonal, were often among the latter, and unlike other craftsmen, such as seal-makers and stone-vase makers who required permanent working areas[1078], they worked largely in the open where they assembled their materials, mainly timber and stone, usually brought in bulk from elsewhere. Still, stoneworkers might prepare in advance lightweight friezes (*fig.* 19), or jamb-bases (*fig.* 186); and carpenters could stockpile smaller wooden pieces requiring joining (door and window framing, tenons, or clamps). The metal tools necessary were the one ingredient for their work that could only be furnished by specialists, such as the smithy who had his workshop in MM II Quartier Mu at Malia, where he cast bronze chisels, as many as three at a time, that could be used equally well for either wood or soft stone[1079]. Some of the tools used no doubt belonged to individual workmen, as implied by a hoard of bronze tools found in a house at Gournia (see below). No doubt he would carry whatever the tools he thought were necessary to a building site, as required by his schedule. Some other tools, such as the huge saws used to cut substantial timbers (*fig.* 41), may well have been furnished by those administering the work, as implied by the discovery in the Palace of Kato Zakros of many saws, some probably stored on an upper floor (see below). Certain tools, such as those used by quarrymen or masons, would probably have been left overnight at the work site, perhaps under guard.

As now, the smaller the project to be done, the fewer were the workers needed. Small house owners probably often built their own walls of stone, earth, and mud brick, but sometimes they no doubt required help, perhaps from neighbors or family members, to gather the materials necessary, to position ceiling beams or window frames, or to deliver and drag into place a heavy threshold block for a front door. On large projects featuring fine construction such as in the villas and palaces often being referred to in this book, no doubt there would have been a hierarchy of duties split between the general administra-

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[1072] Ventris and Chadwick 1973, pp. 123, 182. PY Fn 7.3, 11, An 18.6, An 35.1.

[1073] Ventris and Chadwick 1973, pp. 349-350. PY Vn 10.

[1074] Melena 1996-97, pp. 171, 175.

[1075] PY Fn 7.5,9.

[1076] PY Fn 7.4.10. Melena 1996-97, pp. 171-176; There are possible equivalents for «woodworking words»: for «roof beams» (e-ru-mi-ni-ja or elumniai); «fittings for insertions in walls» (e-to-ki-ja or entoikhiai); «columns» (ki-wo or kiwôn); «dowels» (pa-ke-te-re or *pâktêres); «door-jambs» (pi-ri-ja-o or gen. pl. of phlîa); «pine» (pe-*65-ka or peukâ)»; «beams» (ta-ra-nu-we, from thrânos), and «pillar» (ta-to-mo or stathmos), for which see Ventris and Chadwick 1973, pp. 349 and 503-505.

[1077] Soles 2003, pp. 96-99.

[1078] Numerous working areas have been found from various periods, as discussed in *Crafts*, pp. 547-554.

[1079] For the mold recovered, see *Malia, Mu Artisans*, p. 55, C 23, pls. 16b, 52d.

tors of the project and the «site supervisor» or *architechnitis* who probably laid out the building plan, most likely with strings[1080], and determined the floor and wall levels. He also decided when, how and where blocks were to be quarried and when wood was to be cut, and in what sizes, before being brought to the building site, as well as any changes on the building site prior to beginning (e.g. foundations for columns, drains for runoff water buried below floor level or in shallow trenches excavated alongside houses set next to streets, or the removal of old walls that would otherwise interfere).

The variety of tools used for these processes has already been presented here in Chapter 1. No single discovery, however, has nearly defined the entire scope of a single craftsman's workshop, but a group of carpenter's tools found in House Fd at Gournia, concealed in a cranny just outside the west door[1081], is instructive. It consisted, along with other items, of a double-axe, a toothed saw 45 cm long, four chisels like those in *fig.* 45, and a drill (*fig.* 46D)[1082].

Of special interest is the broad array of tools found in various parts of the Palace of Kato Zakro, in particular at least 11 chisels, 10 large toothed and un-toothed saws (like those in *figs.* 41,42), some eight double-axes, four adzes (as in *fig.* 38 a), three hammer-like tools, of which one is actually an abused double-axe (*fig.* 35B), and at least two drills. Enough of this impressive hoard has been partially published[1083], fortunately, to illustrate graphically the unique number and variety of tools present within even part of a Minoan Palace, this one abandoned, along with its contents, after its destruction by fire in LM IB. Two bronze saws found folded together on the ground floor, according to N. Platon, the discoverer, apparently most likely fell from an upstairs storeroom. Of interest here is that one saw was a «stone» saw, quite possibly the bent, un-toothed saw in *fig.* 43, used for cutting hard gray ironstone. It probably was stored upstairs, far from where all stone working must have taken place, namely on ground level, another indication that the saws were in storage. Also, four large bronze saws, each of the type used by two workmen, one at each end, were found lying on the floor of the main downstairs room (xxviii, the «Room of the Ceremonies»). This suggests that major timbers were being cut in that room not long before the time of the destruction. The very number of saws found in the room suggests that a group of sawyers was engaged in the work. The fact that so many tools were used in the Palace introduces the probability that both carpenters and masons may have been drawing upon a common group of tools that had been fashioned especially for Palace work and «belonged» to the Palace rather than to individual workmen. Also, particularly for very specialized tools like masonry saws, the demand for use is unlikely to have been high enough for many individuals to have invested in their own sets[1084].

As we have seen, large-scale architecture involving special expertise (e.g. ashlar masonry, columns, pier-and-door partitions, massive amounts of wood for ceiling and roof spans, as well as the vertical timbers to support them) began on Protopalatial sites such as Malia,

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[1080] For discussions of possible methodologies used in laying out Minoan buildings, see especially Graham's *P. of C.* pp. 222-29 and Addendum 5. An investigation of palace orientation is in J.W. Shaw 1973c. Preziosi (1983, Chapter 4) proposed the use of grids to which, however, the buildings may not conform.

[1081] Hawes, Williams, Seager and Hall 1908, pp. 22-23. See also *Crafts, passim*, for the individual tools.

[1082] Respectively, in *Crafts*, chisels nos. *26, 27, 84* and *85*; saw no. *34*; double-axe *No, 13*, and drill no. *11*.

[1083] Respectively, in *Crafts*, chisels nos. *28, 153-161*; saws nos. *24-31*; double-axes nos. *133, 159-160, 161-165*; pick-adze nos. *1,2*; flat axe-adze nos. *2,3*; drills nos. *6, 12*; hammers nos. *15, 24, 25*. See also Platon 1971, pp. 123-130, 139, 157-158.

[1084] Suggested by Todd Whitelaw (personal correspondence).

Phaistos, and Knossos. The sites themselves were already substantial by that time and no doubt had townspeople with expertise in carpentry and wall-making, so locals probably built the first palaces, although their calling in a few individuals with special talent or experience from elsewhere, cannot be ruled out. During the Neopalatial period no doubt this custom continued, and at numerous other settlements as well, but the spread of «Neopalatial Architectural Style» beyond the larger settlements to smaller ones (e.g. to Galatas, Kommos, or Kato Zakros) and to completely rural areas (e. g. the well-built Pitsidia Villa)[1085] probably brought about the need for experienced builders who were simply not available in a particular area. Thus may well have developed groups of «itinerant» workmen who were either ordered to work[1086] for a time away from their homes or could be hired independently[1087]. Also relevant is the scale of demand for such specialized construction – there is unlikely to have been sufficient demand outside the major centers to support local specialists.

The site of Myrtos-Pyrgos is probably a perfect candidate, for during LM I a complex rural establishment was built over this site, which was without an earlier history of architectural ostentation. The new construction featured extensive wooden framework of at least two stories, a columned portico and exposed walls of both poros limestone and gypsum ashlar construction (e.g. our cover illustration). Moreover, and strengthening the suggestion that a non-local, «traveling» group was involved[1088], aspects of the architecture, especially, the light-well with its balustrades, repeat the overall design of similar features that appear to have originated at Knossos[1089]. Further east along the same coast, east of Hierapetra, at Makrygialos, is a Palace-style building with a central court that was built from scratch, also in LM I[1090]. Its materials and techniques are usually inferior to those used at Myrtos-Pyrgos, but in one southwestern room the visitor is surprised by a bench of poros blocks cut with the technique found only at Palatial centers such as Hagia Triadha (e.g. that shown in our *fig.* 113). In this case at Makrygialos, no doubt an experienced mason from another area, perhaps even an itinerant mason «borrowed» from work at the possibly contemporary Myrtos-Pyrgos site, made the bench.

C) Diffusion: Minoan Architectural Style Abroad (*figs.* 266-271)

As just recounted, during LM I the «Palatial Style» of architecture proliferated throughout Crete, especially in the central and eastern parts of the island. This may reflect the political and economic control of a then dominant Knossos[1091]. What happened outside of Crete? A similar phenomenon occurred in the southern Aegean, one in which pottery (rather than architecture), however, often serves as a better indicator of the spread of «Minoanizing»[1092], whether in the Cyclades north of Crete, or in the Dodecanese Island area group to the east. A similar cultural diffusion can be traced via the

[1085] Vallianou 1989.

[1086] Driessen 1989-90, believes (p. 20) that by LM III the central palace administration sent out groups of builders to help construction in dependent secondary centers.

[1087] At Kommos in the Mesara, for example, conservation and consolidation work has been carried out by a professional from Hagios Nikolaos backed up by masons (some related) from Neapoli and workmen from Kamilari and Hagios Ioannis in the Mesara.

[1088] See also Driessen 1989-90, pp. 20-21, and Nodarou *et al.*, p. 3014.

[1089] See also Cadogan 1978; 1992.

[1090] Davaras 1985, pp. 87, 91, fig. 13 (Hall 22); 1997, p. 124.

[1091] Wiener 2007; Driessen 1989-1990, p. 22.

[1092] For the term, see also Raymond 2007, p. 222. A shorter version of this text was part of a presentation given at an archaeological colloquium in Munich in the spring of 2008 (J.W. Shaw, *forthcoming*).

island of Kythera, into Messenia in the southwestern Peloponnesus and, northward into the Plain of Argos and from there north to Attica and, further, into Boeotia[1093].

The character and reliability of the Minoanizing architectural evidence one can point out vary in terms of geographical distance from Crete and relative differences in chronology, if any, between it and the Cretan Palatial Style. The evidence can be examined by placing it in three categories, 1) geographical proximity and contemporaneity within the Aegean island group; 2) Mainland evidence from not too long after LM I; 3) Mainland evidence from Late Helladic IIIB, the final acme of Mycenaean culture but a time on Crete when innovative Minoan architecture was only a memory, if that[1094]. As might be expected, distance and estimated time differences may dilute the degree of accuracy of identification.

For the first category just listed[1095], the primary example is the town of Akrotiri on the island of Thera, 40 miles north of Crete (*fig.* 1a), where a central part of an entire Late Cycladic (= LC I or LM I) town was excavated. The architecture, preserved as high as the third story, to a large extent mirrors elite Minoan house construction. In some cases, as in that of the many-windowed openings (*polyparathyra*) usually on the second floors, Theran houses actually help clarify our view of what many Minoan buildings on Crete, for instance the mansions at Tylissos, must actually have looked like, for their upper stories have disappeared. Clairy Palyvou, the excavation architect at Akrotiri, describes the circumstances of the Theran town:

«Sometime around the very beginning of LM IA, the Therans were already using the Minoan building technology, in a sporadic manner. Then, the big earthquake (still within the first phase of LM IA) destroyed their town to a large extent. This dramatic event, far from detrimental, gave the Therans the opportunity to rebuild their town and to reform their houses by lavishly using the sophisticated technology they were already familiar with. They even went so far as to import building materials [gypsum paving slabs][1096] from Crete after the *seismic destruction,* the remains of a vague Cycladic past, already influenced by the Cretan building technology, blended with an innovative architecture of Cretan origin. In terms of form and function, the new look of the houses was comparable to those of many Cretan towns (e.g., Malia, Zakros, Palaikastro). In terms of building technology, however, Akrotiri differs from those Cretan towns because it is closer to the sophisticated technology used in Crete by the palace people and by 10-15% of the Cretan society. This new picture of Akrotiri alludes to the architecture of an affluent society»[1097].

In the case of Akrotiri, its affluence no doubt originates from a special relationship with Crete, as well as with the burgeoning trade made possible, most likely, by commodious harbors on either side of the peninsula where the Akrotiri town was built[1098].

While the architectural relationship between Crete and Akrotiri is relatively clear, a combination of less affluence, simpler architectural development, and poor preservation gives us less that we can separate out as «Minoan» from among indigenous architecture. At Phylakopi on Melos (*fig.* 1a), northwest of Thera, for instance, we can only point with assurance to a few LC I (= LM I) gamma-type ashlar bases, cut with the technique used in the pier-and-door partition system on Crete (*fig.* 186), and in this case probably intended for single doorways[1099]. Use of such bases in the town suggests local imitation of a system

[1093] A general view of some of the evidence for the Islands can be found in Driessen and Macdonald 1997, pp. 248-258.

[1094] See, however, the LM III revival in the western Mesara centered at Hagia Triadha, pp. 74-75 here.

[1095] For the cultural characteristics of Minoanizing sites on Aegean islands, see also Branigan 1984.

[1096] Einfalt 1978, p. 527; Gale, Einfalt, Hubberten, and Jones 1988, p. 58; Chlouveraki 2006, p. 300.

[1097] Palyvou 2005, p. 187. See also Doumas 1983.

[1098] J.W. Shaw, with M. Luton 2000; Doumas 2007.

[1099] Atkinson *et al.* 1904, p. 59.

known to be attractive in elite architecture elsewhere, probably learned about firsthand by an islander visiting Crete (or Akrotiri). It also suggests awareness of the practical advantages furnished by the bases, for the projecting lower door pivot could be stabilized by the interior angle formed by the projection on the jamb-base.

North of Melos and East of the Plain of Argos is the island of Kea, where excavation at Ayia Irini revealed most of a Middle and Late Bronze Age town. The buildings were constructed in the manner of Minoan Pseira (*figs.* 78-80), of slabs of local greenish schist, without using imported stone. The largest structure, House A, a veritable «mansion», had 15 basement rooms with about 40 small-to-medium-sized rooms on the ground floor above, and with fewer, but larger rooms on a now missing second floor. Along its eastern flank there were probably the largest rooms, where site architect Cummer restored a spacious parlor decorated with frescoes, on the east side of which was a bath and on the west side a toilet and a light-well[1100]. Those rooms, it is thought, being within a context flavored by much imported Minoan pottery and Minoanizing wall-painting, are «distinctive Minoan elements ... assimilated into a well-developed local tradition»[1101]. This is most likely true, but the Minoan form of the light-well (usually with at least one column) or a «parlor» with a pier-and-door partition (the room may, however, have had one of wood) are nevertheless missing. Still, as Cummer suggests, the arrangement was likely «inspired by Minoan refinements at the beginning of the Late Bronze Age»[1102].

Far to the southeast of Kea, in the LM IA levels at Trianda on Rhodes, among the Dodecanese Islands that border modern Turkey (Anatolia) (*fig.* 1a), Minoanizing architecture has been positively identified in the form of three partly preserved rooms in separate buildings, each with pier-and-door partition bases[1103]. At least one room was originally decorated with fresco[1104]. A variety of Gamma-shaped, I-shaped, and rectangular (reused?) bases was used[1105]. Two rooms had four bases each, implying three doorways, each with two leaves. Thus the Minoan technique of separating living spaces by means of flexibly opened or closed partitions (*polythyra*) traveled this far east, reflecting not simply the upper-class form and pivot-friendly bases recognized at Phylakopi, but memories of a comfortable living style imported, as it were, from abroad, one that would, hopefully, continue in the new house. Dressed triangular blocks creating a smooth exterior and a rough rubbly interior intended to be plastered over (perhaps like the Zakros wall in our *fig.* 122), are also reported at Trianda[1106]. A similar structure has been reported at the Serraglio site on the island of Kos, north of Rhodes. There a wide LM IA four-opening *polythyron* was set on, unusually, five rectangular (rather than articulated) bases[1107], again denoting the dissemination of Minoanizing cultural traits if not the presence of the Minoans themselves. To be pointed out also is the proximity of Rhodes and Kos to the Anatolian shore, where numerous sites with close contacts with Crete and the western Aegean have been reported[1108]. Again, Aegean style pottery found there remains the crucial confirmatory evidence, but it is only a matter of time before indications of Minoanizing architectural style are discovered, as for instance at Miletus[1109] or other coastal sites along the littoral.

1100 Cummer 1980, p. 5.

1101 Cummer and Schofield 1984, p. 145.

1102 Cummer 1980, p. 6.

1103 I am much indebted to excavator Toula Marketou for this important information about Trianda.

1104 Marketou 1988, pp. 27-33, pl. 5.

1105 The lower part of one I-shaped base continued, undressed, into the dirt floor.

1106 *AD* 42 (1987), pp. 614-615 (T. Marketou).

1107 *AD* 45 (1990), p. 496 (T. Marketou).

1108 See Niemeier 1988.

1109 At Miletus, for instance, a significant Middle and Late Bronze Age Minoanizing settlement is being excavated by the Niemeiers. They suggest that a LB I

Away from the islands and on the Greek Mainland, if we begin in Messenia, approachable from Crete via a very Minoanised Kythera (still without relevant architectural evidence, however), our more suggestive examples are at Pylos (*fig.* 1a), where Nelson's careful cleaning, study, and publication of early ashlar walls have added substantially to our understanding[1110]. Some of these ashlar walls, originally found by Blegen, were later plausibly identified by Klaus Kilian as belonging to a Minoan or Minoan-influenced «Cretan» structure which, as in Minoan palaces, had «wings» around a large court[1111]. From the point of view of technique, the walls (e.g. in *figs.* 267, 268)[1112], dated by Nelson to late LH II/early LH IIIA1[1113] are done in the orthostate fashion with a squared poros slab set on edge upon an ashlar socle, a style otherwise unknown on the Mycenaean Mainland[1114]. The tops of the slabs have square mortise cuttings which, as in Crete, indicate that horizontal wooden beams were set upon them, to strengthen the wall above them. In one orthostate wall (*fig.* 268) there is a mortised corner or end base (*anta*). Of particular interest is the double-axe «mason's mark» engraved on the face of one block (*fig.* 267), similar in nature to the branch and double-axe signs engraved on the stomion blocks of the LH IIA tholos tomb at Peristeria[1115] and often cited as characteristically Minoan[1116]. Also, the ends of the orthostate blocks at Pylos were cut at an angle so that only the tips of the blocks met, although from outside the viewer saw what appeared to be a solid stone wall, this being a thoroughly Minoan approach as we have already seen, and strengthening an argument for a Minoan-style inspired origin[1117] if not Minoan masons[1118].

The next major architectural effort at Pylos, in LH IIIA, was to construct at least part of large room groups, often with façades of coursed poros ashlar which mirrored the Minoan technique of even courses, «triangular» tight-jointing, as well as the use of dowels to attach beams to upper surfaces, epitomized in the northeastern section of the later Palace, into which the room group was later incorporated[1119]. Deviations from Minoan practice are represented there in the lack of a projecting socle (except in façade set-backs) and the usual mud mortar between Minoan coursing, as well as the use of horizontal timber inserts[1120]. Concerning the last, Blegen found courses of ashlar blocks tumbled alongside the northeastern façade here[1121],

wall found there illustrates the wedge-shaped Minoan wall block technique (B. and W.-D, Niemeier 1999, p. 547, pl. CXVII), but the example illustrated is not sufficiently convincing. Further excavation might no doubt be more successful from that point of view.

[1110] Nelson 2001, 2007a, 2008.

[1111] Kilian 1987. Also emphasizing the Minoan connection, Westerburg (2001) proposed that a series of bases in the Northwest Building at Pylos originally supported pillars of a Minoan-type stoa and were later reused, in situ, in the later building.

[1112] For a photograph of the face of the wall in our *fig.* 267, see Blegen 1966, pl. 16.

[1113] Nelson 2007a, p. 153, note 46, and pp. 159 and 161. Warren and Hankey (1989, p. 169) suggest that LH II is roughly equivalent to LM IB/LM II on Crete, with the subdivisons of LH III being equal to those of the LM III period (see our Table 1).

[1114] Küpper, however, illustrates a possible orthostate block in a main wall of the Tiryns Palace court (1996, fig. 14 (A 12); see also Nelson 2001, p. 124, fig. 141). Since the finished face of the block was set against the interior rubble packing of the wall, it is clearly in reuse from some earlier building. In his drawing he connects the block with another, fragmentary one, as if they belonged together.

[1115] Rutter 2005, p. 24 for the date.

[1116] Rutter 2005; Nelson 2007a, p. 155.

[1117] See also Dickinson's comments after Rutter's presentation in Rutter 2005, pp. 55-57.

[1118] J. Wright 2006, p. 17.

[1119] Perhaps somewhat earlier, in LH II, coursed ashlar began to be incorporated into the construction of tholos tombs (Nelson 2007a, pp. 145-148). He also notes (p. 159, note 59) that the architectural form of the tholos may have developed on Crete, for which see also J. Wright 2006, p. 17.

[1120] Nelson 2007, pp. 159, 161.

[1121] Blegen 1966, pl. 18.

showing that lower ashlar courses were actually set *upon* the beams stabilized by mortises along the length of the façade. In Minoan architecture, although there are exceptions, normally a horizontal wood course was surmounted by either an opening such as a window, or non-ashlar construction. This difference at Pylos could well herald the beginning of the later LH IIIB «Mycenaean» style of ashlar construction where both horizontal and vertical beams were set into the wall structure, sometimes as framing around blocks of ashlar masonry [1122]. With the construction of the final, LH IIIB Palace at Pylos, most obvious visual traces of Minoan architectural influence in wall-building disappeared[1123], although structurally a major Minoan contribution remained, for which see below.

Sandy Pylos seems somnolent when compared with the Argolid, where the chief citadel, Mycenae, synonymous with an era of power and opulence, was in contact, through the port of Tiryns on the Gulf of Argos, with many areas of the Mediterranean, including Crete. Through the Tiryns area passed raw materials such as glass, copper, tin, but also slabs of Cretan gypsum from the Knossos area, destined to be cut into floor slabs for the porch, vestibule, and inner room (domus) of the Mycenae Palace[1124]. This suggests that some of the gypsum floors of the declining Minoan Palace at Knossos there may have still been visible for people of the 13th century B.C., or that tales of its former splendor were still being sung. Two hundred years earlier, the burghers at Akrotiri on the island of Thera had done something similar by obtaining gypsum from the Knossos quarries for their house flooring[1125]. Gypsum was also used at Tiryns for dressing benches and for an extensive gypsum frieze, some 0.28 m high, of triglyphs and half-rosettes[1126]; but that stone was imported from sources on the Mainland or the Ionian Islands[1127].

Among the earliest souvenirs garnered by intrepid antiquaries from Mycenae, before «archaeologists» Schliemann, Stamatakis, or Tsountas wielded pick there, were parts of the decorated façade of the so-called «Treasury of Atreus» (*fig.* 270), the largest and most impressive tholos tomb in the Argolid. Although looted of its contents, enough remains of its entrance passage, façade, and interior to inspire. Some façade slabs from it were bought by Lord Elgin, and ended up in the British Museum. They are of reddish-brown porphyry carved with beam ends as well as running spirals. These, as well as the Tiryns gypsum triglyph and half-rosette frieze noted above, recall similar designs on carved frieze slabs of hard metamorphic limestone from Knossos, many recovered from the West Wing of the Palace, such as that in *fig.* 19, of greenish limestone found near its Northwestern Entranceway[1128]. While the resemblance between the two groups cannot be doubted, their relative dating vis-à-vis each other remains controversial, for those from Knossos were all found in LM IIIB (13th century B.C.) destruction contexts and the Treasury of Atreus' date

[1122] For later Mycenaean examples, see J. Wright 2006, fig. 1.15a (Mycenae) and 1.15b (Thebes). Cretan ashlar walls with similar use of vertical and horizontal beams within ashlar construction, more a Mycenaean than a Minoan characteristic, can be seen in the LM III Hagia Triadha Shrine (*fig.* 125a here) where, almost miraculously, the ashlar courses are still in place.

[1123] Nelson 2001, p. 158.

[1124] Mylonas 1966, p. 62 for the vestibule and domus; Gale, Einfalt, Hubberten, and Jones 1988, p. 58. See also Chlouveraki 2006, pp. 300-301, for her review of gypsum used in buildings outside of Crete. Marinatos suggested that the sculpted gypsum slabs in the Elgin Collection were once placed in the façade of the Treasury of Atreus (our *fig.* 270).

[1125] Gale, Einfalt, Hubberten, and Jones 1988, p. 58; Einfalt 1978.

[1126] Moser Von Filseck 1986, p. 6 and *passim*.

[1127] Gale, Einfalt, Hubberten, and Jones 1988.

[1128] The slabs, some found outside the Palace, and all not found by Evans, are enumerated in Moser von Filseck (1996), p. 19 (nos. 1-6). See also Driessen 2007b, p. 181.

has been estimated at LH IIIA (ca. 1325 B.C.) to LH IIIB (ca. 1250 B.C.)[1129]. This writer is inclined to place at least some of the Knossian examples at a time when its artistic technique was still high, so a date as early as late LM I (ca. 1450 B.C.) can be proposed, certainly earlier than the Treasury of Atreus, which in turn implies that visiting Mycenaeans were impressed by such friezes and incorporated them into their own work. The suggestion[1130] is strengthened by Minoan pictorial tradition where spiral and triglyph and half-rosette friezes occur at an early date. Of special interest here is Evans's suggestion that the friezes were positioned at Palace entrances[1131], where they could serve as an announcement and reminder of temporal power, religious authority, perhaps the eternal, which would also be the case at Mycenae at the entrance to the tomb of a great ruler, just as the carving of lions, column, and incurved altars above the entrance into the Mycenaean citadel were reminders of dominion and fealty to rule and tradition[1132].

Supporting the upper part of the façade of the Treasury of Atreus (*fig.* 270) were two tall, chevron-decorated stone half-columns with cushion-like capitals, one column on either side of the doorway, which have been used by many, partly since they diminish in diameter from top to bottom, as major confirmatory evidence that Minoan and, presumably, Mycenaean wooden columns had this shape[1133]. One of the columns there, the most complete one, also found its way into the British Museum along with Lord Elgin's collection. The other, found later where it had served as a threshold of a modern house, is in the National Museum in Athens. It is interesting to contemplate that stone replaced wood to assure the permanence, and truly the ultimate success, of the dedication, or commemoration, of the king being interred[1134]. Also implied, although by most estimates the tomb postdates all major Minoan periods of architectural construction, is that Mycenaeans, or their representatives, used standing Minoan columns as their models.

As we have seen, entrances, whether for the living or the deceased, were imbued with symbolism, which is further confirmed by the use of the pier-and-door system mentioned earlier. This represented for the builders, probably Minoan, in Rhodes or Kos in the 16th century B.C., a nostalgia for Crete and a hope for gracious living. Its use on the Mycenaean Mainland, however, is different and appears to reflect other concerns. There are only two instances where the form is known, the first being at Tiryns between the open porch and the lobby leading toward the main reception room, or domus, of the King, in the form of five wooden pier bases, two C- or gamma-shaped and the two between I – or T – shaped (for the

[1129] Pelon's study (1976, pp. 175, 483) refers to dating by Wace of 1330 B.C., and by Mylonas of 1250 B.C., Pelon favors the later date.

[1130] Marinatos (Marinatos and Hirmer 1973, p. 148) estimated LM I-II. Macdonald (2005, p. 211) thought «around 1400 B.C., slightly earlier than on the mainland ...».

[1131] *Knossos* II, pp. 696-697; IV, pp. 222-223. It comes as no surprise, therefore, that Shear (1967, p. 63) noted the discovery of a triglyph and half rosette stone frieze at the Northwest Propylon at Mycenae, on the way up to the palace, as well as a frieze with the same design running around the dado of the Palace's porch and forecourt.

[1132] Since none of the friezes was found in its original position, we remain unsure of where they were set. One possibility is that, like the triglyph and rosette frieze found at Tiryns, it was positioned at dado level. Another, proposed by Nelson after the discovery of a stone frieze section at Pylos, is that stone friezes were inset into the walls at lintel level, covering and protecting horizontal timbers set into walls at that point. This is strengthened by the discovery in the Hall of the Double Axes at Knossos of a running spiral frieze painted on plaster covering a beam imbedded in the wall at that point (Nelson 2007b). See also Fyfe's comments on their projection from walls in *Knossos* II, p. 605, and our *fig.* 181, right.

[1133] See our pp. 104-106 for a discussion.

[1134] Columns, but of gypsum rather than limestone, similarly graced the entrance into another tholos, the nearby Tomb of Clytemnestra.

arrangement see *fig.* 269) at the three-door entrance into the throne room. The description by Schliemann's architect, Wilhelm Dörpfeld, writing long before Evans excavated Knossos and its ubiquitous pier-and-door bases, shows his acuity in summing up the situation:

«Three large folding doors connect the vestibule with the *anteroom*. They occupy almost the whole partition wall, leaving room only for four narrow doorposts. The three huge door-sills are still in their place – breccia blocks 1.50-60 m. broad by about 2.30 m. long. On the short sides they are irregular in edge, but at the long sides they are cut smooth ... Each door-sill had two [bored] pivot-holes, about 90 mm. diameter and 25 mm. deep, and 1.72 m. apart ... set in the door-sill itself, about 0.35 m. from the its outer edge. Hence it follows, the three doors must have had a separate door-case about 0.30 m. thick, into which the doors fitted when shut. When opened, they remained flat against the pilasters, or fitted into the door-case so as not to narrow the entrance»[1135].

It is difficult not to interpret the installation of such an arrangement as a symbolic gesture, for such bases were not used elsewhere at the Tiryns site. The nearby gypsum triglyph and half-rosette frieze, set alongside the southern wall in the entrance porch there, also the only decorative stone frieze at Tiryns, reinforces the thought.

The second instance of the bases occurs at Gla, an isolated military base in the Copaic Lake Basin in Boeotia[1136]. There two long complexes of rooms within a walled compound, presumably barracks, faced each other at some distance, suggesting two separate groups of warriors[1137]. Not far away are the extensive quarters for living and for provision for storage, with a single larger room set at opposite ends of the complex. Of significance is that one of these two large rooms is somewhat smaller than the other, but most significant is that the entrance into the larger room (*fig.* 269) was by means of a Minoanizing pier-and-door partition like that at Tiryns[1138]. That the second large room mentioned was not graced by a similar entrance was certainly intentional, the inference being that the activities carried out in the larger room, or the person living there, or both, were higher in rank than in the other. My own guess would be that two collaborating military forces occupied the bastion but that one, the leader of one of the groups, as suggested by the architecture, was in overall command.

Up to this point much of our discussion of Minoan architectural influence on the Mainland has centered about cosmetic aspects of architecture, such as coursed ashlar façades and exotic stone, rather than support structure. One example of structural transfer, however, was use of the pier-and-door partition but, as seen, this occurs symbolically, and then only rarely at the entrances into those single most important rooms where power was being enshrined, as at Tiryns and Gla.

But it does appear that a major Minoan structural element, namely part of its vertical wooden and stone support system, was transferred from Crete to the Mainland, where we find it appearing in LH IIIB Mycenaean upper-class building. Minoan Palatial Style, as we have seen, involved the use of cut stone bases to which horizontal wooden frames were first attached. The framework in turn stabilized groups of vertical timbers that rose like squared columns, but still as part of the wall, up to the level of the wooden ceiling structure from where it could continue further. This was fully developed on Neopalatial Crete through LM I, but used also during LM III when it reappears, like an echo of the past, at Hagia Triadha[1139]. On Crete the system varied from a series of vertical posts bound together by means of earth,

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1135 Dörpfeld in Schliemann 1885, pp. 214-215.

1136 Iakovides 1989.

1137 Or simply barracks for seasonal workers to plant and harvest the grain (Todd Whitelaw, personal correspondence).

1138 Iakovides 1989, fig. 22 (our *fig.* 269) and p. 116.

1139 For instance in the pillar bases that alternate with columns in front of the large Stoa (the «Mercato») there.

	Antae at Wall-end	Bases at Wall Corner	Wall Projection	Pillar Base	Total
Mycenae					
Palace	4	–	–	–	4
House of Columns	1	–	–	–	1
General Cult Area	5	–	–	–	5
Pylos					
Palace	11	6	2	–	19*
Tiryns					
Palace	8	4	–	2	14
Total	29	10	2	2	43

TABLE 4: RELATIVE POSITIONING OF MORTISED ASHLAR BASES AT MAJOR MYCENAEAN SITES. BASED ON KÜPPER 1996, PLANS 2, 4-6, AND NELSON 2001, FIG. 7 (*AT PYLOS, BASES 18L.B AND 18L.A WERE ORIGINALLY A WALL CORNER AND WALL-END, RESPECTIVELY. BASE 11-20 IS A CORNER BLOCK OR ANTA FROM AN EARLIER [ORTHOSTATE] PERIOD: NELSON 2001, FIG. 7, AND 2003; ALSO PERSONAL COMMUNICATION).

mud, rubble and clay plaster set on flat slabs (*fig.* 177) to single squared poros ashlar blocks supporting vertical timbers, just described above, to piers or pillars composed of two or three squared blocks stacked one above another, the top block being mortised to stabilize the frame supporting the ceiling joists (*fig.* 200). The positions of many base blocks can be seen in *fig.* 182b of part of the Residential Quarter of the Palace at Knossos, where they are usually rendered in a darker color than the remainder of the wall.

On the Mainland, as shown in Table 4, this support system was used selectively for strengthening vulnerable wall-ends (*antae*), and wall corners and only rarely as pillar bases[1140]. Almost invariably a single base block sufficed. Sometimes at wall corners only three sides of the block were finished and thus only three dowel mortises would be chiseled out back from the two exposed edges along the top of the block[1141]. Those that can be studied most easily are at well-preserved Pylos, for Blegen's room-by-room description is blessed by excellent illustration, and Nelson's numeration completes the record[1142]. At Pylos some 11 bases served as *antae*, with another six strengthening wall corners, and with two part of an ashlar façade (*fig.* 266).

For Tiryns, again we are fortunate because Küpper's study includes descriptions of the relevant bases, as well as their locations. They were used, again, as *antae* (8), wall corners (4), and, unusually in a Mycenaean context, pillar bases (2). Of particular interest is that almost all the bases are of hard limestone or conglomerate, which is much more difficult to prepare than the poros limestone usually used by the Minoans (and Pylians) and, in the Argolid, was cut by toothless curved bronze pendulum saws suspended from a wooden framework[1143].

By LH IIIB the pier system was used consistently in the Palaces at Pylos, Tiryns, and, perhaps less so, Mycenae. The bases can be understood by their overall size, the number of

[1140] A similar method was used by the Hittites at Bogazköy, but is later and, in appearance, different from what we find on the Greek Mainland and, certainly, on Crete (Naumann 1955, p. 41; Küpper 1996, pp. 118-122; J. Wright 2006, p. 33).

[1141] See, for instance, at Tiryns, Küpper (1996) Base A 11, p. 125, fig. 11 and, for Pylos, Küpper (1996) Base A 27, p.127 and fig. 27.

[1142] Blegen 1966; Nelson 2001, fig. 7 and *passim*.

[1143] Küpper 1996, pp. 111-121.

squared sides, and the number and positioning of cuttings, especially mortise holes, on their top surfaces, just like those in Neopalatial Crete. But what about earlier building stages there? For that, the best evidence is at Pylos, for one of the early, LH II/LH IIIA early poros limestone orthostate walls mentioned above (*fig.* 268) actually ended at a squared, mortised pier block set on their common socle course[1144]. Nelson suggests that it may have been a wall corner[1145]. This should represent a stage in the evolution from simple orthostate to more developed ashlar construction. Since ashlar orthostate courses are characteristically Minoan, and the context is, as described above, Minoanizing, the conclusion is obvious. When the northwest ashlar section of the Palace was constructed next to this wall, later in LH IIIA, the same supporting system of piers was used. Then, in LH IIIB, when the main Pylos Palace was built, even though the building of coursed ashlar walling was, surprisingly, discontinued[1146], the «ashlar base» pier system was retained.

At Tiryns the practice of using orthostates may have begun as early as at Pylos, but the evidence there is more tenuous. Still, of the only two mortised poros bases used as subsidiary wall corners in the Tiryns Palace, one appears to have been cut to belong to an earlier orthostate course, for it is, clearly, in re-use[1147]. The second base also has evidence for re-use[1148]. Perhaps like Pylos, Tiryns also had a «poros» phase. Then harder conglomerate and metamorphic limestone began to be used, partly because of its durability but also admired because the difficult, time-consuming preparation process made of it a prestigious material[1149]. No doubt partly because of poor preservation, the record for such construction at Mycenae is limited to only four bases in the palace itself, five in the area of the Cult Center and one in the House of the Columns. All are *antae*, eight of poros and two of conglomerate[1150].

Those within the Mycenae Palace[1151] are of particular interest for they are included in an unusual stairway construction being set as *antae* at opposite ends of a central or «spine» wall of what is probably a U-shaped staircase[1152]. The staircase form (*fig.* 204 a), with the mortised pier base at its entrance, is typically Minoan, certainly rare on the Mainland, and invites the suggestion that it was used in the Palace at Mycenae as a structural ornament complementing the Megaron next door[1153].

[1144] Nelson, personal communication. The pier is earlier than the LH IIIA ashlar façade wall set next to it, suggested by how the latter was «snuggled up» against it and a small block was set in the gap between the two.

[1145] Nelson 2001, fig. 80.

[1146] Nelson 2001, p. 208.

[1147] Küpper 1996, Base A 9, p. 125, fig. 10.

[1148] Küpper 1996, Base A 12, p. 125, fig. 14. The interior (southwestern) corner of the block is both completed and with a mortise, rather than being unfinished and unmortised. Perhaps not by chance, this and Base A 9 (above) occur at corresponding projections of the court façade.

[1149] Küpper 1996, pp. 115-118.

[1150] The system may also have been used at the LH II-LH III Menelaion, where some eight poros blocks were found built into Mansions I and II (J. Wright 2006, p. 11 and n. 4; Darcque 2005, p. 95).

[1151] Küpper 1996 Bases nos. A 17 and A 18, p. 126, and *figs.* 17 and 18, respectively, in Corridor 49 of the Mycenae Palace. Not indicated on his Plan 4.

[1152] Mycenae Palace, Spaces 47 and 48. Wace 1921-23, pp. 204-205. For this type of staircase see also *P. of C.*, pp. 18-185. A U-shaped staircase in the Pylos Palace (Rooms 14-15), unfortunately, is missing its «spine» wall, which may have been similar in delineation to that mentioned in the text. At the 2009 AIA Conference in Philadelphia, Kim Shelton, discussing new Mycenae excavations at «Petsas's House», showed what appears to be another staircase «spine wall», with ashlar bases at either end. The two bases are unusual, for each is composed of two mortised blocks facing each other and sharing a square socket in the center. The sockets must be for vertical posts carrying up to a second story, and are quite analogous with those otherwise unique Minoan stairway «spine» blocks in the eastern wing at Knossos (*figs.* 206A, 209). The Knossian connection seems to be a strong one here, although the gap in the center of its blocks is open and rectangular rather than closed and square. The «square» version could well be a Mycenaean version of the Minoan prototype.

[1153] For such a staircase see our *fig.* 204a; for its typology see J.W. Shaw 1999.

Perhaps one of the least known but certainly one of the most important architectural discoveries made at Mycenae is what Alan Wace, its excavator, aptly called the «Grand Staircase». The staircase (*fig.* 271), built in LH III, led from the roadway to the south up an otherwise precipitous slope to the Palace[1154]. Nowadays the casual visitor to the citadel usually takes a more northerly path to reach the Palace and can thus miss the staircase completely. In Mycenaean times, however, it was one of if not the chief way up to the Palace, and was certainly intended to impress visitors. Like the stairway just described, it was also U-shaped, but was very long (ca. 17.60 m), and built in places with cut ashlar, the initial flight with some 22 broad treads (ca. 5.80 m) covered by white stucco and lit by windows. At the beginning of the central «spine» wall, as one turned right to go up the stairs from the lower entrance lobby, there was a mortised ashlar block, a wall-end pier that either continued up in wood, rubble and plaster the entire distance to the next landing or, more likely, supported a balustrade with a pier or a column. Further east along the wall was inset another mortised pier base, at the point where the probable balustrade ended and the spine wall continued up. The inspiration for the design is clear, namely the Grand Staircase in the East Wing of the Palace at Knossos[1155], still visible at the time, and one of the most successful engineering feats in Minoan architecture. With its broad gypsum steps and views out and down, one's standing on it remains a memorable experience. The Mycenae Grand Staircase, however, was not the first built in emulation of Knossian design, for that with its adjacent light-well in Myrtos-Pyrgos, our cover illustration, surely was drawn much earlier from the same source.

Overall, the nature of Minoan influence on the structure of Mainland architecture is clear, beginning with the introduction of sophisticated orthostates along with single-block pier bases. At Pylos that style was superseded by coursed ashlar, incorporating such bases. Later, it, too, was replaced, this time by plastered rubble masonry[1156]. That technique, however, continued the earlier pier system which we find ubiquitous in elite Minoan as well as Mycenaean building. Minoan cultural influence was also obvious in pictorial design, sometimes imitated in frieze-like form within formal Mycenaean structures, where the Minoan pier-and-door partition occasionally also played a symbolic role. While Minoan style permeated much Mycenaean visual expression, however, and the pier-base structural system gave the buildings stability and strength[1157], as James Wright (2006) has shown the actual form of the buildings, with their axiality, courts and lobbies, had deep roots in the Middle and Early Late Helladic periods. The one exception to this generalization may be the Grand Staircase at Mycenae, which could have been built by Minoans in Crete.

[1154] For the stairway see Wace *et al.* 1921-23, pp. 149-159. The state plan of the stairway (below, in *fig.* 271) shows two large, aligned ashlar blocks bordering the south wall of the lobby leading toward the first flight of stairs up. Mortised beddings cut in the sides of the tops of the blocks, as well as transversely there, clearly indicate the position of a strong timber framework, probably for two or more windows offering views of the adjacent hillside, also sills where visitors might rest before the climb up. In the restored plan (*fig.* 271 above), however, the window openings are shown in black, as if they were solid walls, probably a mistake.

[1155] For which see *Knossos* I, pp. 337-342, and *P. of C*, pp. 180-185.

[1156] Nelson has coined a new term, «pier-wall masonry», for a wall-making method that he has identified at Pylos (Nelson 2001, pp. 154-168).

[1157] Blegen and Wace wrote concerning Mycenaean civilization, that it «was not merely transplanted from Crete but was the fruit of the cultivated Cretan graft set on the wild stock of the mainland» (Blegen and Wace 1916-1918, pp. 188-189, after Galanakis 2007 p. 241). In the case of the pillar system being discussed here, one might substitute «set within» for «set on».

APPENDIX A

METAL USED IN BUILDING

Although a few Minoan nails and molds for nails are known[1], there is little evidence that nails were actually used for building. An exception is that they attached bronze caps to the round, vertical pivots of doors. Of these caps at least five have been found, three at Malia, one at Phaistos, and one at Hagia Triadha[2]. These are shallow, bowl-shaped caps, ranging from 11 cms. to 17 cms. in diameter and about 5 cms. high. That shown in *fig.* 49C is from the South Wing of the Palace of Malia (Area xiv, 4), and is 5 cms. high and 16 cms. in diameter, being about 0.8 cm. thick at its base. Five holes are pierced through the side, most likely for nails which fastened the cap to the wooden door pivot[3], and the bottom is worn by constant wear. That from Phaistos may have been set below floor level in a block of wood. To judge from the two examples found in their original positions, one in front of the Grand Staircase (or Theatral Area) at Malia, and the other at the entrance into Room 25 at Phaistos, such caps were used only for particularly important entrance ways.

The only other known instance where metal was used in architecture is for lining the interior of cists found below floor level in the Magazines in the West Wing of the Palace of Knossos. Here the insides of the cists were lined with lead sheets in order to protect their contents from dampness[4]. There is no direct evidence for the bronze gates thought by Evans to have been used in the High Priest's House at Knossos[5]. Nor do we have any evidence that metal hinges were ever used for doors, although they seem to have been used occasionally for wooden boxes. There is some evidence that bronze pins, such as those found within the Temple Tomb and the South House at Knossos, were used to lock heavy wooden doors[6].

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[1] See the section here on tools, p. 53, note 306.

[2] *Mallia* I, p. 32, pl. XX, 1 and fig. 6, Herakleion Museum no. 2096 according to *Guide*, p. 21; see also *P. of C.*, fig. 104 a; *Mallia, Nécropoles*, I, p. 52, pl. LXIV, 1 and 2; *Mallia* II, p. 42, fig. 12; *Festòs* II, pp. 69-71, figs. 32, 33, 240*f*; Herakleion Museum no. 1459, also *P. of C.*, fig. 104 *b*; and describing that from Hagia Triadha, *Festòs* II, n. 34, p. 407. Hazzidakis has disputed the identification of the example from Phaistos, but apparently was unaware of the similar examples from Malia and Hagia Triadha (*Tylissos* [2], p. 55).

[3] Nails were found in the holes in the example from Chrysolakkos.

[4] *Knossos* I, pp. 451, 456, fig. 325; IV p. 630.

[5] *Knossos* IV, pp. 206-208, figs. 157, 158; also *Mallia*, *Maisons* I, p. 68, n. 2.

[6] For an interpretation of the use of these pins, see *P. of C.*, pp. 175-179, figs. 112, 113.

APPENDIX B

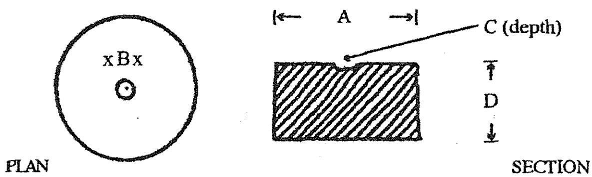
COLUMN BASES: STONE TYPES AND SITES

	Knossos	Phaistos	Hagia Triadha	Kommos	Vathypetro & Archanes	Nirou Khani & Amnisos	Tylissos	Malia	Gournia, Pyrgos	Petras	Palaikastro	Zakro	*TOTALS*
Limestone													
Dark Gray (Sideropetra)	1	1	2		7			30	2		18	11	72
Creamy or white	18	8	1	10			5			3		2	47
Veined: Gray or Blue	5	14	5		2	2		2					30
Veined: Red		5	3	1					2				11
Gypsum	15	3											18
Schist													
Calcareum, Green								20					20
Marble													
White Cipolin								17					17
Opheiolite													
Green	1	9	1									1	12
Wavy-Veined		1	1										2
Conglomerate	1	1	2	2	1	1		5					13
Other	4	3	2					5				7	21
TOTALS	45	45	17	13	10	3	5	79	4	3	18	21	263

The above table does not attempt to be complete, but representative only. Only round bases are included. Total for Malia are from van Effenterre 1980, p. 131, note 169.

APPENDIX C

COLUMN BASES WITH MORTISES



Measurements calibrated in centimeters unless otherwise noted.

	A	B	C	D	
Knossos					
East Wing	50	6,5	5	24	White streaked limestone
Malia					
Next to guard's house	35	4,3	3		Gray limestone
Next to guard's house	36	4,3	2		Gray limestone
Outside North Court XXXIII Area[4] (*fig.* 142)	46	3,5			Gray limestone
House Za[5]					
Building A, Quartier Mu, Room I, 1. Two examples 6 (*fig.* 139)	41	4	2,1		White limestone
House ΔB[7]					
Phaistos					
West Propylon, First Palace[8] (*fig.* 144 *a*, 144 *b*)	1.20-1.16		14	14-18	Streaked red limestone
NE Area[9]	44-55	5,4	3	25	Streaked gray limestone
NW Area[10]	39	7	3,5		Streaked gray limestone
Room 8[11]	55	8			Streaked red limestone

---

[1] Not in situ.

[2] Not in situ.

[3] Not in situ.

[4] In situ in MM context, hole not in center. (See also *Mallia*, III, p. 17, fig. 3, pl. xlv 4, 5).

[5] *Mallia, Maisons* I, pl. xxxviii, 4, and pl. lxv. In Room 4. Worn.

[6] Daux 1967, pp. 883-884, figs. 1, 2.

[7] *Mallia, Maisons* I, p. 51, pl. xxv 1, 2, and pl. lxvii. End of Corridor 14. In reuse?

[8] In situ, in MM context.

[9] Not in situ.

[10] Not in situ.

[11] Not in situ.

Hagia Triadha				
Workshop [12]	35	5	*fragment only*	Streaked red limestone
NE of Room 13 [13]	47	6		Streaked red limestone
West of Room 16 [14]				Streaked red limestone

[12] Not in situ.
[13] In situ in LM I context.
[14] In situ in LM I context.

APPENDIX D

DIMENSIONS OF MUD BRICKS

Below are listed the dimensions of over 100 mud bricks from fourteen Minoan sites. The measurements are my own unless noted otherwise. They have been rounded off up to the nearest higher centimeter (i.e., 8.5 cms. = 9 cms.). In cases where mud bricks in a particular wall are presumably contemporary, as defined by placement and use, they are listed as a group. A cross (+) indicates that a brick is only partly preserved. A dash (-) indicates that that no reliable measurement is available.

SITES	SIZES	REMARKS
Myrtos EM II		
Passage 65 [1]	19 × 16 × 10	
	15 × 15 × 10	Three examples
	14 × 15 × 10	
	15 × 15 × 9	
	17 × 15 × 10	
	20 × 14 × ?	
Room 88 [2]	– × – × 8	
Vasiliki EM II	47 × 40 × 10	
	45 × – × 10	
	45 × – × 10	
Malia (M) Palace (1-16) and House AB (17)		
1. Area XIII, interior walls (*figs.* 227A, B)		
	49 × 39 × 9	Average 50 × 37 × 9
	40 × 33 × 9	
	49 × 33 × 9	
	50 × 37 × 9	
	50 × 36 × 10	
	52 × 38 × 8	
	50 × 37 × 9	

[1] *Myrtos*, p. 59, note 1.

[2] *Myrtos*, p. 80.

Area XIII 2[3]	49 × 34 × 9	Four examples
	52 × 38 × 9	Six examples
	50 × 36 × 9	Five examples
	52 × 36 × 9	Three examples
		Average 51 × 36 × 9
Area xiii 3[4]	52 × 36 × 9	
2. Area IX, 2, south wall of Hypostyle Hall (*fig.* 227C) MM IB/II	45 × – × 10	Average 45 × 34 × 8
	× 34 × 8	
	– × 37 × –	
	45 × 33 × 8	
3. Area IX, 1-2[5]	45 × 35 × 9	Three examples
4. Near XXI, 1 (Late use ?)	45 × 36 × 9	Average 45 × 36 × 9
	45 × 36 × 9	
5. Area XVII	50 × 37 × –	
6. Area I, 1 (Group 1)	63 × – × 9	Two sizes:
	– × 41 × 9	63 × 41 × 9 (A)
	– × 41 × 9	54 × 29 × 10 (B)
	54 × 29 × 10	
	54 × 29 × 10	
7. Area I, 1, Group 2 (Top of wall)	64 × 40 × –	Two sizes ?
	+ 55 × 40 × 9	
	+ 58 × 40 × 9	
8. Area I, 1, Group 3 (Blocking wall) Neopalatial	+ 30 × 36 × 9	Average 46 × 36 × 9
	+ 31 × 36 × 9	
	46 × 36 × 9	
	46 × 36 × 9	
	70 × 29 × 9	Three examples[6]
9. Area VII, between 2 and 5 (late)	60 × 41 × 10	Average 62 × 41 × 10
	63 × 41 × 10	
	62 × 43 × 10	
	62 × 42 × 10	
	61 × 41 × 10	
	61 × 42 × 10	
	61 × 42 × 10[7]	

[3] Guest-Papamanoli 1978, p. 14.
[4] Guest-Papamanoli 1978, p. 14.
[5] Guest-Papamanoli 1978, p. 14.
[6] Guest-Papamanoli 1978, p. 14.
[7] Guest-Papamanoli 1978, p. 14.

10. Area VI, 3, north wall (late)	59 × 34 × 8	Average 60 × 35 × 9
	60 × 35 × 9	
11. Area VI, 3, east wall (late?)	50 × 35 × 9	
12. Area II, 10, east wall	53 × 28 × 9	Average 54 × 28 × 10
	54 × 28 × 10	
	54 × 28 × 10	
	54 × 28 × 10	
	54 × 28 × 10	
	43 × 33 × –	Three examples[8]
13. Area VI, 1	– × 27 × –	Set on edge
	– × 27 × –	
	– × 27 × –	
14. Area V, 2	+ 50 ×+33 × 7	Set on edge
	59 × 37 × 9[9]	Five examples
15. Area IV, 10[10]	A. 62 × 42 × 10	
	B. 54 × 29 × 10	
16. Area X, 10[11]	52 × 28 × 10	
	50 × 28 × 14	
17. House DB[12] Neopalatial	56 × 40 × 10	Average 56 × 40 × 110
	56 × 40 × 10	
	56 × 40 × 10	
	52 × 38 × 10[13]	

Palace of Kato Zakro (Z) MM III B-LM I B

1. Room xxxii, south wall	60 × 40 × 10	
	64 × 35 × 10	
2. Room xiv, east wall	41 × 38 × 10	Average 42 × 38 × 10
	42 × 38 × 10	
	42 × 38 × 10	
	42 × 38 × 10	

[8] Guest-Papamanoli 1978, p. 14.
[9] Guest-Papamanoli 1978, p. 14.
[10] Charbonneaux 1928, p. 354.
[11] Charbonneaux 1928, p. 354.
[12] See also *Mallia, Maisons* I, p. 48.
[13] Guest-Papamanoli 1978, p. 15.

3. Room x	43 × 38 × –	
4. Outside excavation (*fig.* 225)	42 × 37 × 14	Not in situ
5. Near north court	42 × 33 × 9	Not in situ
6. Room L, south wall (*figs.* 230, 231)	60 × – × 10	
7. Room L (Fallen) (*figs.* 230, 232)	60 × – × 10 61 × 42 × 10	
8. Room xxiii	49 × 44 × 13	Set on edge
9. Room xxiv	65 × 42 × 8	Set on edge
10. Room xi	63 × 41 × 7	Set on edge
11. Room xxvii	40 × 31 × 5	Set on edge

Zakro Houses (ZH) MM III

1. House A, cellar [14]	A. 61 × 44 × 10 B. 34 × 31 × 9	
2. House I [15]	38 × 38 × 10	

Palace of Phaistos (P)

1. Lustral Basin south of Room 63	42 × 26 × 11 42 × 26 × 11 42 × 26 × 11	Restored in cement and set on edge [16]
2. Room xl (*fig.* 236)	+ 48 × 34 × 12 + 45 × 35 × 10	Set on edge [17]
3. Room lv (Steps in Early First Palace) [18] MM IB-II	36 × – × – 39 × – × 9 39 × – × 9	
4. On Stairway 66 (fallen) [19]	+ 36 × 24 × 12	

[14] Hogarth 1900-1901, pp. 130, 132.
[15] Hogarth 1900-1901, Ibid., p. 141.
[16] See also *Festòs* II, pp. 171, 179.
[17] *Festòs* I, p. 354.
[18] See also Fiandra 1961-1962, p. 120.
[19] *Festòs* I, p. 238.

5. Room x[20]	+ 28 × 30 × 11	
6. Near Room xxiii (fallen)[21]	43 × 30 × 8	
7. Room viii (fallen)[22]	43 × 27 × 11 43 × 26 × 11 43 × 26 × 11 42 × 35 × 10 + 40 × 26 × 11 + 27 × 31 × 12	

Knossos (K)

1. House alongside the Royal Road EM II	52 × 25 × 9[23]	
2. Kouloura House basement (MM I A)[24]	30 × 9 × 9	
3. Little Palace, now on parapet of «Fetish Shrine» LM II-III	45 × 34 × 12	Not in situ
4. Little Palace (LM I)[25]	45 × 45 × 12	

Sklavokambos

1. Entrance to house (MM III-LM I)	52 × 36 × 10[26]	Set on edge

Tylissos

1. House C[27] Neopalatial	– × – × 8	

Nirou Khani (LM I)

1. Room 18	43 × 35 × 11 40 × 33 × 9	
2. Room 27	– × 34 × 10	Set on edge
3. Room 7[28]	50 × 35 × 10-12	

[20] *Festòs* I, p. 241.
[21] *Festòs* I, p. 299.
[22] *Festòs* I, p. 228.
[23] Warren 1972b, p. 392 (from Guest-Papamanoli 1978, note 57).
[24] *Knossos* IV, p. 69, n.3.
[25] *Knossos* II, p. 519, fig. 320. See also Evans 1904-1905, p. 5, figs. 1, 2.
[26] Marinatos 1939-1941, p. 72.
[27] *Tylissos* (2), p. 43.
[28] Xanthoudides 1922, p. 9.

Gournia (LM I)		
1. Blocking wall in Palace storeroom [29]	– × 35 × 9	
2. West Storerooms of Palace [30]	50 × 35 × 9	
3. House Ac, Room 16 (*fig.* 235)	A. 45 × 30 × 9 B. 60 × 30 × 9	
4. Location unspecified [31]	48 × 36 × 10	
Mochlos (LM I)		
1. House C3 [32]	30 × 42 × 8.5	Six examples
Pseira (LM I) [33]	46-64 × 26-42 × 9-12	Average
Palaikastro (PA)		
1. House B (LM I) [34]	A. 56 × 42 × 14 B. 40 × 30 × 10	
2. House N [35] (LM I)	34 × 34 × 15	
Kato Chondros Viannos (LM III) [36]	40 × 35 × –	

[29] Concerning the bricks in this wall, Soles notes that they show a low ridge around their edges on one side, left from the wooden forms in which they were pressed (1991, p. 34, note 19).

[30] *Gournia*, p. 25.

[31] *Gournia*, p. 28, pl. I, no. 1.

[32] Soles 1996, p. 197.

[33] *Pseira* V, p. 31.

[34] Bosanquet 1901-1902, p. 315.

[35] Sackett, Popham and Engstrand 1965, p. 260.

[36] Platon 1957, p. 138.

APPENDIX E

TERRACOTTA PIPES, CHANNELS AND CATCH-BASINS

Terracotta Pipes

(In the following lists, «x» = measurement incomplete or unknown. Measurements in cms).

Knossos

1. Under South Porch. Round, tapering, some with handles. MM I A (*fig.* 237A)[1]. L. 78.5-82.5, D. 8.5-17.
2. Draft Board and Stone Drain-Head Area. Round, tapering, without handles. Pre-MM III (*fig.* 237B)[2]. L. 76, D. 9.3-15.3.
3. North Entrance. Round, tapering, no handles or stop-ridges[3]. L. x; smaller than above.

Tylissos

1. Near houses. Round, socketed, tapering, without handles[4]. LM I-LM III? (*fig.* 238A). L. 80 cm, 10-16.5.

Myrtos-Pyrgos

1. Villa. Two squared hollow terracotta drains with three removable tile lids. Painted with LM I motifs[5].

Palaikastro

1. Block II. Round, only 1, apparently not tapered. Reused?[6]. LM III (*fig.* 238C). L. x; D. ca. 23.

Zakros

1. House B, Room M[7]. MM IIIB-LM I A.

Gournia

1. House C 2, stored in basement[8]. MM III-LM I. L. 41.5, D. 13-17.

Phaistos

1. Room 38. Round, no taper[9]. MM IIIB-LM I A?. L. 82.1 + - 83.1 + cm; D. 7-9.

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[1] *Knossos* I, pp. 141-143, *figs.* 103, 104a; IV, pp. 146-148, *figs.* 112-114.

[2] *Knossos* I, pp. 141-142, *fig.* 104b; III, *fig.* 173; IV, p. 147; Evans 1901-2, pp. 13-14.

[3] *Knossos* I, p. 396, *fig.* 286; III, p. 253; IV, p. 147, n. 3; Evans 1901-1902, pp. 13-14.

[4] *Tylissos* (2), pp. 61-62, *fig.* 14.

[5] Cadogan 1978, p. 83, *fig.* 39 (with scale). These unusual drains are closed save at their ends and part of one side where the lid was placed.

[6] Dawkins 1904-1905, p. 290, *fig.* 16b, PL XIII.

[7] Platon 1962, p. 148.

[8] *Gournia*, pp. 24, 28; Pl. I, no. 22.

[9] *Festòs* II, p. 103; *fig.* 52.

Three-sided (U-Shaped) terracotta channels

Typology:
Type 1: U-shaped, straight ends
Type 2: U-shaped, splayed end
Type 3: U-shaped, flattened end

Knossos (all Type 1)
1. NW corner Central Court[10]. L. x, W. 12, H. 30.
2. Stone Drain-Head Area[11].
3. East of Stairway to Piano Nobile, West Wing[12]. W. 13-19, H. 9.
4. Southeastern Residential Quarter (*fig.* 239b). W. 18, H. ca. 9.
5. Caravanserai[13]. MM III-LM I.

Archanes (Types 1, 2)
1. Fourni. Burial Building 3. Six U-shaped drains, some appearing complete, three with straight ends (Type 1), three with splayed ends (Type 2)[14].

Kommos (Type 1)
1. Town site only. None complete. House X. LM I[15].

L	W	H
19.6	13.7	9
x	9.8	10.7
10.9	x	6.8
21.6	5.8	9.3

Malia (Types 1, 2, 3)
1A. House Z (Room xv). L. 25, W. 12. Neopalatial. Unusual, curving[16].
IB. House E, three sections. L. 60, W. 9-12, Th. 0.8. Type 1[17].
2. Villa A[18]. L. ca. 80, W. ca. 16. MM I? (*fig.* 238B); unique elbow; 6 sections, some splayed for overlapping (Type 2); c. 4.20 m. total L.
3. MM II Quartier Mu, Building F. Large fragment. L. 79 (Type 2)[19].
4. Palace Room?[20]. L. ca. 46 (Type 3).
5. Quartier E. L. 61, W. 13, H. 7.5. MM IIIB (Type 1)[21].

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[10] *Knossos* I, p. 230, n. I «square in section».

[11] *Knossos* I, p. 379; figs. 275, 276; Knossos III, p. 492, n. 2, fig. 341; «square-cut terra-cotta conduit» (*Knossos* I, p. 379).

[12] *Knossos* I, plan A.

[13] *Knossos* II, p. 119; figs. 48, 57.

[14] *Archanes* pp. 205, 241, and fig. 273 on p. 316.

[15] Of the many fragments from the Kommos site only the first listed here, C 319, perhaps once splayed at one end, has been published (Kommos I (2), p. 201, pl. 5.12; see also J.W. Shaw 2004, pp. 180-182, fig. 10). The fragmentary nature of the U-shaped drains at the site, where they are not found in positions of use at ground level, suggests that they functioned primarily, if not exclusively, for draining roofs.

[16] *Mallia, Maisons* II, p. 74, pl. xxii, 1.

[17] *Mallia, Maisons* II, p. 106, pl. xxviii.

[18] *Mallia, Maisons* I, p. 13, fig. 2.

[19] *Malia, Mu Artisans*, p.192, no. 392, pl. 74, 75.

[20] *Mallia* IV, pl. XLII.

[21] *Mallia, Maisons* III, p. 130 and pl. xxvi, no. 264.

Mochlos (Types 1,3)
1. Artisan's Quarters and Farmhouse. Neopalatial [22].
Type 1. (U-shaped, straight ends)

L	W	H
37.6	10.8	7.4
6.6	x	5.2
27.6	9.6	9.2

Type 3. (U-shaped, one flattened end [Type 3])

23	15 to 19	x

Petras (Type 3)
1. Drain to east of Central Court [23].

Pseira (Type 1)
1. Plateia Building, Space BY 5. Max. dim. 17.5. LM I [24].
2. Building AD North. Two fragments. LM I [25].

Gournia (Types 1, 3)
Type 1
1. Town site [26]. MM III-LM I? L. + 55, W. 10.5.
2. House D 46 [27]. MM III-LM I L. (inc.) 23.2, W. 6.9.
Type 2
1. Town site [28]. MM III-LM I. Fragmentary L. (inc.) 33.5, W. 30.5, Th. 1.2.

Palaikastro (Types 1, 2, 3)
Type 1
1. House P 17 [29]. LM III (*fig.* 238C). L. 70 (2).
2. Block A [30]. LM I.
3. Inscribed [31].
Types 2, 3
1. LM III house [32] (*fig.* 238C); 5 sections, 3 drain types, 2 flattened end (Type 3) (reused?).

[22] *Mochlos* I C, pp. 19-20. See also J.W. Shaw 2004, pp. 184-186. Only samples are included. The four examples below in their publication are no. 16, fig. 8.2, no. 25; no. 26, fig. 8.3; and no. 15.
[23] Tsipopoulou 2007, pp. 51, 53, figs. 6, 7.
[24] *Pseira* III, nos. 484 and 494, fig. 46.
[25] *Pseira* I. Building AD North 9, 10, fig. 46, pl. 23 A-B; *Pseira* V, pp. 34, 83, fig. 28.
[26] *Gournia*, p. 28; pl. I, no. 5.
[27] *Gournia*, p. 28.
[28] *Gournia*, p. 28, pl. I, no. 4. Used for «tubs or vats» in houses.
[29] Dawkins 1904-1905, p. 290, pl. XIII.
[30] Dawkins 1904-1905, p. 290, figs. 16 *a*, *b*, *c*.
[31] Davaras 1977.
[32] Dawkins 1904-1905, p. 290, figs. 16 *a*, *b*, *c*.

Zakro Palace (MM IIIB - LM IB) (See *fig.* 164, bottom row). All Type 1.
1A. North of xi. L. 62, 28, 49, W. 12, H. 9.
1B. Below «shrine» xxiii. W. 19, H. 12.
1C. Below xxv. W. 19, H. 12.
2A. Near xi. W. 12, H. 8.
2B. As above. L. 69, W. 12, H. 7.
3. Outside toilet, Room xxiia (one with lip). L. 46, W. 26, H. 11.
4. Outside toilet, Room xix. L. 80, 49 (?); W. 14.

Catch-basins

Phaistos (terracotta). Neopalatial.
1. Room 38[33]. Round, interior Diam. 23. Exit 5 (interior D.).
2. Room 69[34]. (Propylon) (*fig.* 240). Round, D. 31, H. 23.5; Triangular exit 13.5 × 11.
3. Room 74[35]. (Peristyle). Round, D. 35; H. 20.

Hagia Triadha (stone)
1. Room 54[36]. Pitharaki-shaped stone vase (*fig.* 241 a, b). Upper D. 24 cms, interior H. 44.

[33] *Festòs* II, p. 103, fig. 52.
[34] *Festòs* II, p. 325, figs. 201, 202.
[35] *Festòs* II, pp. 347, 349; figs. 217, 218, 221.
[36] Halbherr, Stefani and Banti 1980, pp. 102-103, figs. 69, 70a.

APPENDIX F

ANALYSES OF PLASTERS

No.	SITE AND AREA	DATE	CHEMICAL CONSTITUENTS						
			CaO (Calcium Oxide or Lime) %	MgO (Magnesium Oxide) %	Al_2O_3 (Alumisium Oxide) %	Fe_2O_3 (Ferric Oxide) %	SiO_2 (Silicon Dioxide) %	Burnt Remainder (CO_2&H_2O) %	TOTAL %
1A	Vasiliki, hard painted exterior coat	EM II	15.36	3.61	12.67	7.21	39.87	18.80	96.72
1B	Vasiliki, thick inner coat	EM II	21.77	2.75	9.40	7.24	32.70	23.20	97.06
2	Mallia, fragment from North Wing	MM III–LMI ?	51.42	0.68	0.09	0.25	3.59	42.87	98.90
3	Mallia, from Blocking wall in C-C'	MM III–LMI ?	25.59	2.85	3.57	6.29	23.51	28.45	93.23
4	Knossos, Royal Road Excavations, Wall ZB	LM I–LM IIIB	51.82	0.64	0.52	1.25	3.21	39.44	96.88
5	Zakro, Plaster sealing joints of Facade	MM IIIB–LM IA	49.83	0.51	1.09	2.26	4.42	40.81	98.92
6	Hagia Triadha, pavement in «Agora»	LM III ?	51.72	0.33	0.12	0.50	3.90	42.62	99.19
7A	Phalasarna, Exterior coat in cistern	C. 400 BC	24.56	3.25	3.60	3.30	38.97	22.13	95.81
7B	Phalasarna, Inner coat	C. 400 BC	24.72	1.91	4.04	5.82	37.50	21.79	95.78
8	Polirrhenia, from Roman circuit wall	100-500 AD	15.59	0.61	1.94	2.18	67.28	12.40	100
9	Peirene Spring, Corinth (Orlandos, II, 62)	500-100 BC	22.62	7.14	3,38		36.22	26.44	100

These analyses are representative. For a greater number and variety see Jones 2005.

ABBREVIATIONS

A. of C. = Pendlebury, J.D.S. 1939. *The Archaeology of Crete,* London.

Archanes = Sakellarakis, Y. and E. Sapouna-Sakellaraki. 1997. *Archanes: Minoan Crete in a New Light,* Two volumes. Athens.

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GUIDE TO SITE PLANS

This book deals with architectural details on many large sites. Publishing their state plans on single pages here, where area details would not be readable, would not help the reader and including the many foldouts needed to provide what would be useful is impractical. Listed below, therefore, are sources for plans of some of the larger built-up Minoan sites mentioned here.

Archanes
Archanes. 1997. Restored plan of Tourkogeitonia, Drawings 5 and 6, with details in text.

Gournia
Gournia. 1908. General Site Plan of settlement by Herr Sejk. 1:400. Soles 1991. Foldout plan of Palace, fig. 1, by Jeffrey S. Soles.

Hagia Triadha
Halbherr *et al.* 1977. General Restored plan in pocket. 1:200, with details, many by Stefani, in text.

Knossos
Hood and Taylor 1981. Separate plan and sections. 1:200. By William Taylor and others.

Kommos
Kommos, I (2). 1996. Foldouts of Hilltop and Hillside areas, by Giuliana Bianco. 1:75.
Kommos, IV (2). 2000. Foldouts of Sanctuary Area by Giuliana Bianco. 1:75.
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Malia
Mallia, Plans du site. 1974. *Études Crétoises* 19. Plans by Elga Anderson and others.

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Myrtos-Phournou Korifi
Myrtos. 1972. Foldout schematic plan 1 by Pat Quinn and Dennis Sykes. 1:160. Detailed plans in text.

Palaikastro
fig. 1.1 in MacGillivray 2000. Detailed plans in various BSA reports.

Phaistos
Festòs I. 1935. Restored plan of Palace in pl. II. Detailed plans in text, also in Festòs II, 1951.

Festòs 1976-1988. Plate B is plan of Palace by R. Oliva and E. Stefani. 1:200. Plate C is plan of southwestern Protopalatial rooms and façade by R. Oliva. 1:100.

Pseira
McEnroe 2001. Schematic site plan in *fig.* 1 and separate house plans in text.

Tylissos
Tylissos 2. 1934. *Études Crétoises* 2. Foldout restored plan (Pl. xxxiii) with details in text.

Zakros
Platon 1971. Restored plan of Palace pp. 80-81, by Joseph W. Shaw and others. Detailed plans in text.

Platon 1974. Foldout restored plan of Palace and surrounding town, by Joseph W. Shaw and others. Detailed plans in text.

ILLUSTRATION CREDITS

Unless specified below, photographs were taken by the author, with the permission of the respective authorities. The Italian School of Archaeology in Athens has furnished figs. 33, 48, 58 a, 58 b, 241 a; The French School of Archaeology in Athens, fig. 139; Stylianos Alexiou, fig. 53; the late Mark Cameron, figs. 244, 248, 249, 250, 251; Kenneth Sams, fig. 224, Gerhard Plath fig. 9; Peter Warren, fig. 77. Gerald Cadogan kindly furnished the images of Myrtos-Pyrgos (fig. 211 b and cover illustration). George Xylouris took the following photographs for the author: figs. 35, 37 a - 46, 60, 96, 118, 199, 218, 226, 245, 252, 255 b, 258. These drawings were made by the author, sometimes with the help of Giuliana Bianco, on the basis of his own measurements: figs. 23, 28, 31 c, 32 b, 49, 65, 67, 69, 87, 90, 91, 93, 107, 112, 122, 136, 151, 164, 165, 170 a, 170 b, 171, 175, 177, 188, 193, 196, 197, 208, 210 a, 210 b, 211, 212 a, 212 b, 216 (c-g), 223, 227, 239. Maria C. Shaw drew the tools in fig. 36 and took the photographs in figs. 84 and 125 a. Drawings adapted by the author from published drawings are the following: figs. 49 c, 179, 186, 206, 207, 216, 217, 222, 238, 246. Those reproduced directly from material published by others are: figs. 6, 19, 24, 34, 47, 123 c, 168, 181, 182 b, 183, 184, 185, 188, 191, 192 b, 192 c, 237, 241 a, 241 b, 260, 261, 263, 264, 267-271. I am indebted to the British School of Archaeology at Athens for the use of figs. 24 and 271; the French School of Archaeology for figs. 6, 183, 184 and 261; Biblo and Tannen Publishers for figs. 34, 168, 181, 182 b, 191, 237, 241 and 260; the Hirmer Verlag for figs. 19 and 270 and I thank Eric Hallager for fig. 192c, Spyridon Iakovides for fig. 269, Michael Nelson for figs. 266-268, Angeliki Lembessi for fig. 264, Clairy Palyvou for figs.185 and 263, also Jeffrey Soles for fig. 47.

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145. Palace of Knossos - Column bases on wall in East Wing (not in situ).

146. Kato Zakro - Column base once set into a floor (not in situ).

147a. and b. Kommos, South Stoa (a) column base S 2265 before removal and (b) its subbase after removal, showing pebbles for setting (from *Kommos* V, Pl. 1.136 f and g).

148a. Kommos - Column base S 2236 of North Stoa set above base S 2253 from South Stoa. Note similar finishing marks (from *Kommos* V, Pl. 1.137).

148b. Kommos - Plan showing column base S 2253 in South Stoa with setting marks incised on its foundation slab (by Giuliana Bianco, from *Kommos* V, Pl. 1.138).

149. Palace of Phaistos - Base with two mortises (not in situ).

150. Hagia Triadha - Column base in Room 21.

151. Sketches of parapet bases at Knossos, Northwest Lustral Basin (gypsum) (A); Phaistos, Room 19 (gypsum) (B); Knossos, Grand Staircase (gypsum) (C); and Knossos, north of the Hall of the Double Axes (limestone) (D) (by author).

152. Palace of Knossos - Parapet of Grand Staircase with base and column restored.

153. Palace of Phaistos - Stylobate and its foundation along western side of Central Court.

154. Palace of Phaistos - Central Court - Foundation slab for column base.

155. Palace of Knossos - East Hall - Column base on foundation.

156. Palace of Knossos - Slab foundations for columns of Stepped Portico.

157. Archanes - Phourni - Pillar in ossuary.

158. Kato Zakro - Pillar in basement room of House A, excavated by Hogarth.

159. Palace of Phaistos - Plan of base slab on western side of entrance to Corridor 41 (by author).

160. Palace of Phaistos - Drain cut in bedrock near Court 64.

161. Hagia Triadha - U-shaped LM III stone drains (looking south).

162a. Palace of Knossos - Basement of East Hall - Partially restored drain head and water channel.

162b. Palace of Knossos - Turn in course of drain in fig. 162a.

163. Palace of Knossos - Court of the Stone Spout - End section of drain leading to court (looking east) (see also fig. 101).

164. Minoan Drains - Top Row: Sections of stone drains at Vathypetro (in front of Megaron and in Press area); Palaikastro (near House N); Knossos (Royal Road); Palace of Kato Zakro (Room xxviii) - Bottom Row: Sections of terracotta drains in the Palace of Kato Zakro (Room ix, xxv, xxiii) (by author).

165. Palace of Kato Zakro, plan of stylish drain in Room xxviii (see fig. 164, 166) (by author).

166. Palace of Kato Zakro - Western section of limestone drain in fig. 165 (see also fig. 164).

167. Palace of Knossos - Drain and catch-basin at East Bastion.

168. Palace of Knossos - Plan and section of southwest part of vertical drain shafts in Residential Quarter (by Christian C.T. Doll, from *Knossos*, I, fig. 171 b, c).

169. Palace of Knossos - Catch-basin along eastern side of Court of the Distaffs.

170a. Hagia Triadha - Sections of built drains (by author).

170b. Palace of Kato Zakro - Sections of built drains (see also fig. 171).

171: Palace of Kato Zakro, plan of a portion of the drainage system in the East Wing (for sections indicated see fig. 170 b, by author).

172. Hagia Triadha - Lower part of vertical drain shaft.

173. Palace of Malia - Impression in clay of side of column once set on marble base (partly restored).

174. Palace of Malia - Impression of column-shaft (left) and vertical prop (right) in blocking wall (partly restored).

175. Palace of Kato Zakro - Room xxviii - Actual and restored plans of props, a pier and a pillar reinforced with wood (see also fig. 176) (by author).

176. Palace of Kato Zakro - Pillar in Room xxviii (looking west) (see also fig. 175).

177. Palace of Kato Zakro - Room xvi – Plan of pier at end of wall (by author).

178. Tylissos - House A - Forms of wooden props in eastern wall of Room 3 - Note cavities for horizontal struts (see also fig. 179).

179. Tylissos - Schematic section through props in wall (after *Tylissos* [2], fig. 11) (see also fig. 178).

180. Hagia Triadha - Bench, partly restored dado and sockets for vertical beams in Room 4 (cf. fig. 83).

181. Palace of Knossos - Schematic drawing looking west in the Hall of the Double Axes (from *Knossos* III, fig. 225).

182a. Palace of Knossos - Restored north exterior wall of the Hall of Double Axes (beam bedding at arrow) (looking south).

182b. Palace of Knossos, plan of area of Queen's Megaron (from *Knossos* III, fig. 249; west is at top of page).

183. Malia. Restored view looking west of wooden window/door combination in the MM II Hypostyle Crypt (from *Mallia, Centre Politique* II, PL. II [3]) (see also fig. 117).

184. Malia - MM II Building A in Quartier Mu. Plan of first stage of pier-and-door partitions (*polythyra*) with Halls (I 13 east, west) and light-well (I 1a) (from Poursat and Schmid 1992, fig. 30) (see also fig. 139) (by Martin Schmid).

185. Akrotiri, Thera - Layout of horizontal timber reinforcement showing typical structural details (from Palyvou 2005, fig. 171) (by Clairy Palyvou).

186. Tylissos - Schematic plans of types of doorjamb bases, showing those for single (1, 2) and double (3, 4) doorways (after *Tylissos* [2] fig. 13).

187. Hagia Triadha - Restored and unrestored jambs in Room 3.

188. Hagia Triadha - LM III double pier-and-door partition entrance in Shrine H (by author).

189. Tylissos - House C - Partly restored jamb without horizontal timber.

190. Palace of Phaistos - Clay lump with impressions of wood discovered in Propylon (Room 69).

191. Knossos - Temple Tomb - Isometric view of wooden roof construction (by Piet de Jong, from *Knossos* IV, fig. 932).

192a. Kommos - Plaster ceiling fragment, with impressions of reeds laid parallel to each other, positioned in ceiling as seen on left (from *Kommos* V, Pl. 2.31) (by Julia Pfaff).

192b. Phaistos - Plaster ceiling fragment with impressions of ceiling beams set one next to another (from Militello 2001, fig. 34) (by G. Fatuzzo).

192c. Chania - Ceiling fragment. Left: side view showing outline of rafters. Right: top of same fragment with impression left by rough-cut bottom of floor plank (from Hallager 1990, fig. 4).

193. Palace of Knossos - Plan of reused blocks with clamp cuttings in Northwest Area (by author).

194. Palace of Knossos - Detail of limestone block B in fig. 193.

195a. Tylissos - House C - Mortise for clamp (arrow) and bedding for beam cut in wall-block, Room 15 (looking southwest).

195b. Tylissos - Detail of mortise in fig. 195a.

196. Plans of triangular corner piers at Knossos (A, B) and Malia (C) (by author).

197. Plans of thresholds in Malia, House E (A) and House Za (B) (by author) (see also fig. 59).

198. Malia - Chrysolakkos - Krepidoma of North Façade (looking east).

199. Malia - Chrysolakkos - Detail of krepidoma block with two drilled holes.

200. Tylissos - House C - Complete pillar in Room 2 - Note square mortises on topmost block.

201. Tylissos - House A - Complete pillars bordering court in Room 15 (looking northwest).

202. Palace of Malia - Three (of six) blocks in Hypostyle Hall (Room ix, 2) (looking east).

203. Kommos - Restored view of wood-reinforced pier at eastern end of North Stoa. (from *Kommos* V, Pl. 1.56) (by M.C. Shaw).

204a. Kommos - Restored stairway plans and section in Neopalatial Building T, Rooms 5A/5B (see also fig. 204 b) (by Giuliana Bianco, from *Kommos* V, Pl. 1.35).

204b. Kommos - Two ashlar blocks with dowel mortises, once set as indicated at turns of the stairway in fig. 204 a (by Giuliana Bianco, from *Kommos* V, Pl. 1.133).

205. Palace of Phaistos - Bottom of partly restored pier in Room 50 - Semi-circular holes left in cement allow one to inspect mortise sockets.

206. Palace of Knossos - Details of a pillar and piers, showing distribution of mortises (after ground floor plan of Residential Quarter, in *Knossos* III, Plan E).

207. Palace of Knossos - Plans of two mortised piers (after first floor plan of Residential Quarter, in *Knossos* III, plan F).

208. Hagia Triadha - Jamb-bases and square pier base south of Room 3 (by author).

209. Palace of Knossos - East Wing - Pier base at turn of stairway.

210a. Palace of Kato Zakro - Isometric drawing of pier base in Room lviii (see also fig. 210b) (by author).

210b. Palace of Kato Zakro - State and restored plans of pier in fig. 210a (by author).

211a. Palace of Phaistos - Pier base next to southern wall of Room 23 (by author).

211b. Myrtos-Pyrgos stairway, showing details of pier bases alongside parapet.

212a. Hagia Triadha - Actual-state drawings of window in Room 2 (see also fig. 212b,c) (by author).

212b. Hagia Triadha - Restored drawings of area in fig. 212a, 212c (by author).

212c. Hagia Triadha - Window-opening in Room 2 (see also figs. 212a,b) (looking southwest).

213. Palace of Kato Zakro - Room xxviii - Paved light-well with windowsill behind (looking northwest).

214. Palace of Knossos - Restored window in the Court of the Distaffs (looking southeast) (see also fig. 217B).

215. Palace of Knossos - Looking west along East-West Corridor - Window is on left (see also fig. 216A).

216. Plans of tops of walls with mortises at Knossos, Light-well of Hall of the Double Axes (A) (after *Knossos* III, Plan E) (see also fig. 215); Palace of Knossos, windowsills on walls east of Queen's Megaron (B,1) and south wall of Hall of Colonnades (B,2) (after *Knossos* III, Plan E); Gournia, near Room 23 (C); Malia, North Court (D); Palace of Phaistos, along Corridor 41 (E); Hagia Triadha, three windowsills along Rampa dal Mare (F); Palace of Phaistos, along northwestern side of Central Court (G) (see also fig. 221).

217. Plans of windowsills - Palace of Knossos, sill bordering Queen's Megaron on east and south (A) and (B) sills in the Court of the Distaffs (both after *Knossos*, III, Plan E) (by author).

218. Palace of Malia - Sill bordering southern side of Central Court (looking west) (see also fig. 219).

219. Palace of Malia - Plan of sill in fig. 218 (by author).

220. Hagia Triadha - Unexcavated (perhaps blocked) window in light-well of Room 21 - arrow indicates location of mortise (looking north).

221. Palace of Phaistos - Top of wall along northwestern side of Central Court - note beam bedding and mortises (see also figs. 62b and 216G).

222. Knossos - Temple Tomb - Plan of southern wall of Sepulchre (partly after *Knossos*, plan in Volume IV).

223. Isometric drawings of pier-jambs in storerooms at Knossos (between Magazines 6 and 7) (left) and Phaistos (between Magazines 35 and 36) (right) (by author).

224. Separate mud bricks (above) and mud in a wooden framework or mold (below) which has not yet been lifted up (courtesy Kenneth Sams).

225. Kato Zakro - Two Minoan mud bricks (not in situ).

226. Texture of mud mortar - Note impressions of disintegrated binding material.

227. Palace of Malia - Three sections of mud brick walls (by author).

228. Palace of Malia - Southern wall of v, 2.

229. Palace of Malia - Room iv, 10 - Niche with mud bricks set on edge.

230. Palace of Kato Zakro - Room L - Intact (A) and fallen (B) sections of mud brick walls (looking south) (see also figs. 231, 232).

231. Palace of Kato Zakro - Wall A in fig. 230 - Vertical inked lines indicate joints between separate bricks.

232. Palace of Kato Zakro - Detail of fallen wall (B) in fig. 230.

233. Palace of Kato Zakro - Partitions in Room xxii (looking south).

234. Palace of Kato Zakro - Supports for archives in Room xvi (looking south).

235. Gournia - House Ac - Plan and partial section of partition wall (by author).

236. Palace of Phaistos - Room xl - Partially restored partitions of mud brick.

237. Palace of Knossos - Terracotta waterpipes from South Porch (A) and Area of the Stone Drain-Head (B) (from *Knossos* I, fig. 104).

238. Waterpipes and channels of terracotta from Tylissos (A), Malia (B) and Palaikastro (C) (after *Tylissos* [2] fig. 14 [A here]; *Maisons* I, fig. 2 [B here]; Dawkins 1904-1905, p. 289, fig. 16 [C here]).

239a. Palace of Kato Zakro - Room xi - Terracotta drainage channel.

239b. Palace of Knossos - Southern Residential Area - Terracotta drain.

240. Palace of Phaistos - Room 69a - Modern replica of ancient catch-basin set below floor level.

241a. Hagia Triadha - Northwestern residential area - looking south at portico and light-well 54 with catch-basin (from Halbherr *et al.* 1977, fig. 69) (see also fig. 241 b) (by E. Stefani).

241b. Catch-basin in fig. 241 a (from Halbherr *et al.* 1977, fig. 70 a).

241c. Interior corner construction at Hagia Triadha in light-well 54 (from Halbherr *et al.* 1977, fig. 69) (see also fig. 241 a) (by E. Stefani).

242. Palace of Kato Zakro - Tiles of terracotta and «*tarazza*» used for floor-paving in Room ix (see also fig. 258).

243. Vasiliki - Detail of wall plastering.

244. Knossos - Section of thick lime plaster (courtesy Mark Cameron).

245. Gournia - Partially restored plaster float of steatite (LM I).

246. Kommos - Bronze trowel (?) for pointing masonry joints.

247. Kommos - Palm-sized stone burnishers for plastering. Plaster still adhering is shown in uneven patches. Scale 1:2. (from *Kommos* I [1], Pl. 8.93) (by Harriet Blitzer).

248. Knossos - Imprints of fingers in a lump of gypsum plaster from a limner's bowl found in a cist in the Long Corridor in the West Wing of the Knossos Palace (courtesy Mark Cameron).

249. Knossos - Fragmentary LM III bowl partially filled with plaster (courtesy Mark Cameron).

250. Knossos - Profile of lump of plaster (courtesy Mark Cameron).

251. Knossos - Holes of square wooden dowels in fragment of wall plaster (courtesy Mark Cameron).

252. Tylissos - Back face of wall plaster - Note impressions of straw binder.

253. Tylissos - House C - Coarse mud plaster with impressions of straw binder in Corridor B.

254. Malia - Hypostyle Crypt - Fine lime plaster (1) applied on backing of small stones (2).

255a. Palace of Malia - Layers of plaster on wall in Room xxiv, 1.

255b. Palace of Malia - Detail of block of West Façade - Note very thin plaster layer still adhering to wall surface.

256. Palace of Malia - Corridor C-C' - Detail of wall showing lime plaster (1), mud plaster backing (2) and mud brick (3) in blocked doorway.

257. Palace of Malia - North Court - Remains of plaster water-channel.

258. Palace of Kato Zakro - Detail of worn *tarazza* floor in Room ix (see also fig. 242).

259. Palace of Kato Zakro - Side-view of partially preserved *tarazza* floor in Room lxi.

260. Knossos - Schematic sections of *tarazza* floors (from *Knossos* II, fig. 185).

261. Malia - Quartier Mu - MM II Building B. Three sections through two rooms showing (center) positions of thin lengths of wood laid on rafters covered with clay plaster, with detail (above) showing mud brick used to raise floor level and (below) reflected plan of ceiling construction (note doorway) (from Schmid 1996, figs. 43-44).

262. Malia - Quartier Mu - MM II Building A. Plan (below) with section (above) showing use of rough-cut beams in stairway in which the lower treads were plastered clay and the top two were planks (from Schmid 1996, fig. 45).

263. Akrotiri, Thera. Details of a well-preserved Theran roof with a splayed terracotta spout and projecting stone slabs, from a building next to the South House (from Palyvou 2005, fig. 185).

264. House model from Archanes (from Lebessi 1976, figs. 4-7) (by K. Iliaki).

265. Akrotiri, Thera. Section of a fallen roof fragment with multiple renewals from the West House.

266. Plan of Pylos Palace, showing locations of piers at wall corners and wall-ends (*antae*) (from Nelson, 2001, fig. 7) (by Michael Nelson).

267. Pylos Palace, plan and elevation of orthostate wall, with double-axe mason's mark, below Room 7 (from Nelson 2001, fig. 22) (by Michael Nelson).

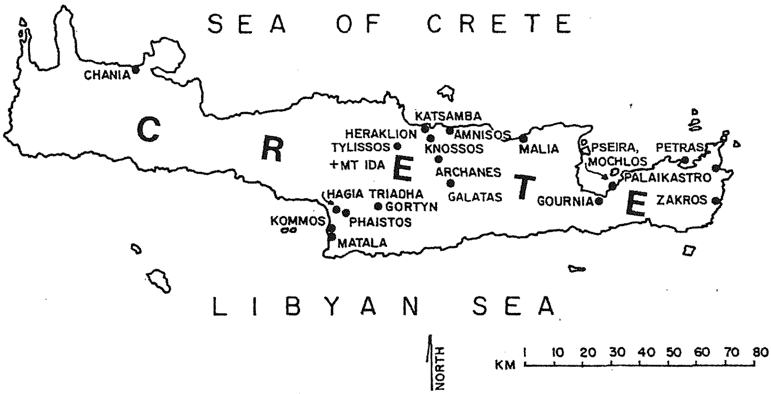
268. Pylos Palace, plan and elevation of orthostate wall northeast of Room 42 (from Nelson 2001, fig. 23) (by Michael Nelson).

269. Gla. Restored (above) and state plans of hard limestone threshold slabs with bored holes for pivots (below) at *polythyron* entrance into Room 3 (from Iakovides 1989, fig. 22) (by Sp. Iakovides).

270. Mycenae. Treasury of Atreus Façade (from Marinatos and Hirmer 1973, fig. 34) (after Sp. Marinatos).

271. Mycenae. Palace. Restored Grand Stairacse leading up to Mycenae Palace (from Wace *et al.* 1921-1923, fig. 34) and (below) state plan of same area (from Wace *et al.* 1921-1923, State Plan) (plans by Piet de Jong and Leicester Holland, respectively).

1A – MAP OF THE AEGEAN AREA.



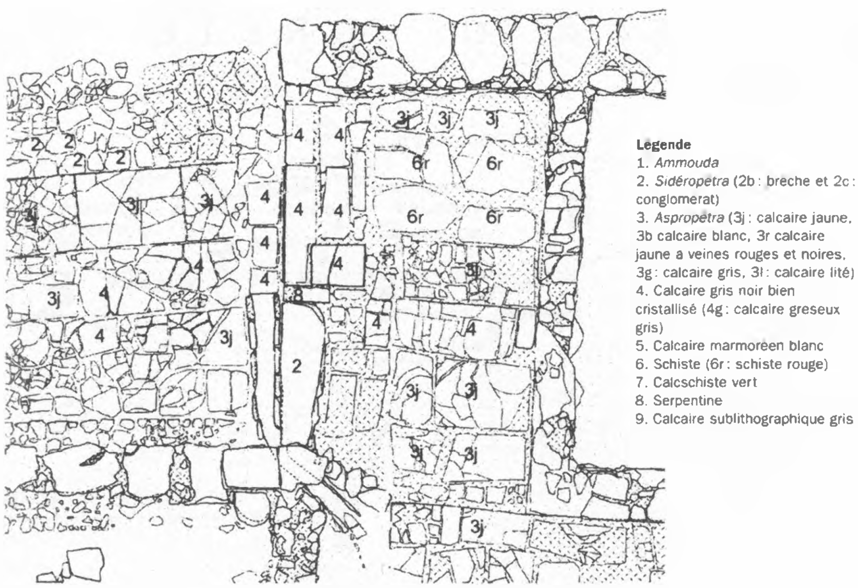
1B – MAP OF CRETE WITH SITES.

2 – Palace of Knossos - Western Entrance (looking southwest).

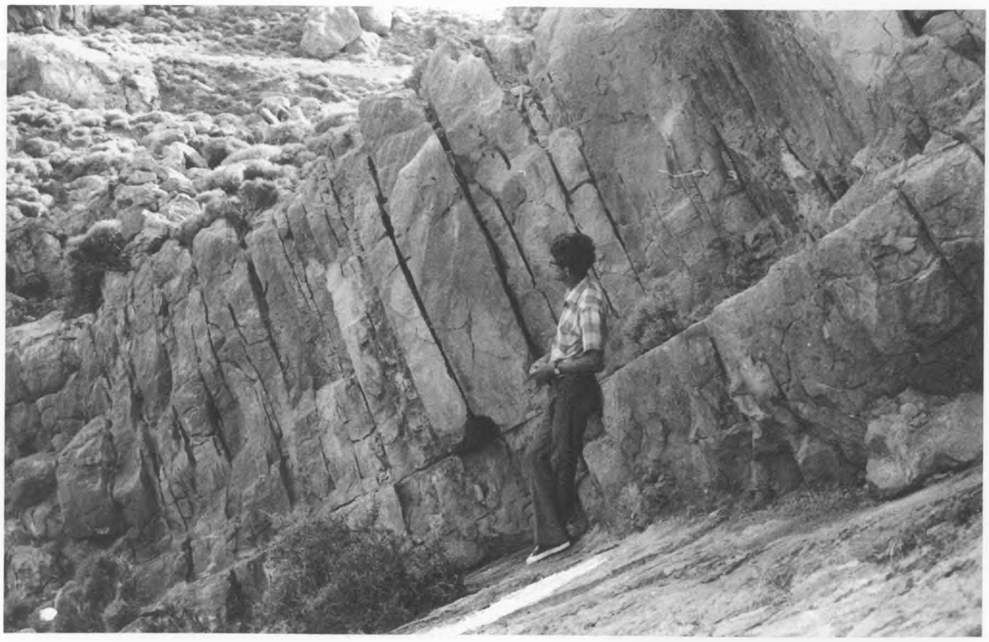
3 – Palace of Knossos - Royal Road (looking southeast).

4 – Palace of Malia - Northwest Entrance (looking west).

5 – Palace of Malia - Northwest Entrance - Detail of cut jamb-base of serpentine (1), sideropetra threshold block (2) and paving slab (3).



6 – Palace of Malia - State plan of Northwest Entrance with stone types indicated (from Dimou *et al.* 2000, Fig. 2).



7 – KATO ZAKRO - SLOPING LIMESTONE FORMATION SOUTHEAST OF PALACE, WITH AUTHOR (LOOKING SOUTH).

8 – MALIA - «TA STENA» - PARTLY QUARRIED LIMESTONE FORMATION.

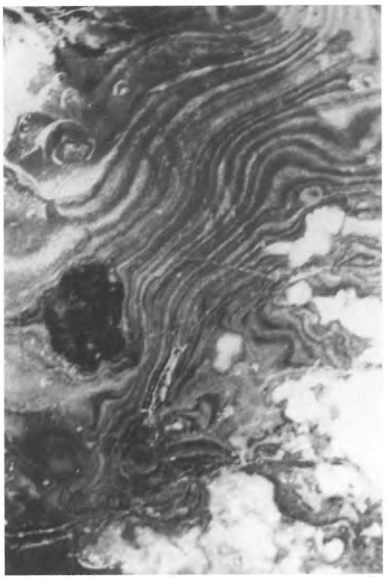
9 – SOUTHEAST *SIDEROPETRA* QUARRY AT CHOIROMANDRES IN ZAKROS AREA (BY G. PLATH).

10 – NIROU KHANI - MAIN COURT, PAVING SLABS OF HARD LIMESTONE.

11 – PALACE OF KNOSSOS - QUEEN'S MEGARON, PARTLY RESTORED PAVING.

12 – Nirou Khani - Dado and pavement in Room 5.

13 – Knossos - South House - Monolithic doorjambs of gypsum (lintel of door and ceiling are restored).

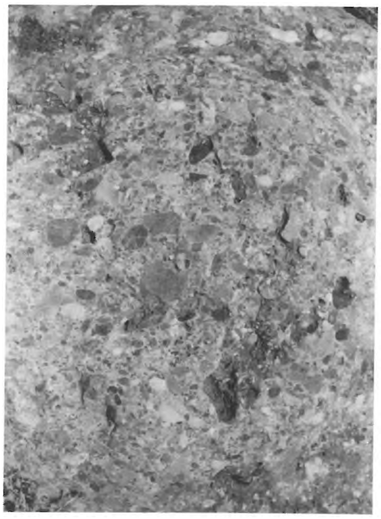


14 – Nirou Khani - detail of veining in scorched gypsum slab.

15 – Rogdhia - Thick layers of green schist in road-cut.

16 – Sphakia - Layers of decomposed schist (lepidha) in modern quarry.

17 – Nirou Khani - Schist paving slabs in main court.



18 – Malia - House Za - Close-up of column base composed of pebbly conglomerate.

19 – Knossos - «Triglyph and rosette» limestone frieze from northwestern entrance, West Wing, Knossos Palace.

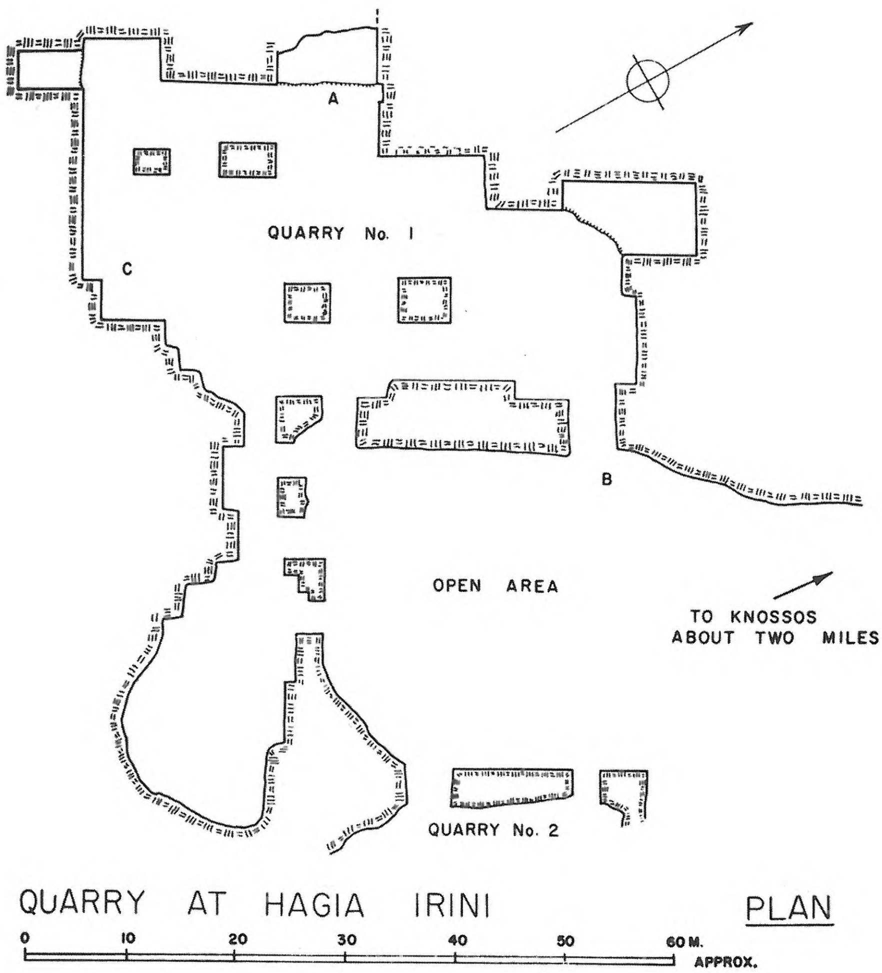
20 – Zakro - Sandstone quarry at Pelekita (looking east) (see also Fig. 21).

30 A – MALIA - HAGIO PNEVMA. DETAIL OF CIRCULAR HOLE WITH WHITISH RIM.

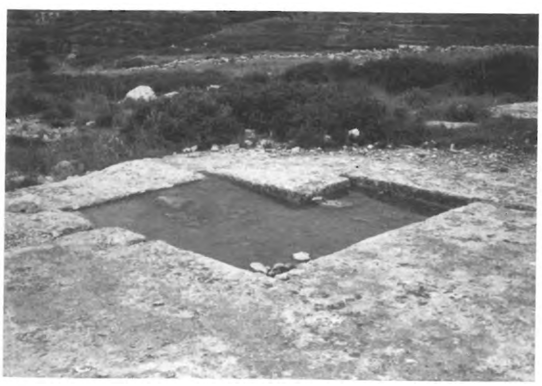
31 A – KNOSSOS - HAGIA IRINI - ENTRANCE TO LIMESTONE QUARRY (SEE ALSO FIGS. 31 B,C).

30 B – PALACE OF MALIA - WESTERN FAÇADE. BLOCK WITH CIRCULAR WATERWORN HOLE.

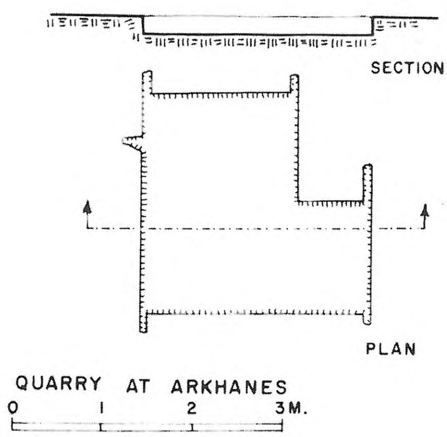
31 B – KNOSSOS - HAGIA IRINI - INTERIOR VIEW (LOOKING TOWARD ENTRANCE).



31c – Knossos - Hagia Irini, partial plan of limestone quarries (by author).

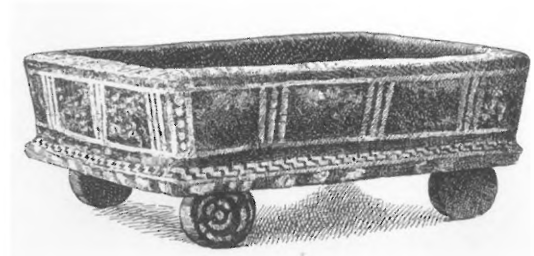


32a – Archanes - Phourni - Hillside quarry for limestone slabs (see also Fig. 32 b).

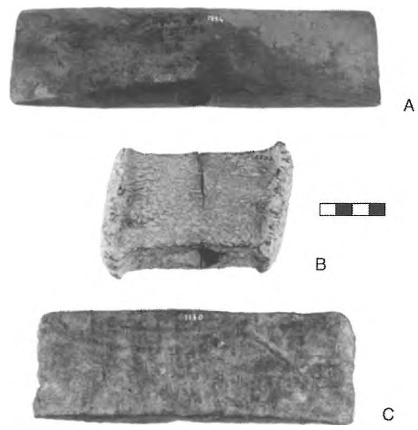


32b – Archanes - Phourni - Plan and section of quarry in Fig. 32a (by author).

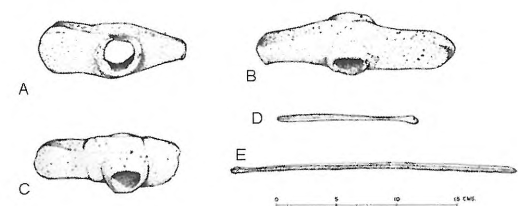
33 – Hagia Triadha - Ancient gypsum quarry being excavated.



34 – Terracotta wagon from Palaikastro (MM IA; from *Knossos* IV, Fig. 787).



35 – Minoan Tools - Hagia Triadha, typical double-axe (A); Kato Zakro, double-axe once used as a hammer (B); Palaikastro, adze (?)(C).



36 – Minoan Tools (LM IB) - Palace of Kato Zakro - Pick-adzes (A, B) double-adze (C); drill or chisel (D); drill (E) (by Maria Shaw).

37a – Minoan Tools - Hagia Triadha, pick-adzes (A, B); Palaikastro, axe-adze (C) (see also Fig. 37b).

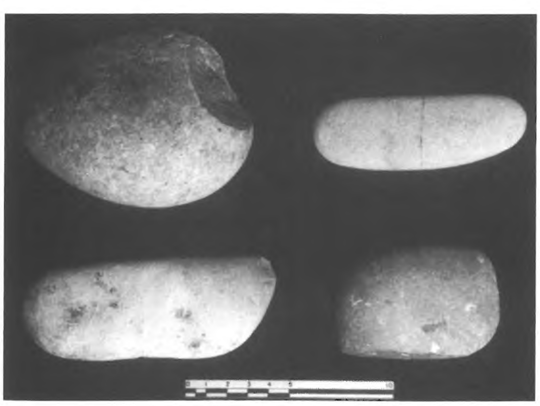
37b – Minoan Tools - Underside of tools in Fig. 37a (same order).

38 A – Minoan double-adzes from Hagia Triadha (A); Kato Zakro - House G (B); Hagia Triadha (C) (see also fig. 38 B).

38 B – Minoan tools - Other side of tools in Fig. 38 A (same order).

39 A – Hagia Triadha - Minoan sledgehammers (A) and (B) (see also Fig. 39 B).

39 B – Hagia Triadha - Minoan sledgehammers in Fig. 39 A.



40 – Kommos - Naturally formed, hand-size cobbles used as hammers, often for crushing (from *Kommos* V, Pl. 4.21).

41 – Palace of Kato Zakro - Bent (intentionally folded ?), toothed saw - Note sets of holes for attachment of handle (ca. 1.22 m. long; LM IB).

42 – Hagia Triadha - Toothless mason's saw (preserved length 0.50 m).

43 – Palace of Kato Zakro - Bent, toothless saw (total length preserved 0.88 m).

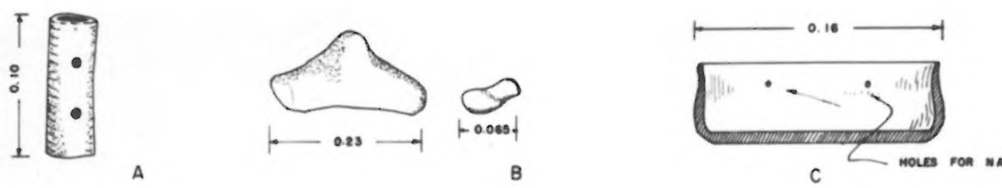
44 – Hagia Triadha - Front (A) and side (B) views of saw teeth.

45 – Minoan chisels (LM I?) from Gournia (A), Ziros (B), Gournia (C).

46 – Minoan chisels from Gournia (A), Pseira (B, C) and a drill from Gournia (D).

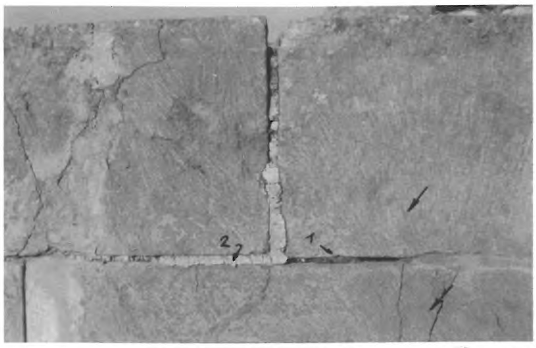
47 – Minoan rasp from Mochlos, with teeth and (detail) file-like surface on handle, for carpentry (courtesy Jeffrey Soles).

48 – Minoan MM whetstones from Phaistos (courtesy Italian School of Archaeology).



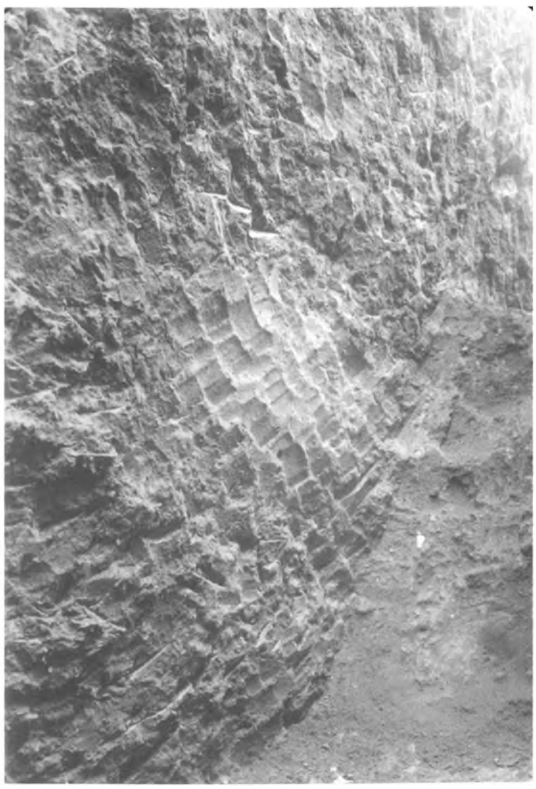
49 – Minoan tools and pivot - Gournia, tubular saw-handle (A); Gournia, stone hammers (B); Malia, section of round bronze cap for door pivot (D) (after *Gournia*, Pl. III, nos. 27, 38, Pl. IV no. 66 [A and B here]; *Mallia* II, Fig. 12 [C here]) (by author).

50 – Hagia Triadha - Detail of modern (reconstructed) wall of blocks of poros limestone near «Potter's Workshop», showing marks of Minoan pick or chisel (at 1), smoothed Minoan blocks (at 2) and block cut by post-Minoan (modern?) toothed chisel (at 3).



51 – Phaistos - Corridor 41 - Detail of coursed ashlar masonry showing overlapping marks (at arrows) from final finishing, mud mortar (at 1) and waterproofing plaster in joints (at 2).

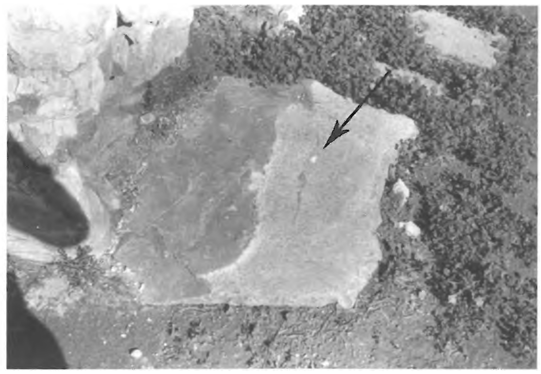
52 – Tylissos - House C - LM III settling basin alongside western wall - Note pick-marks on interior.



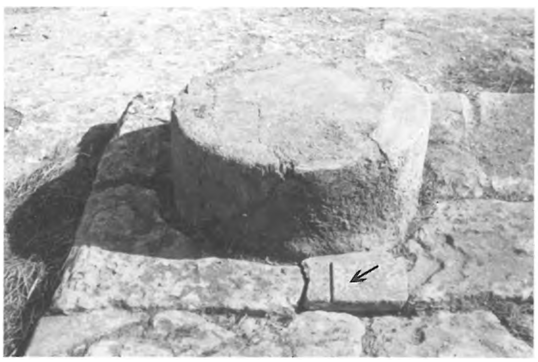
53 – Katsamba - Double-adze (or pick) marks of LM date on bedrock wall of Chamber Tomb Z (courtesy Stylianos Alexiou).

54 – Knossos - Workman breaking up blocks of poros limestone with a sledgehammer.

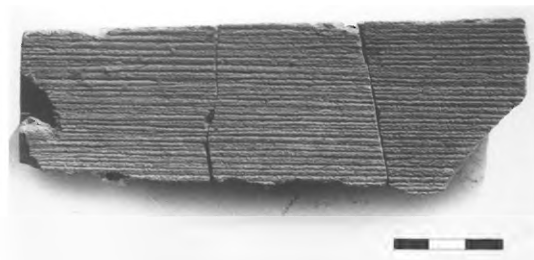
55A – MALIA - CHRYSOLAKKOS - HAMMERED KREPIDOMA BLOCK OF BLUISH-GRAY LIMESTONE (NORTHERN WALL).



55B – PALACE OF MALIA - AREA VI - HAMMERED SURFACE (AT ARROW) ON SLAB OF HARD BLUISH LIMESTONE.



56 – PALACE OF PHAISTOS - ROOM 64 - SAW-CUT (AT ARROW) IN STYLOBATE SLAB OF SOFT LIMESTONE.



57A – KATO ZAKRO - HOUSE E, ROOM 10 - MARKS LEFT BY SAW ON FRAGMENT OF HARD LIMESTONE THRESHOLD. VERTICAL LINES ARE BREAKS IN STONE (LENGTH OF FRAGMENT C. 0.20 M).

57B – TYLISSOS - HOUSE C, ROOM 10 - SQUARED THRESHOLD SLAB OF HARD GRAY LIMESTONE.

57C – PSEIRA - DISCARDED EDGE FROM SAWN SLAB OF GREEN CALCAREOUS SCHIST.

57D – Hagia Triadha - Side of squared paving slab in upper court - Hard grayish-white limestone. Note bottom of saw-cut.

57E – Palace of Malia - North Court. Overlapping saw marks on paving slab.

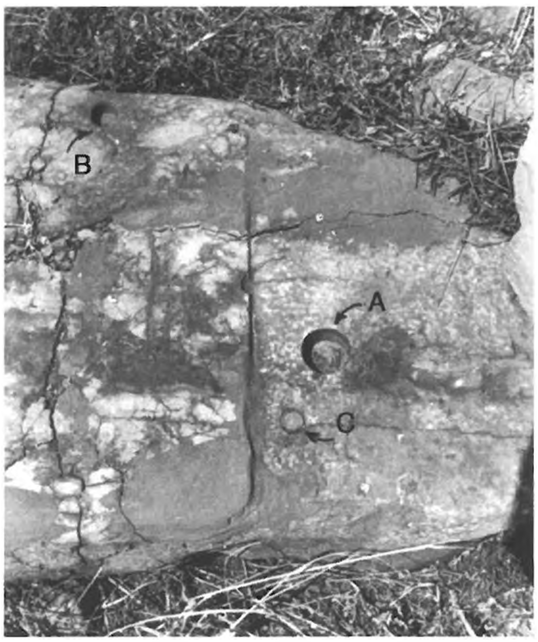
57F – Palace of Kato Zakro - Northeastern corner of Central Court - Detail of over-cutting on pier-base - Saw-cut to left of and below arrow.

57G – Palace of Knossos - Lapidary's Workshop - Blocks of imported *lapis Lacedaemonius* - Note saw-cut at arrow.

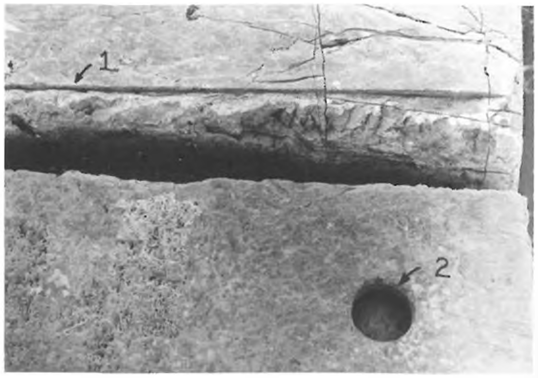
57H – Palace of Phaistos - Central Court. Squared block of hard-veined limestone.

58A – Hagia Triadha - Cutting of large slabs of gypsum for modern restoration work - The saw-frame is partially supported by ropes; the steel saw is toothed. Man in center adds water to cool the blade and to reduce friction.

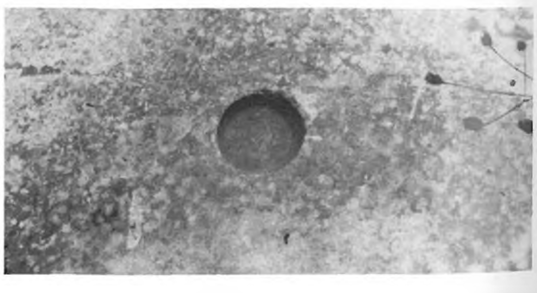
58B – Hagia Triadha - A workman trims a gypsum slab with a hand-saw - Steel saw-blade is toothed (see also Fig. 58A).



59 – Malia - House Za - Eastern end of threshold, showing two drilled holes with cores removed (A, B) and one incomplete drilling (C) - Hard gray-blue limestone (see also Fig. 197).



60 – Malia - Chrysolakkos ossuary - Krepidoma block with saw-cut (1) and drilled hole (2). The hole is 4.5 cm in diameter and 3 cm deep.



61 – Malia - House E - Jamb-base of hard blue limestone with «saucer-shaped» drill-hole (diameter 5 cm).

62 A – PALACE OF PHAISTOS - MAGAZINE 29. JAMB WITH CHISEL MARKS.

62 B – PALACE OF PHAISTOS - CENTRAL COURT - WALL-BLOCK IN SECOND COURSE IN NORTHWESTERN CORNER - NOTE TOOL MARKS (FOR TOP OF BLOCK, SEE FIG. 221).

62 C – KNOSSOS - LITTLE PALACE - PILLAR-BLOCKS WITH UPPER CORNERS RESTORED IN CEMENT. NOTE TOOL MARKS.

62 D – PALACE OF KATO ZAKRO - SOUTH WING. NOTE TOOL MARKS ON WALL-BLOCK.

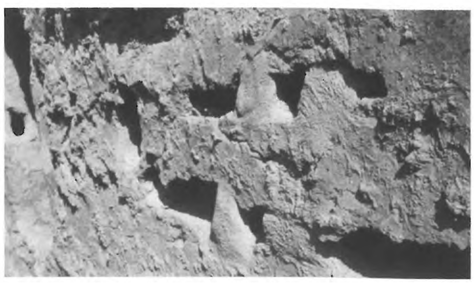
62 E – FIRST PALACE OF PHAISTOS - DETAIL OF BLOCK IN FIG. 88.

62 F – FIRST PALACE OF PHAISTOS - REUSED WALL-BLOCK IN CORRIDOR L.

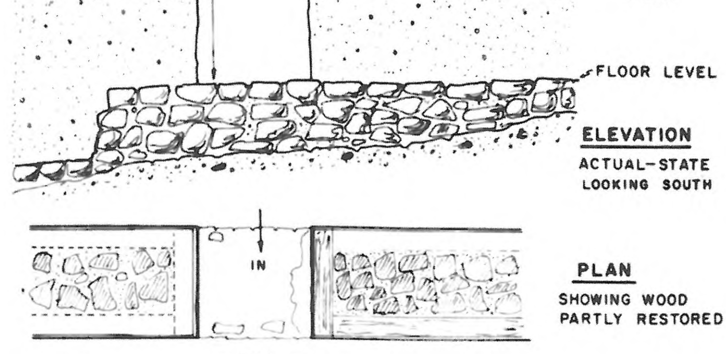
63A – PALACE OF PHAISTOS - MARKS OF CHISELS OR PICKS ON WESTERN KREPIDOMA OF MAGAZINE BLOCK (SEE ALSO FIGS. 26, 50 [AT 1]).

63B – PALACE OF PHAISTOS - BACK FACE OF WALL-BLOCK IN ROOM 43 - AREA OF PHOTOGRAPH C. 0.55 BY 0.75 M (SEE ALSO FIG. 99 B).

63C – PALACE OF PHAISTOS - WESTERN SIDE OF CORRIDOR 41 - ENDS OF WALL-BLOCKS SHOWING SMOOTHING OF JOINTS.



64 – VASILIKI - PARTIALLY RESTORED WALL, SHOWING HARD PLASTER FACING AND CAVITIES CAUSED BY THE DISINTEGRATION OF WOODEN BEAMS (LOOKING WEST).



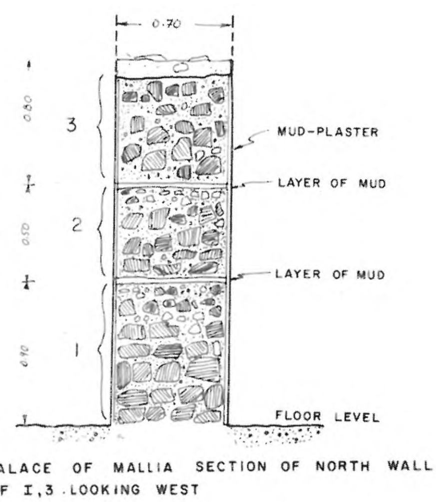
VASILIKI.— DOORWAY ON GROUND FLOOR OF EM II - HOUSE

66 – VASILIKI - DETAIL OF WALL IN FIG. 65, SHOWING CAVITIES LEFT BY DISINTEGRATED TIMBERS (AT 1, 2) AND SMALL OPENING (WINDOW?) IN WALL (AT 3) (LOOKING SOUTH).

65 – VASILIKI - PLAN AND ELEVATION OF ENTRANCE TO HOUSE IN FIG. 66 (BY AUTHOR).

67 – Gournia - House Ac - End of a wall built of mud and fieldstones (by author).

68 – Palace of Malia - West Wing - Southern side of Corridor E (looking west) (see also Fig. 69).



69 – Palace of Malia - Section of wall in Fig. 68 (by author).

70 – Palace of Knossos - Monolithic Pillar Basement (looking northwest).

71 – Palace of Knossos - Detail of platform retaining wall along northwestern border.

72 – First Palace of Phaistos - Beam sockets in western wall of Room IL.

73 – First Palace of Phaistos - Section of Early South-western Façade, showing construction. Note back of orthostate block (right) (looking southwest from Room Liii).

74 – Archanes - Phourni - Wall alongside stairway of ossuary.

75 – Palace of Kato Zakro - Exterior corner of Room xii - Topmost block has been replaced by excavators (looking south).

76 – Palace of Malia - Entrance into Room v, 1 (looking south).

77 – Myrtos - Phournou Korifi - House O, Room II, Wall E (looking east) (courtesy Peter Warren).

78 – Pseira - Basement stairway (looking east).

79 – Pseira - Buttress wall (looking east).

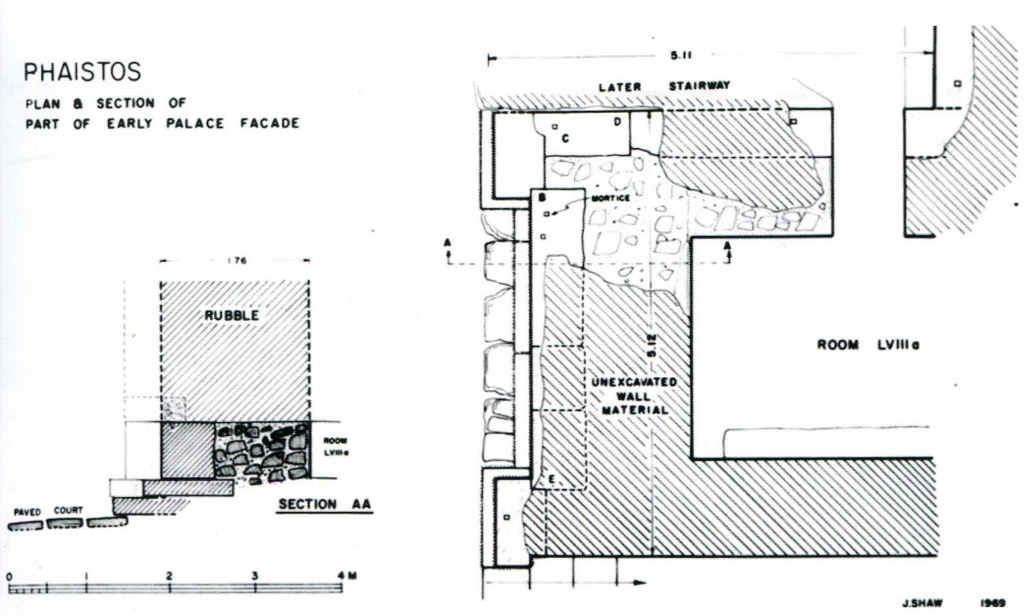
80 – Pseira - Corner of building (looking east).

81 – Phaistos - First Palace - Northeastern corner of Room LXIV - Note the unusual wall of slabs (lower left) and reused pier-base in fill (right) (looking east).

82 – Palace of Knossos - South Wing - Reused limestone blocks in basement wall.

83 – Palace of Knossos - West Wing - Reused gypsum slabs in wall (behind bench) in the Lobby of the Stone Seat.

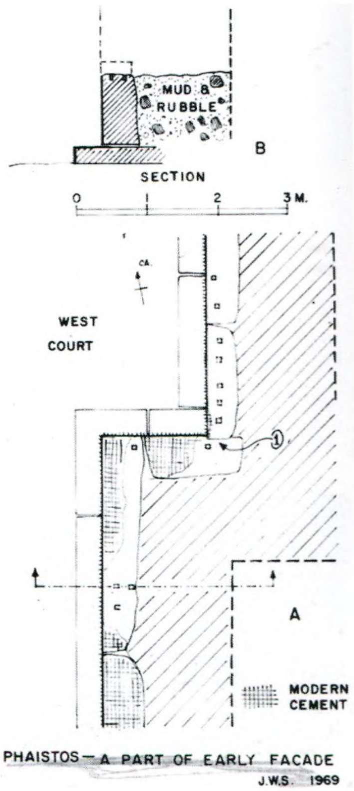
84 – Kommos - Looking south at southern wall of Spaces 29/25b of Building T, showing probable sockets for wooden scaffolding.



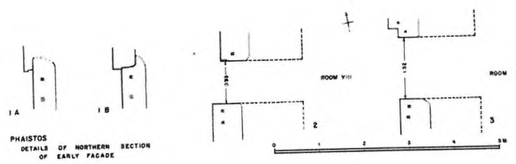
87 – Phaistos - First Palace - Plan and section of façade north of Room LIX (in the plan, north is at the top of the page) (by author).

88 – Phaistos - First Palace - Northern (upper) section of partly restored façade (looking southeast) (see also Figs. 62 E, 90-91).

89 – Phaistos - First Palace - Northernmost blocks of façade, stepped here (looking northeast).

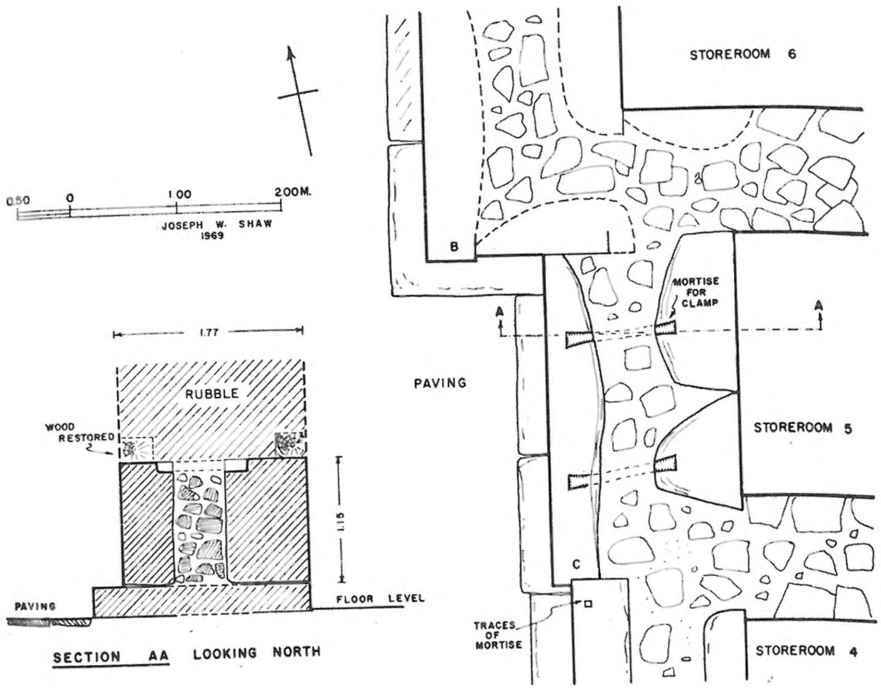


90 – Phaistos - First Palace - Plan and section of a portion of façade (by author).



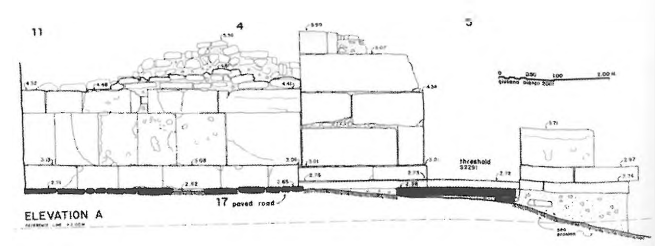
91 – Phaistos - First Palace - Details of portions of façade (by author).

92 – Palace of Knossos - Partly restored western façade - Orthostates are original (looking northeast).



93 – Palace of Knossos - Plan and section of unrestored part of west façade (by author).

94 – Palace of Knossos - Rounded corner in northwestern corner of Central Court. The concrete restoration indicating coursed ashlar masonry is probably erroneous.



95 – Kommos - Elevation, from the north, of a portion of northern orthostatic wall of Building T (by Giuliana Bianco; from *Kommos* V, Pl. 1.42).

96 – Malia - Chrysolakkos - East Façade of MM ossuary (looking north).

97 – Palace of Knossos - Hall of the Double Axes - Southwestern corner of western light-well.

98 – Palace of Knossos - West Bastion (looking southwest).

99 a – Palace of Knossos - Southern wall of Pillar Hall (looking southwest) (see also Fig. 99 b).

99 b – Palace of Knossos - Back face of wall in Fig. 99 a.

100 – Palace of Knossos - Queen's Megaron - Southern wall of southern light-well - Note coping block (upper right) (looking west).

101 – Palace of Knossos - Court of the Stone Spout (looking northwest).

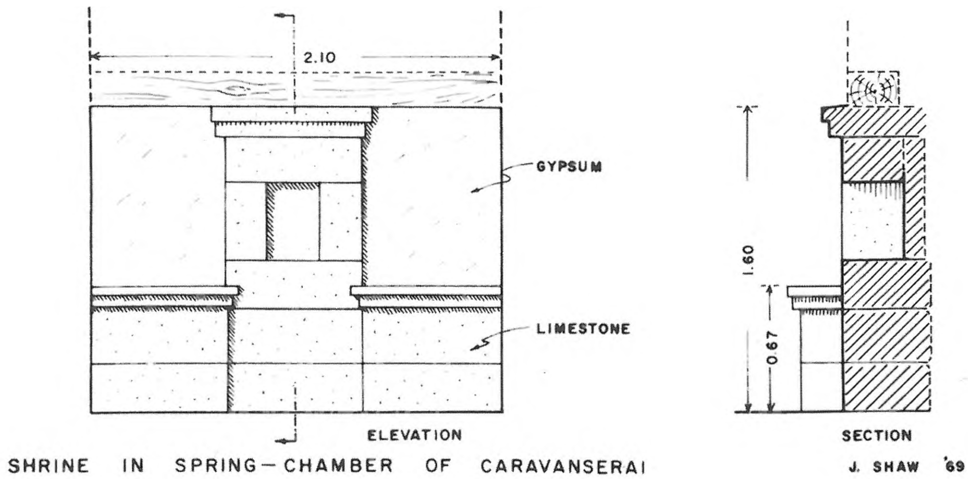
102 – Palace of Knossos - Northern wall of East-West Corridor (looking west).

103 – Knossos - Western wall of Little Palace (looking south).

104 – Knossos - Supports for bridge between the Unexplored Mansion and the Little Palace (looking northwest).

105 – Knossos - Eastern wall in basement of South House.

106 – Knossos - Viaduct (looking northwest).



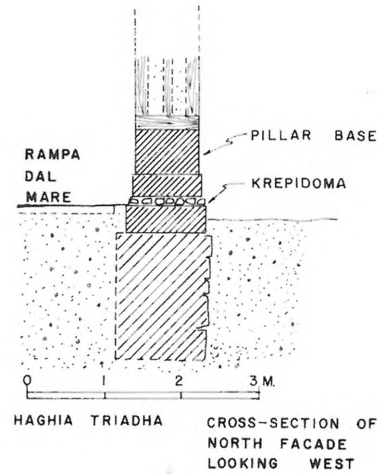
107 – Knossos - Elevation and section of western wall of the springhouse near the Caravanserai (by author).

108 – Palace of Phaistos - Retaining wall of Room 74. Top row of small blocks is modern (looking southwest).

109 – Palace of Phaistos - Western wall of Corridor 41 (looking south) (see also Figs. 51, 63c).

110 – Palace of Phaistos - Northern row of storerooms in Magazine Block (looking northeast) (see also Fig. 223).

111 – Palace of Phaistos - Southwestern retaining wall.



112 – Hagia Triadha - Section of northern wall of main complex (by author).

113 – Hagia Triadha - Blocking wall near Room 1.

114 – Tylissos - House A - Southern light-well - Note window opening left of center (looking west).

115 – Tylissos - House C - Southern wall (looking northwest).

116 – Palace of Malia - Rooms III, 5, 6 (looking southeast).

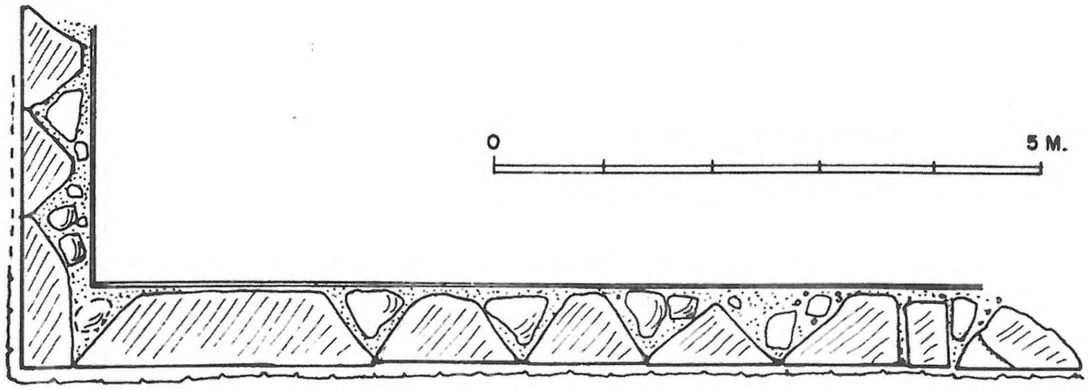
118 – Palace of Malia - Southern part of West Façade (looking southeast).

117 – Malia - Hypostyle Crypt - Southern wall (looking west) (see also Fig. 183).

120 – Palace of Kato Zakro - Set-back in western side of Central Court - Note plastering (looking southwest).

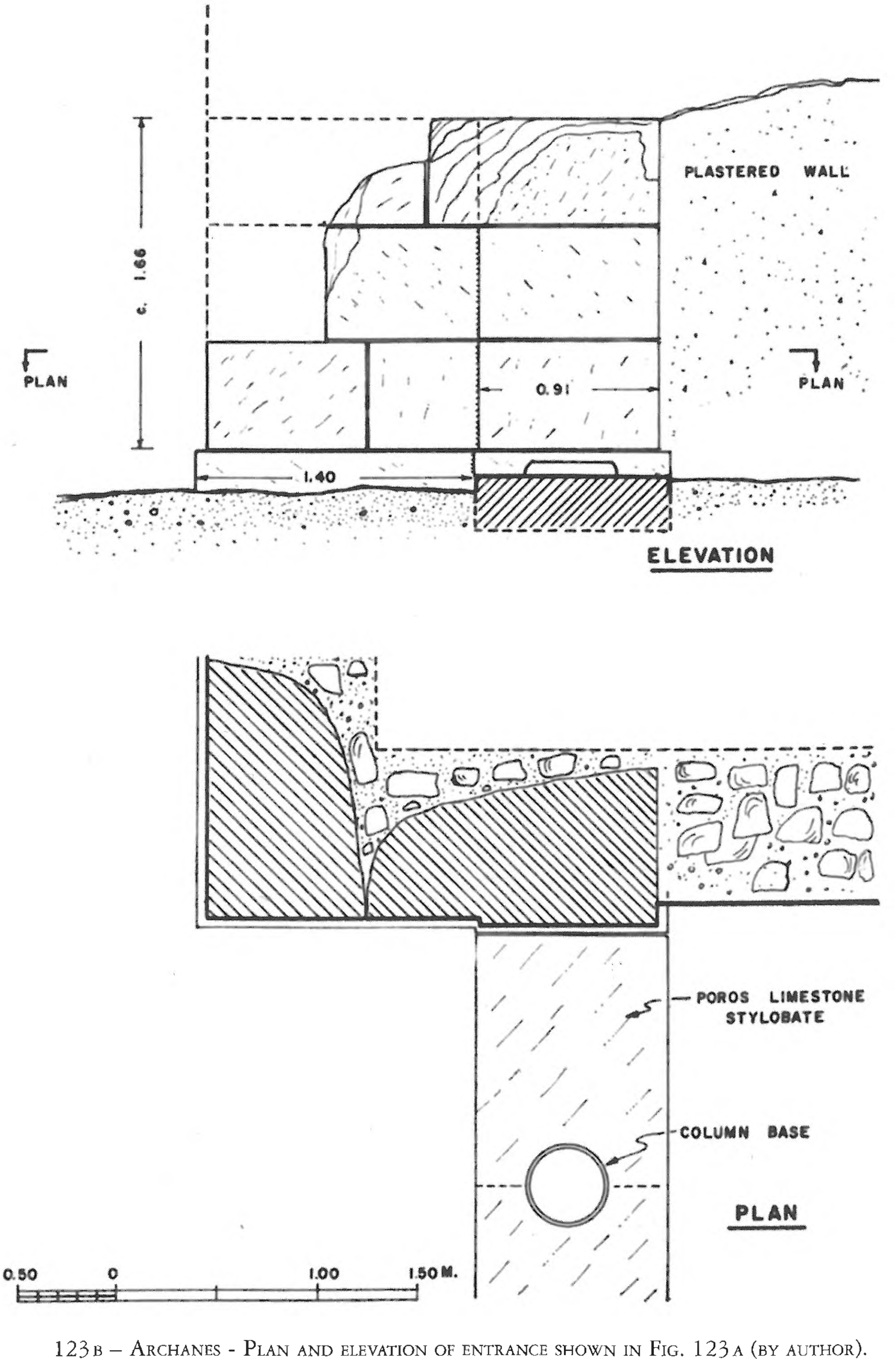
119 – Palace of Malia - Set-back along façade in Fig. 118 - Note plastered joints.

121 – Palace of Kato Zakro - Detail of southern façade along Central Court (looking south).

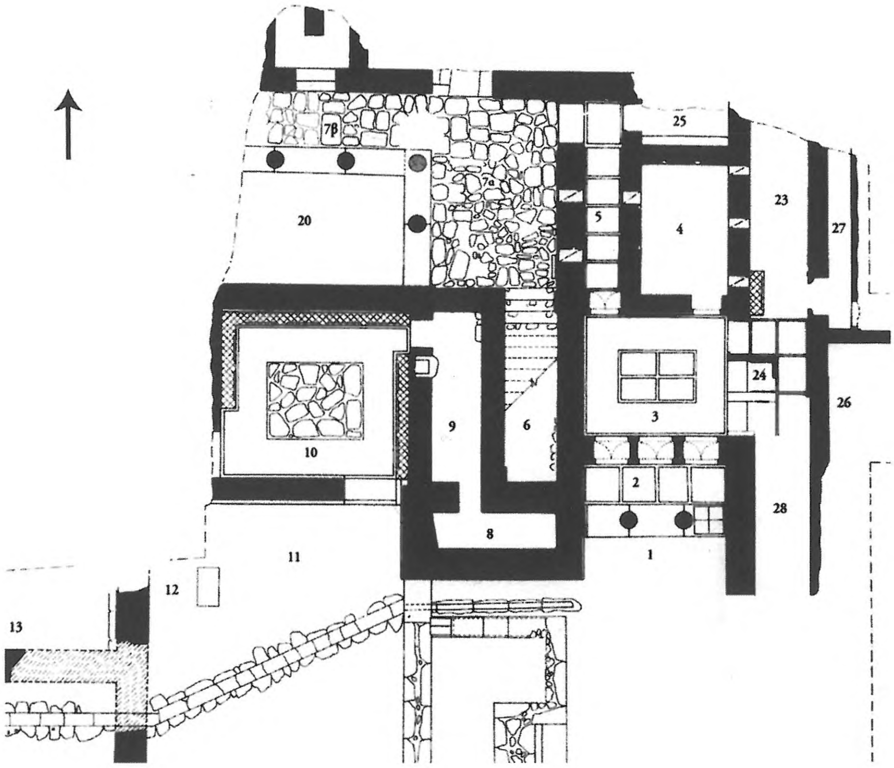


122 – Palace of Kato Zakro - Plan of part of wall along western side of Central Court, showing construction (by author).

123 a – Archanes - Entrance to monumental building (looking southwest) (see also Fig. 123b).



123 B – ARCHANES - PLAN AND ELEVATION OF ENTRANCE SHOWN IN FIG. 123 A (BY AUTHOR).



123 c – Archanes - Plan of northern section of palatial building (from *Praktika* 1999) (north is at top).

124 – Knossos - Detail of western wall of Little Palace (see also Fig. 103).

125 a – Hagia Triadha - LM III Shrine (H) with portion of ashlar wall set upon horizontal timber (note cement-filled chase above ashlar base course. Note chase for vertical timber at center, left) (looking south) (see also Fig. 188).

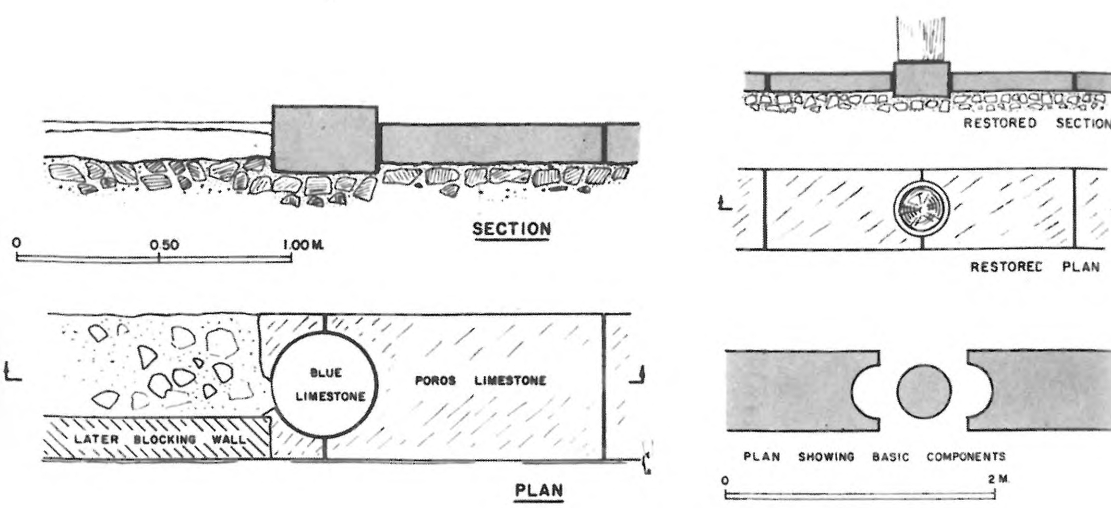
125 b – Hagia Triadha - LM III Building ABCD (the «Megaron») showing mortised ashlar base course to which wooden beams were dowelled (looking east along southern wall).

126 – Palace of Kato Zakro - Blocks from west façade of Central Court (not in situ).

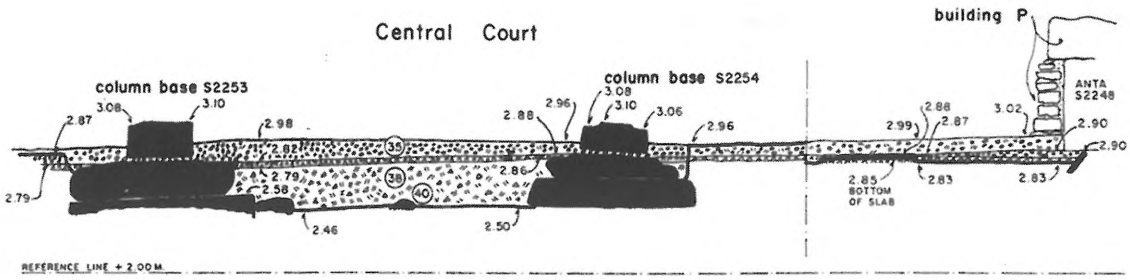
127 – Palace of Phaistos - Detail of plastering in horizontal joint of pillar in West Magazines.

128a – Mason's mark from Phaistos.

128b – Mason's mark from Phaistos.



129 – Kato Zakro, Room xxviii - Actual-state plan and section of stylobate (left) and restored views (right).



130 – Kommos - South Stoa - West-east section looking north showing two easternmost column bases set upon stacked slab foundations (by Giuliana Bianco; from *Kommos* V, Pl. 1.117).

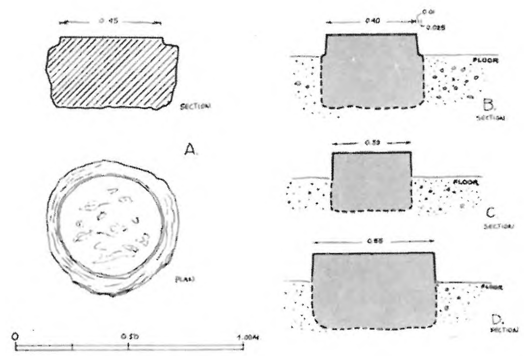
131 – Palace of Phaistos - Bases in stylobate of Room 69 (looking north).

132 – Palace of Malia - Base set into stylobate along eastern side of Central Court.

133 – Hagia Triadha - Base within partly destroyed stylobate.

134 – Palace of Knossos - Base with column restored in light-well of Grand Staircase.

135 – Palace of Malia - Northern side of Central Court (looking west).



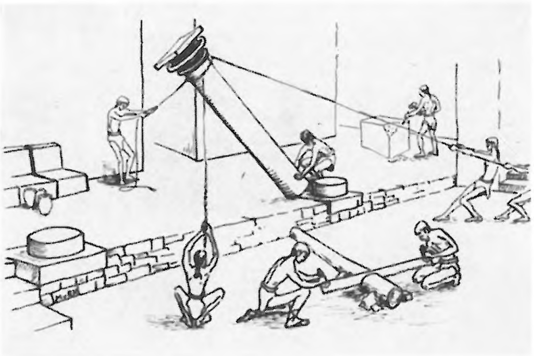
136 – Kato Zakro - Column bases (by author).

137 – Palace of Malia - Area vii. Base with pivot-hole.

138 – Palace of Malia - Area xxi, 1 - Column base in slab pavement.

139 – Malia - Area Mu - Building A, Room I, 1 - Detail of MM II column bases and pavement in court (see also Fig. 184) (courtesy French School of Archaeology).

140 – Palace of Kato Zakro - Base set on edge of veranda (Room xxxiv).



141 – Conjectural restoration suggesting a method for positioning of column on base in Fig. 140 (by Marianna van Rossen Hoogendyk).

142 – First Palace of Malia - Mortised MM II base of veined limestone in North Court Area.

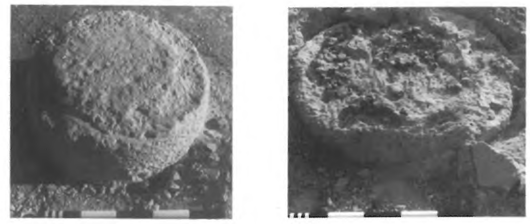
143 – Malia - Chrysolakkos - Squared MM base.

144a – Palace of Phaistos - Column base at entrance to Early Propylon (Room ii).

144b – Palace of Phaistos - Detail of mortise for dowel in Fig. 144 a.

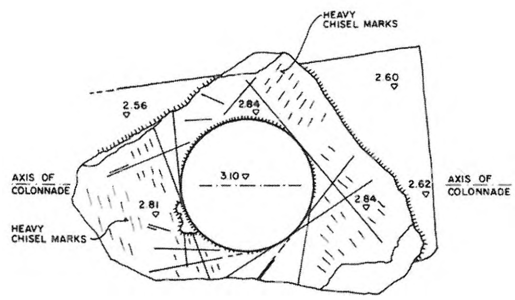
145 – Palace of Knossos - Column bases on wall in East Wing (not in situ).

146 – Kato Zakro - Column base once set into a floor (not in situ).



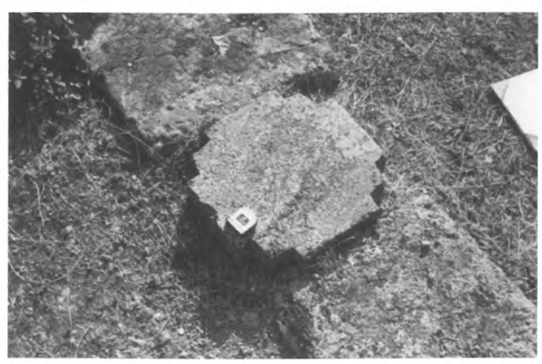
147a-b – Kommos, South Stoa (a) column base S 2265 before removal and (b) its subbase after removal, showing pebbles for setting (from *Kommos* V, Pl. 1.136 f and g).

148a – Kommos - Column base S 2236 of North Stoa set above base S 2253 from South Stoa. Note similar finishing marks (from *Kommos* V, Pl. 1.137).

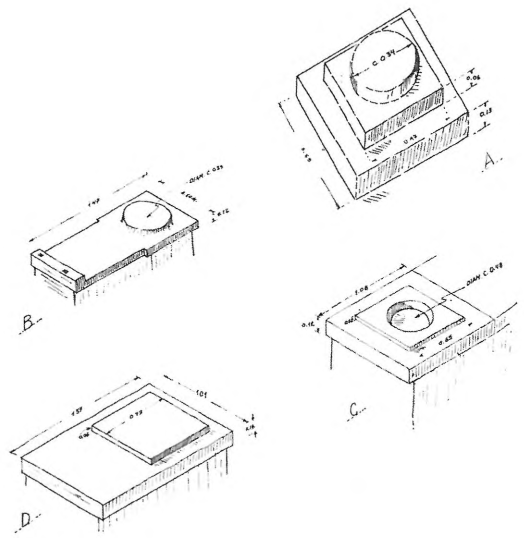


148b – Kommos - Plan showing column base S 2253 in South Stoa with setting marks incised on its foundation slab (by Giuliana Bianco, from *Kommos* V, Pl. 1.138).

149 – Palace of Phaistos - Base with two mortises (not in situ).



150 – Hagia Triadha - Column base in Room 21.



151 – Sketches of parapet bases at Knossos, Northwest Lustral Basin (gypsum) (A); Phaistos, Room 19 (gypsum) (B); Knossos, Grand Staircase (gypsum) (C); and Knossos, north of the Hall of the Double Axes (limestone) (D) (by author).

152 – Palace of Knossos - Parapet of Grand Staircase with base and column restored.

153 – Palace of Phaistos - Stylobate and its foundation along western side of Central Court.

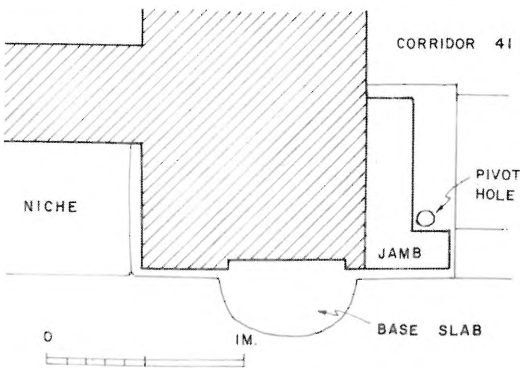
154 – Palace of Phaistos - Central Court - Foundation slab for column base.

155 – Palace of Knossos - East Hall. Column base on foundation.

156 – Palace of Knossos - Slab foundations for columns of Stepped Portico.

157 – Archanes - Phourni - Pillar in ossuary.

158 – Kato Zakro - Pillar in basement room of House A, excavated by Hogarth.



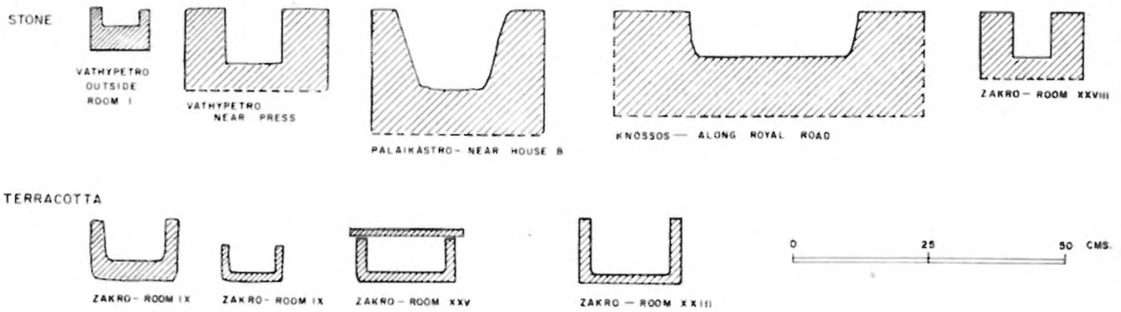
159 – Palace of Phaistos - Plan of base slab on western side of entrance to Corridor 41 (by author).

160 – Palace of Phaistos - Drain cut in bedrock near Court 64.

161 – Hagia Triadha - U-shaped LM III stone drains (looking south).

162A – Palace of Knossos - Basement of East Hall. Partially restored drain head and water channel.

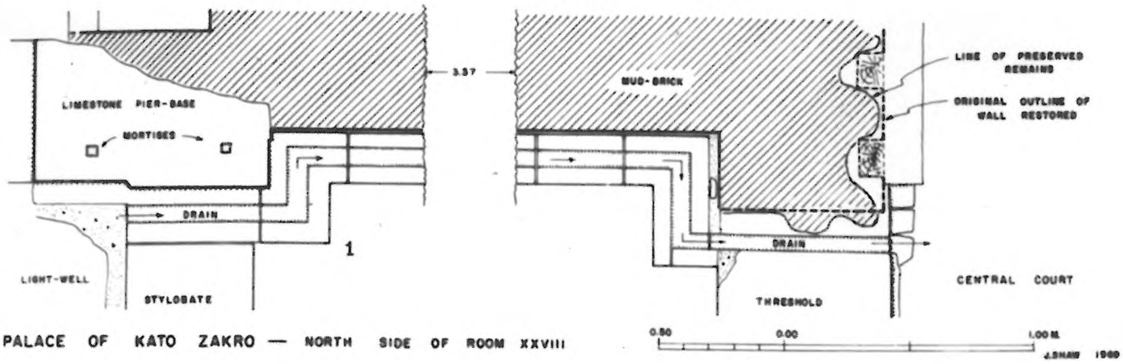
162B – Palace of Knossos - Turn in course of drain in Fig. 162A.



164 – Minoan Drains - Top Row: Sections of stone drains at Vathypetro (in front of Megaron and in Press area); Palaikastro (near House N); Knossos (Royal Road); Palace of Kato Zakro (Room xxviii) - Bottom Row: Sections of terracotta drains in the Palace of Kato Zakro (Room ix, xxv, xxiii) (by author).

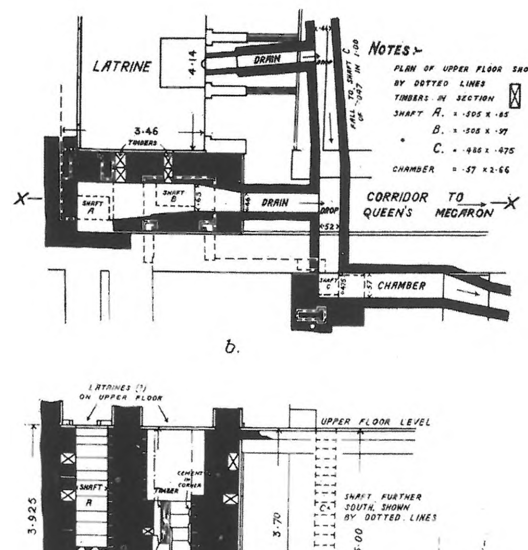
163 – Palace of Knossos - Court of the Stone Spout. End section of drain leading to the court (looking east) (see also Fig. 101).

166 – Palace of Kato Zakro - Western section of limestone drain in Fig. 165 (see also Fig. 164).



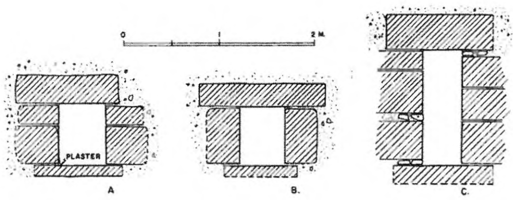
165 – Palace of Kato Zakro, plan of stylish drain in Room xxviii (see Figs. 164, 166) (by author).

167 – Palace of Knossos - Drain and catch-basin at East Bastion.

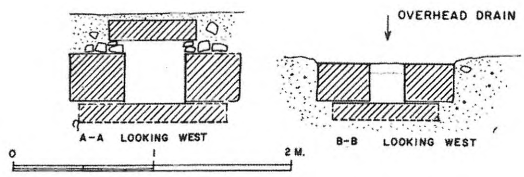


168 – Palace of Knossos - Plan and section of southwest part of vertical drain shafts in Residential Quarter (by Christian C.T. Doll, from *Knossos*, I, Fig. 171 b, c).

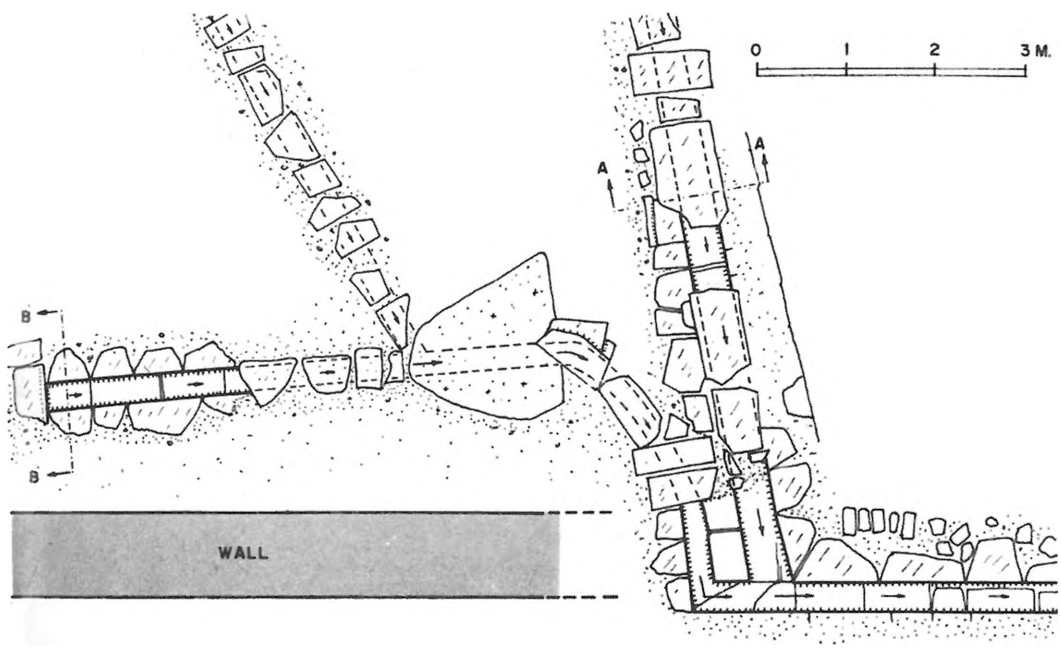
169 – Palace of Knossos - Catch-basin along eastern side of Court of the Distaffs.



170A – Hagia Triadha - Sections of built drains (by author).



170B – Palace of Kato Zakro - Sections of built drains (see also Fig. 171).

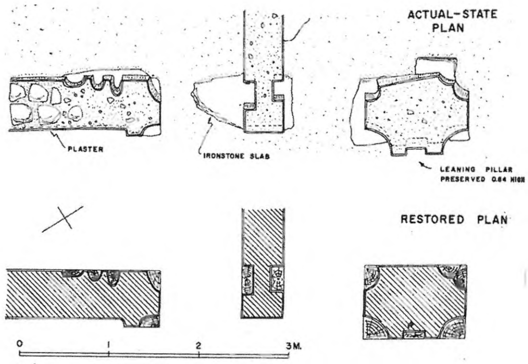


171 – Palace of Kato Zakro, plan of a portion of the drainage system in the East Wing. (For sections indicated see Fig. 170B, by author).

172 – Hagia Triadha - Lower part of vertical drain shaft.

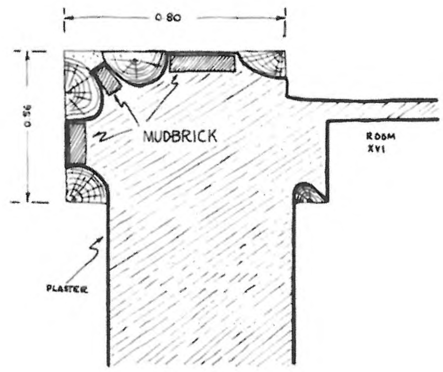
173 – Palace of Malia - Impression in clay of side of column once set on marble base (partly restored).

174 – Palace of Malia - Impression of column-shaft (left) and vertical prop (right) in blocking wall (partly restored).



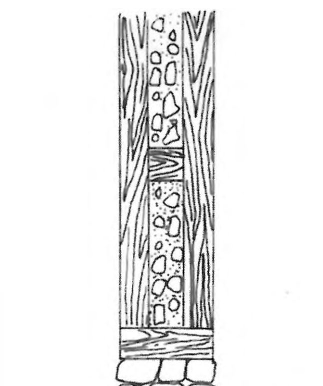
175 – Palace of Kato Zakro - Room xxviii - Actual and restored plans of props, a pier, and a pillar reinforced with wood (see also Fig. 176) (by author).

176 – Palace of Kato Zakro - Pillar in Room xxviii (looking west) (see also Fig. 175).



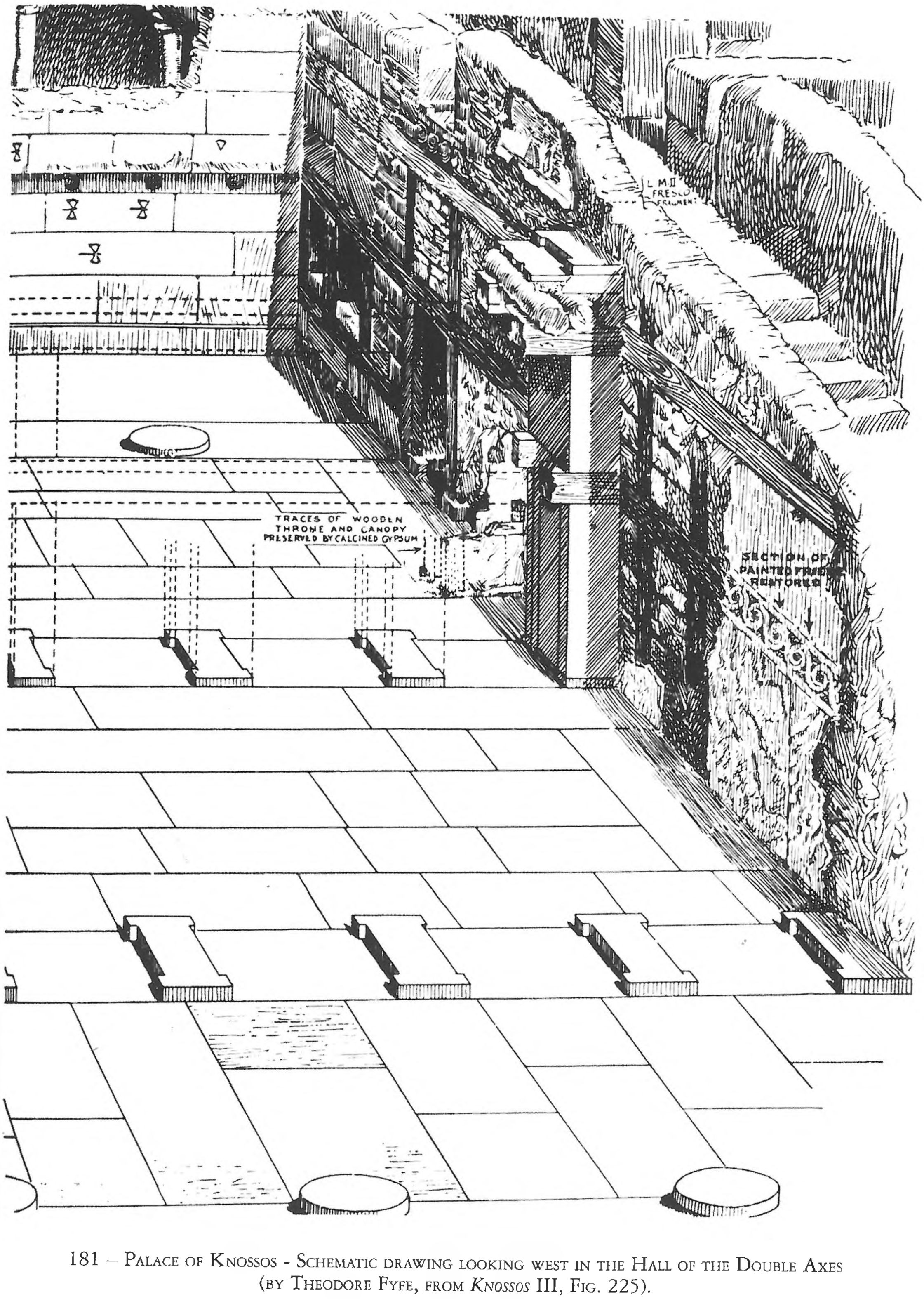
177 – Palace of Kato Zakro - Room xvi. Plan of pier at end of wall (by author).

178 – Tylissos - House A. Forms of wooden props in eastern wall of Room 3. Note cavities for horizontal struts (see also Fig. 179).



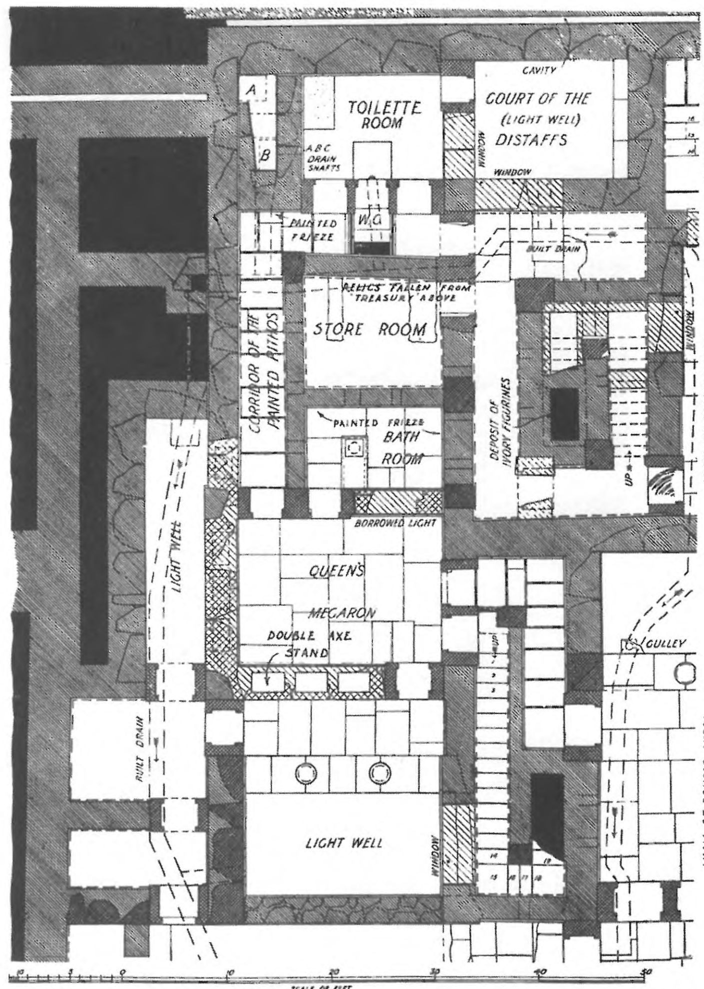
179 – Tylissos - Schematic section through props in wall (after Tylissos [2], Fig. 11) (see also Fig. 178).

180 – Hagia Triadha - Bench, partly restored dado, and sockets for vertical beams in Room 4 (cf. Fig. 83).

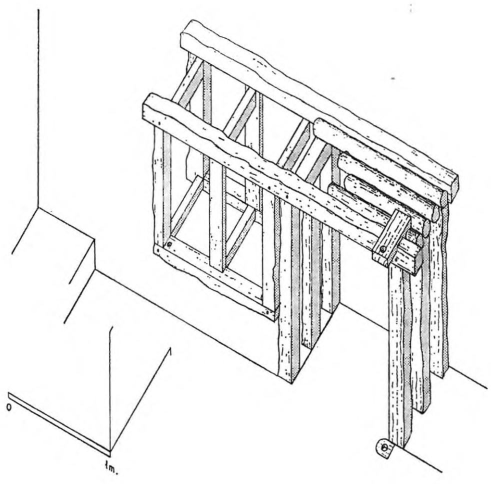


181 – Palace of Knossos - Schematic drawing looking west in the Hall of the Double Axes (by Theodore Fyfe, from *Knossos* III, Fig. 225).

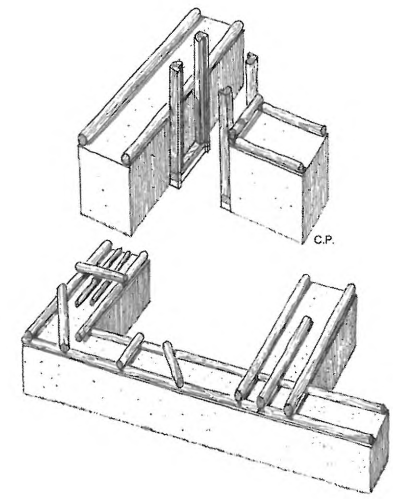
182A – Palace of Knossos - Restored north exterior wall of the Hall of the Double Axes (beam bedding at arrow) (looking south).



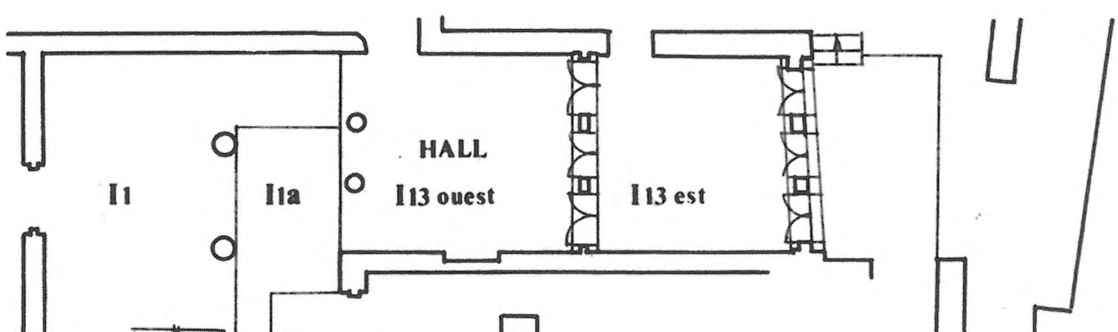
182B – Palace of Knossos, plan of area of Queen's Megaron (by Theodore Fyfe and Christian C.T. Doll, from *Knossos* III, Fig. 249; west is at top of page).



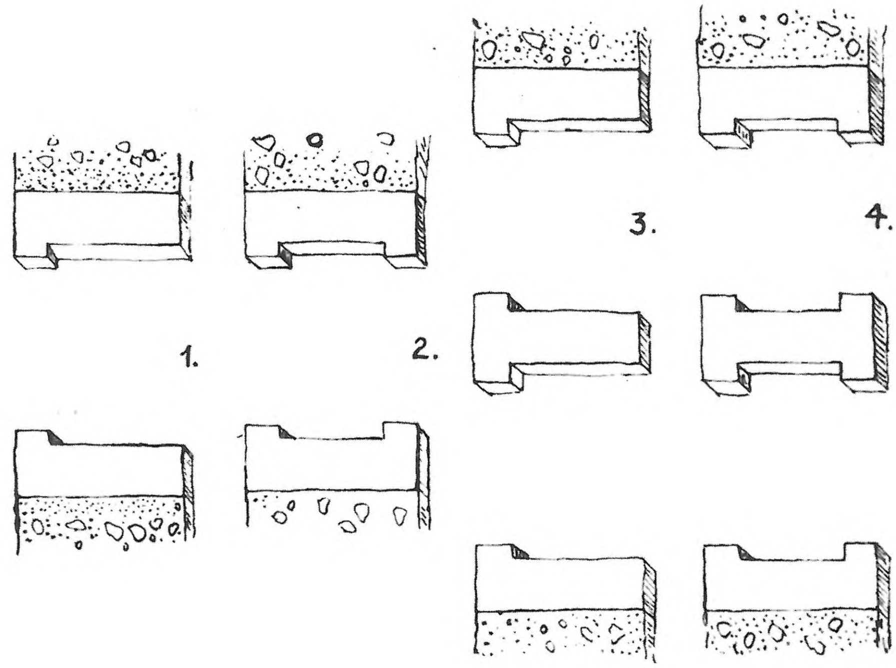
183 – Malia. Restored view looking west of wooden window/door combination in the MM II Hypostyle Crypt (from *Mallia, Centre Politique* II, pl. II [3]) (see also Fig. 117).



185 – Akrotiri, Thera - Layout of horizontal timber reinforcement showing typical structural details (from Palyvou 2005, Fig. 171) (by Clairy Palyvou).

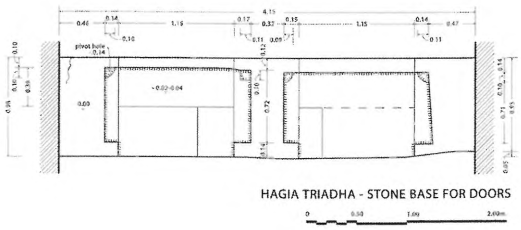


184 – Malia - MM II Building A in Quartier Mu. Plan of first stage of pier-and-door partitions (*polythyra*) with Halls (I 13 east, west) and light-well (I 1a) (from Poursat and Schmid 1992, Fig. 30) (see also Fig. 139) (by Martin Schmid).



186 – TYLISSOS - SCHEMATIC PLANS OF TYPES OF DOORJAMB BASES, SHOWING THOSE FOR SINGLE (1, 2) AND DOUBLE (3, 4) DOORWAYS (AFTER *TYLISSOS* [2], FIG. 13).

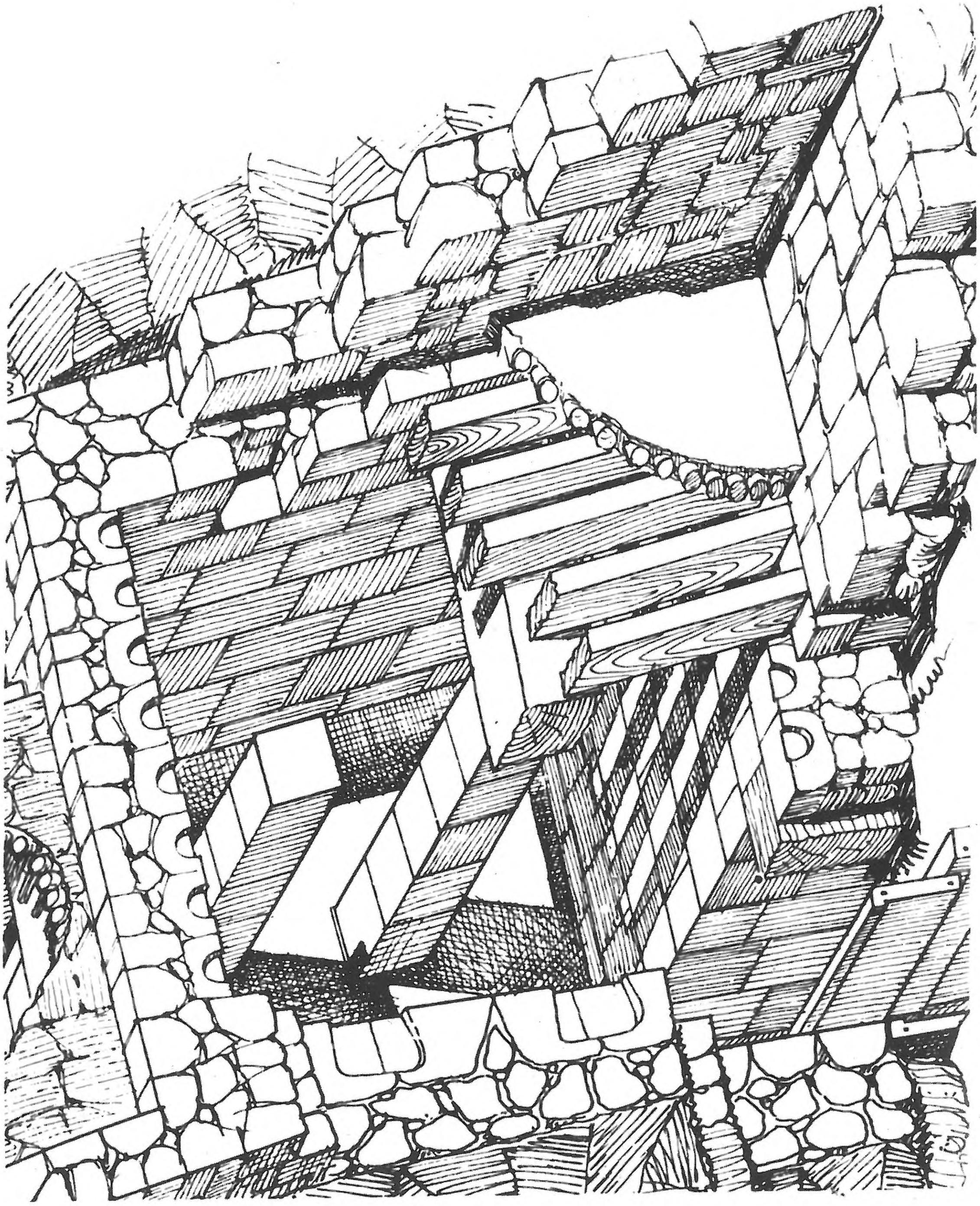
187 – HAGIA TRIADHA - RESTORED AND UNRESTORED JAMBS IN ROOM 3.



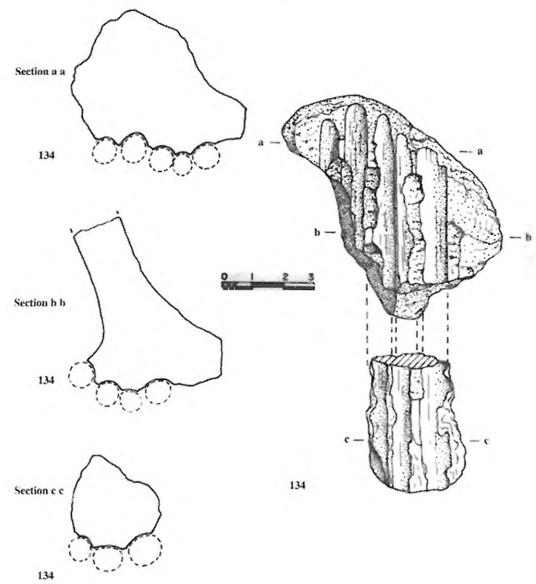
188 – HAGIA TRIADHA - LM III DOUBLE PIER-AND-DOOR PARTITION ENTRANCE IN SHRINE H (BY AUTHOR).

189 – TYLISSOS - HOUSE C - PARTLY RESTORED JAMB WITHOUT HORIZONTAL TIMBER.

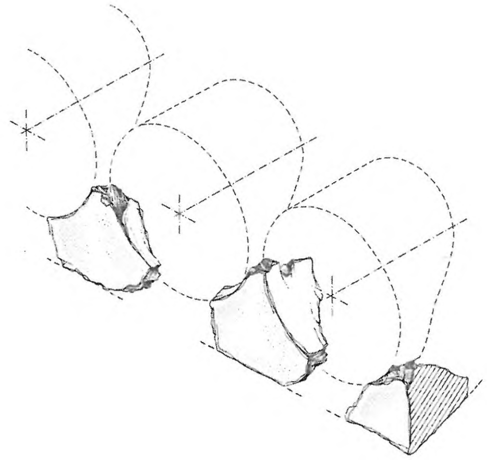
190 – PALACE OF PHAISTOS - CLAY LUMP WITH IMPRESSIONS OF WOOD DISCOVERED IN PROPYLON (ROOM 69).



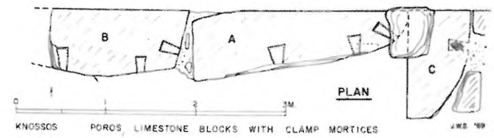
191 – Knossos - Temple Tomb - Isometric view of wooden roof construction (by Piet de Jong, from *Knossos* IV, Fig. 932).



192a – Kommos - Plaster ceiling fragment, with impressions of reeds laid parallel to each other, positioned in ceiling as seen on left (from *Kommos* V, Pl. 2.31). (by Julia Pfaff).



192b – Phaistos - Plaster ceiling fragment with impressions of ceiling beams set one next to another (from Militello 2001, Fig. 34) (by G. Fatuzzo).

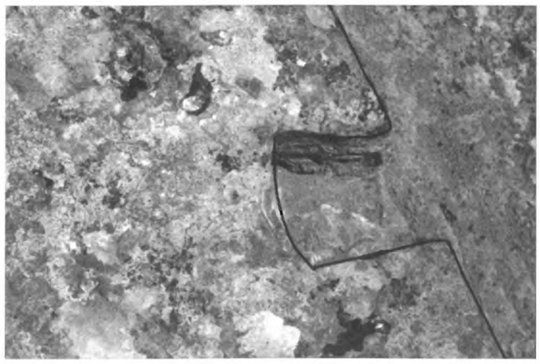


193 – Palace of Knossos - Plan of reused blocks with clamp cuttings in Northwest Area (by author).

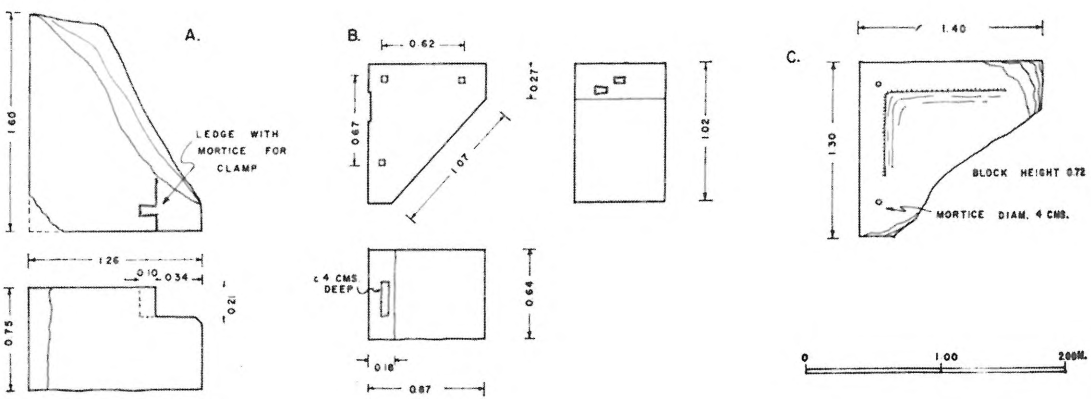
192c – Chania - Ceiling fragment. Left: side view showing outline of rafters. Right: top of same fragment with impression left by rough-cut bottom of floor plank (from Hallager 1990, Fig. 4).

194 – Palace of Knossos - Detail of limestone block B in Fig. 193.

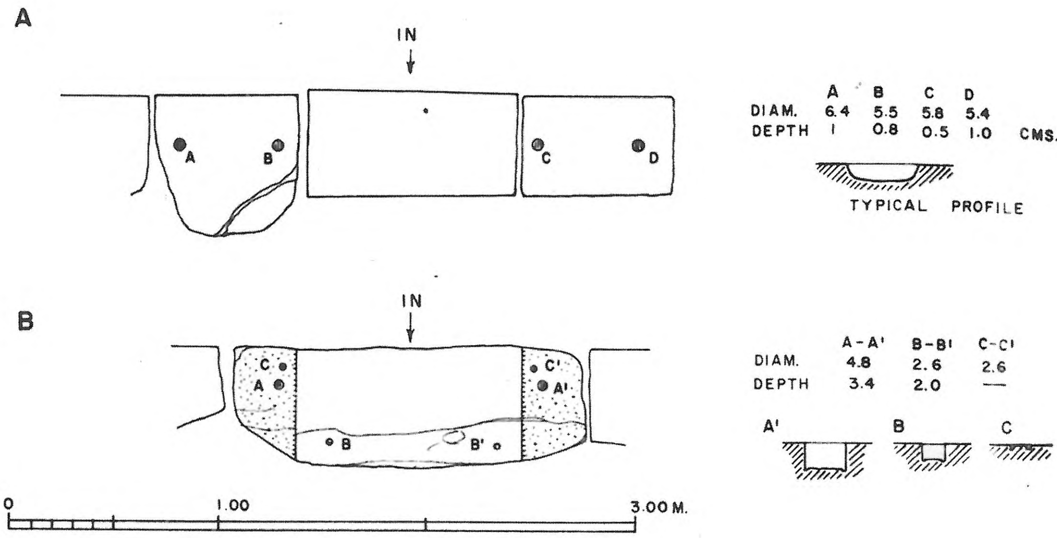
195A – Tylissos - House C - Mortise for clamp (arrow) and bedding for beam cut in wall-block, Room 15 (looking southwest).



195B – Tylissos - Detail of mortise in Fig. 195A.



196 – Plans of triangular corner piers at Knossos (A, B) and Malia (C) (by author).



197 – Plans of thresholds in Malia, House E (A) and House Za (B) (by author) (see also Fig. 59).

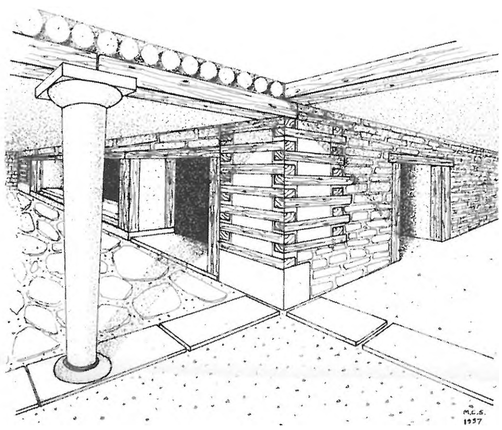
198 – MALIA - CHRYSOLAKKOS - KREPIDOMA OF NORTH FAÇADE (LOOKING EAST).

199 – MALIA - CHRYSOLAKKOS - DETAIL OF KREPIDOMA BLOCK WITH TWO DRILLED HOLES.

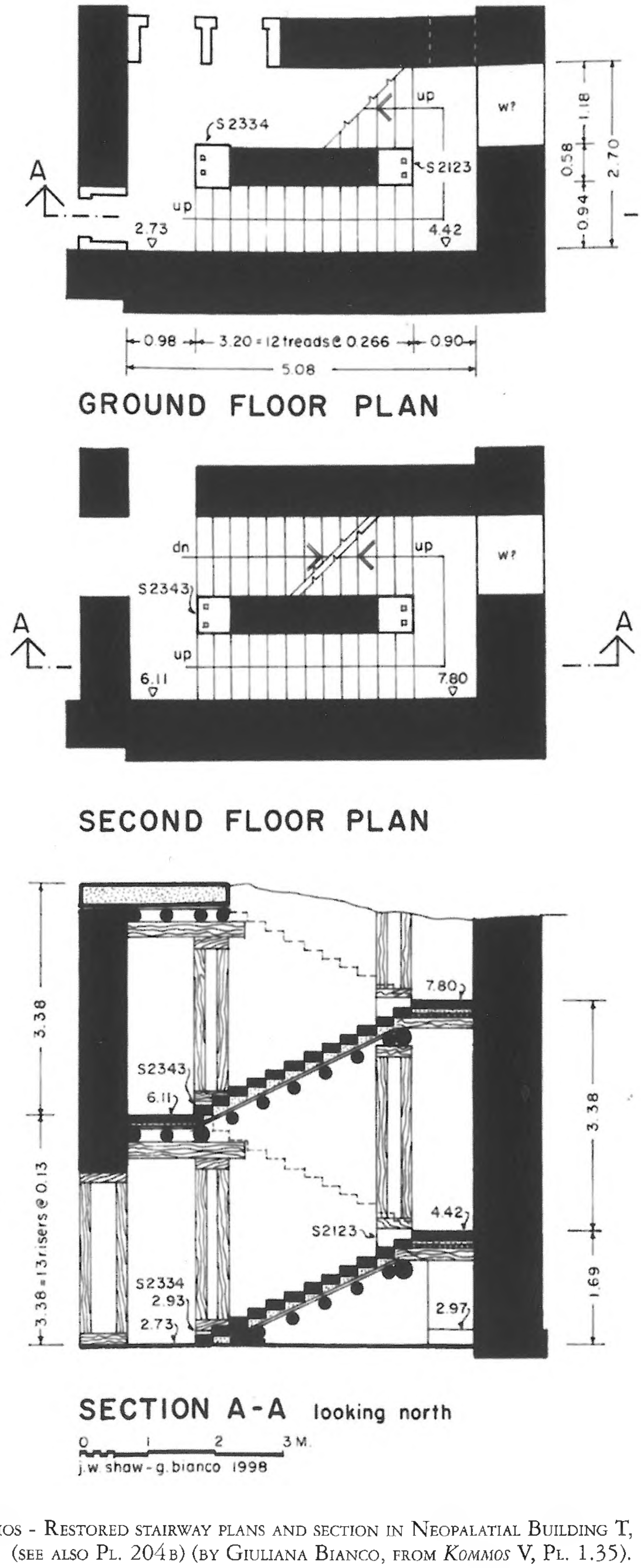
200 – TYLISSOS - HOUSE C - COMPLETE PILLAR IN ROOM 2. NOTE SQUARE MORTISES ON TOPMOST BLOCK.

201 – TYLISSOS - HOUSE A - COMPLETE PILLARS BORDERING COURT IN ROOM 15 (LOOKING NORTHWEST).

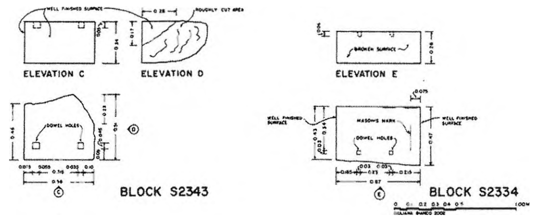
202 – PALACE OF MALIA - THREE (OF SIX) BLOCKS IN HYPOSTYLE HALL (ROOM IX, 2) (LOOKING EAST).



203 – KOMMOS - RESTORED VIEW OF WOOD-REINFORCED PIER AT EASTERN END OF NORTH STOA (FROM *KOMMOS* V, PL. 1.56) (BY M.C. SHAW).

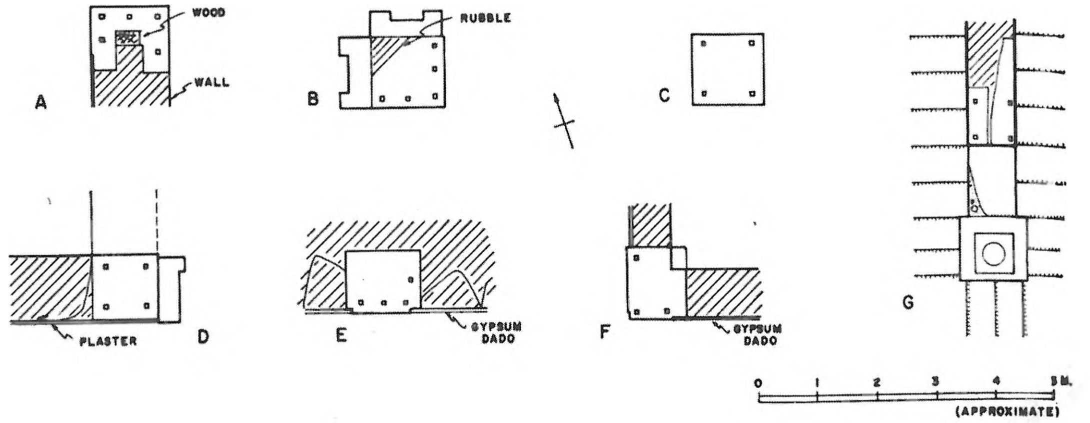


204A – KOMMOS - RESTORED STAIRWAY PLANS AND SECTION IN NEOPALATIAL BUILDING T, ROOMS 5A/5B (SEE ALSO PL. 204B) (BY GIULIANA BIANCO, FROM *KOMMOS* V, PL. 1.35).

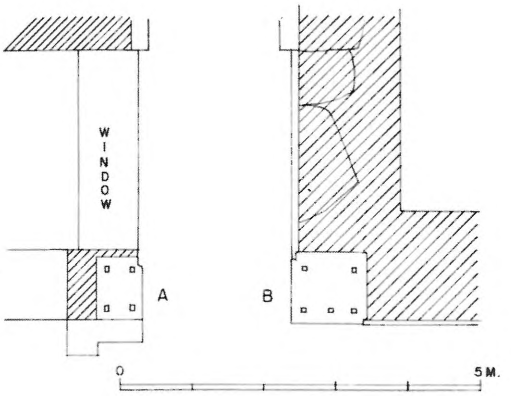


204B – Kommos - Two ashlar blocks with dowel mortises, once set as indicated at turns of the stairway in Fig. 204A (by Giuliana Bianco, from *Kommos* V, Pl. 1.133).

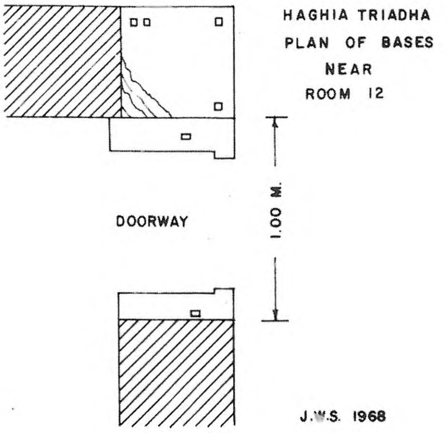
205 – Palace of Phaistos - Bottom of partly restored pier in Room 50 - Semi-circular holes left in concrete allow one to inspect mortise sockets.



206 – Palace of Knossos - Details of a pillar and piers, showing distribution of mortises (after ground floor plan of Residential Quarter, in *Knossos* III, Plan E).

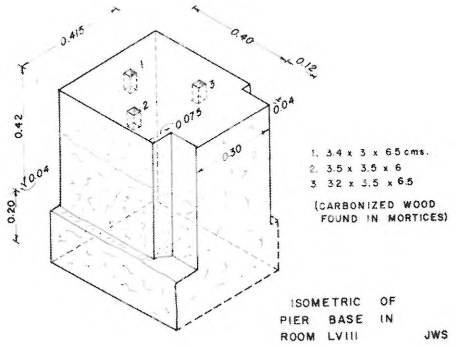


207 – Palace of Knossos - Plans of two mortised piers (after first floor plan of Residential Quarter, in *Knossos* III, plan F).

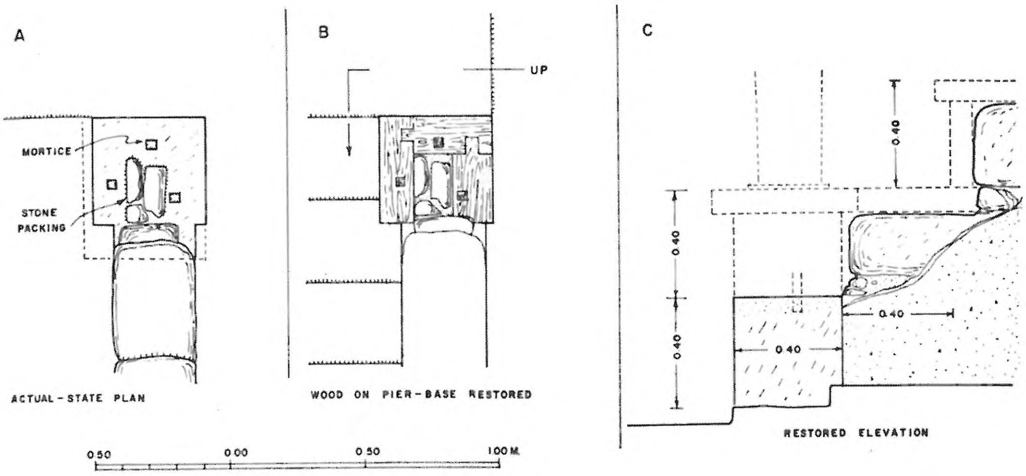


208 – Hagia Triadha - Jamb-bases and square pier base south of Room 3 (by author).

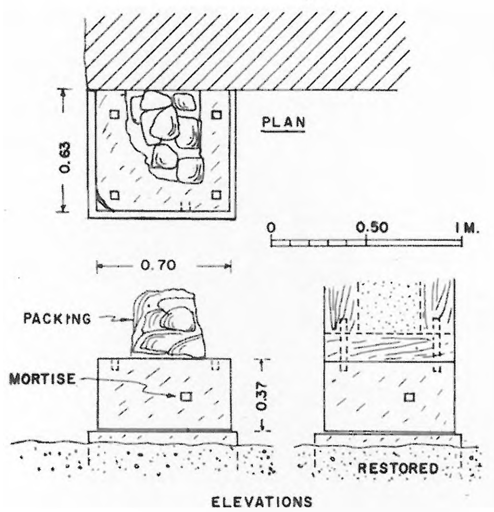
209 – Palace of Knossos - East Wing - Pier base at turn of stairway.



210 A – Palace of Kato Zakro - Isometric drawing of pier base in Room LVIII (see also Fig. 210 B) (by author).

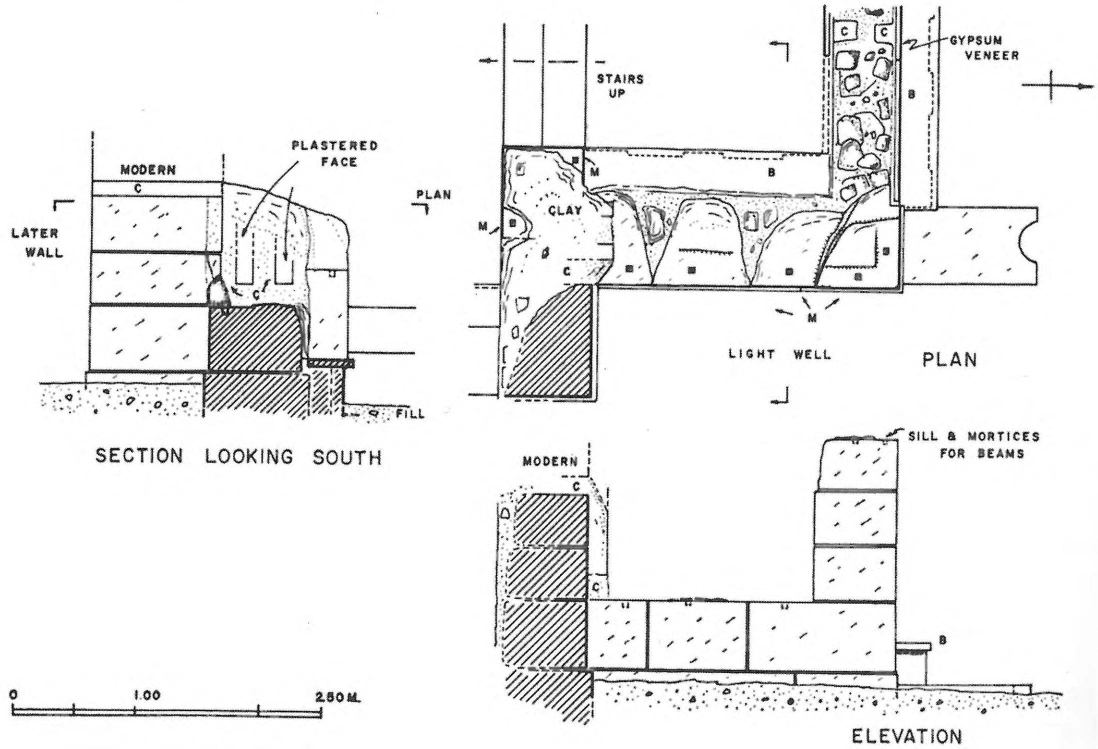


210 B – Palace of Kato Zakro - State and restored plans of pier in Fig. 210 A (by author).

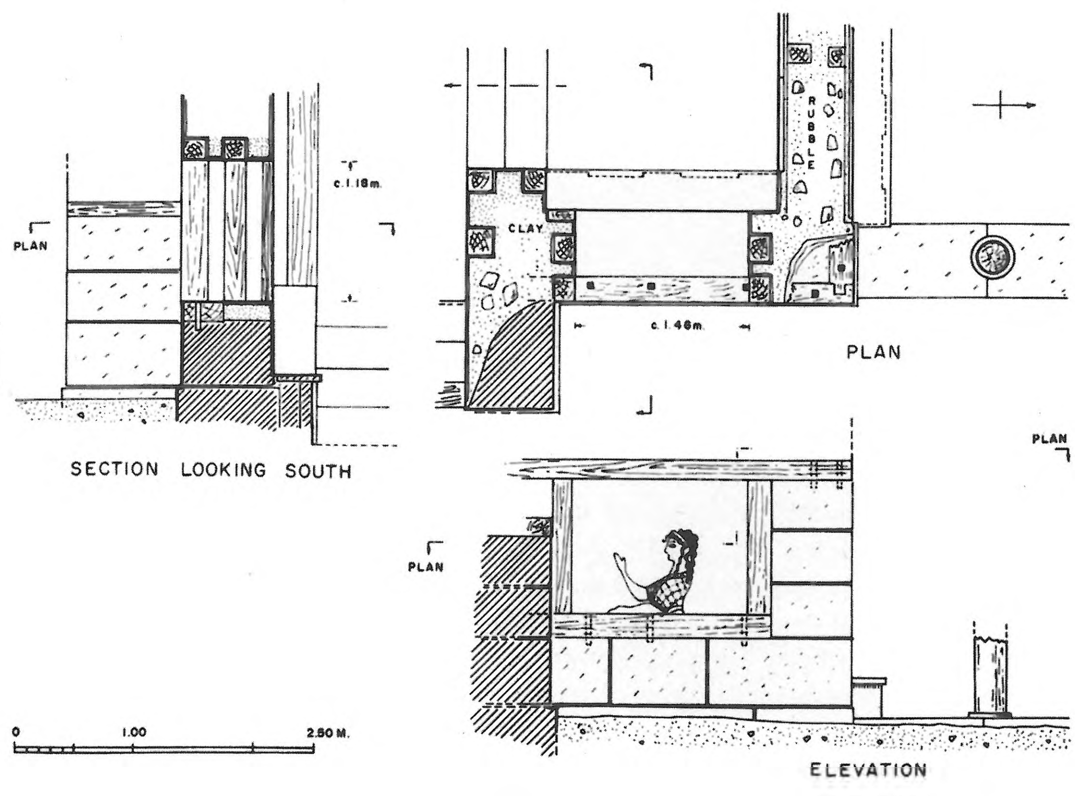


211 A – Palace of Phaistos - Pier base next to southern wall of Room 23 (by author).

211 B – Myrtos-Pyrgos stairway, showing details of pier bases alongside parapet.



212A – Hagia Triadha - Actual-state drawings of window in Room 2 (see also Figs. 212B, C) (by author).



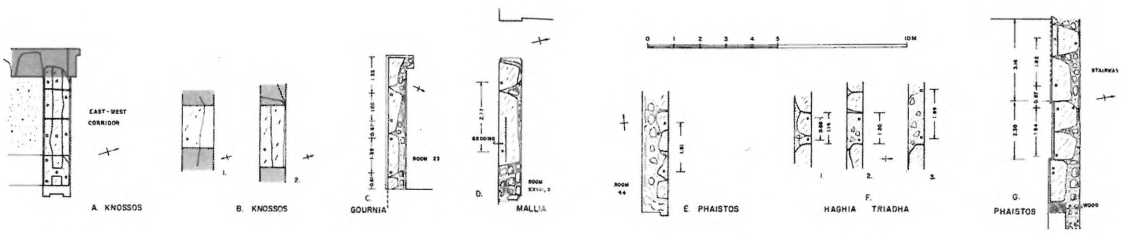
212B – Hagia Triadha - Restored drawings of area in Figs. 212A, 212C (by author).

212c – Hagia Triadha - Window-opening in Room 2 (see also Figs. 212 a, b) (looking southwest).

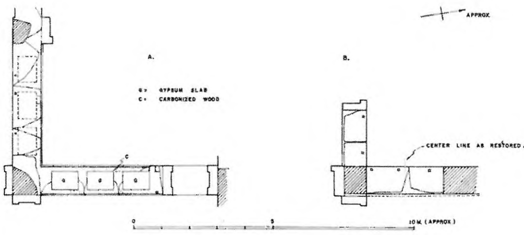
213 – Palace of Kato Zakro - Room xxviii - Paved light-well with windowsill behind (looking northwest).

214 – Palace of Knossos - Restored window in the Court of the Distaffs (looking southeast) (see also Fig. 217 [B]).

215 – Palace of Knossos - Looking west along East-West Corridor - Window is on left (see also Fig. 216 [A]).

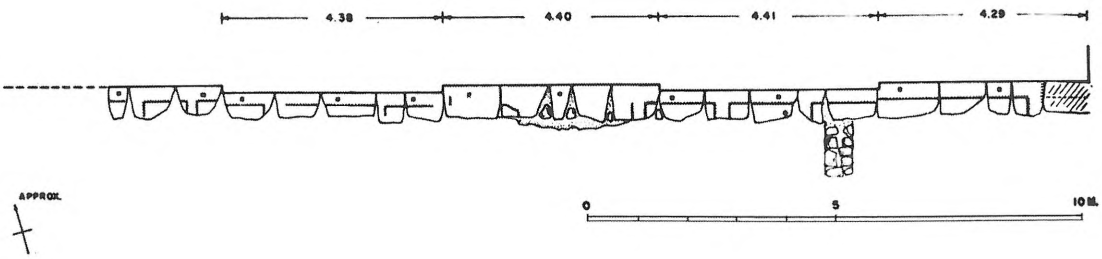


216 – Plans of tops of walls with mortises at Knossos, Light-well of Hall of the Double Axes (A) (After *Knossos* III, Plan E) (see also Fig. 215); Palace of Knossos, windowsills on walls east of Queen's Megaron (B, 1) and south wall of Hall of Colonnades (B, 2) (After *Knossos* III, Plan E); Gournia, near Room 23 (C); Malia, North Court (D); Palace of Phaistos, along Corridor 41 (E); Hagia Triadha, three windowsills along Rampa dal Mare (F); Palace of Phaistos, along northwestern side of Central Court (G) (see also Fig. 221).



217 – Plans of windowsills - Palace of Knossos, sill bordering Queen's Megaron on east and south (A) and (B) sills in the Court of the Distaffs (both after *Knossos*, III, Plan E) (by author).

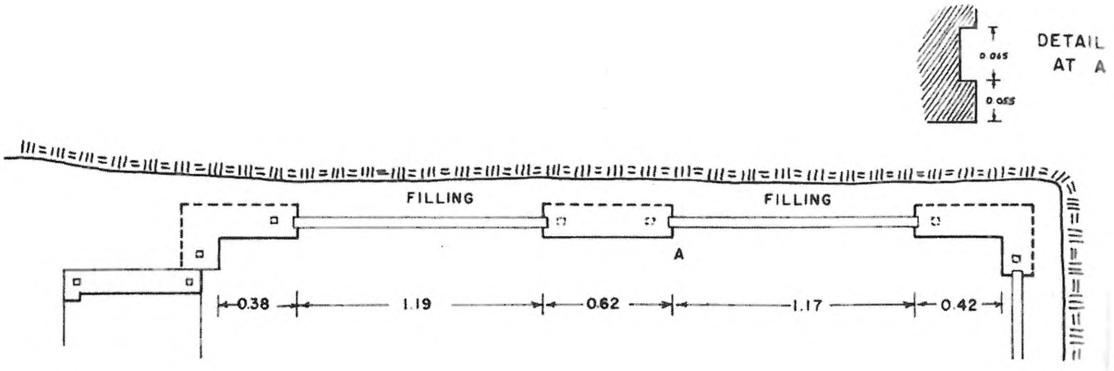
218 – Palace of Malia - Sill bordering southern side of Central Court. (looking west) (see also Fig. 219).



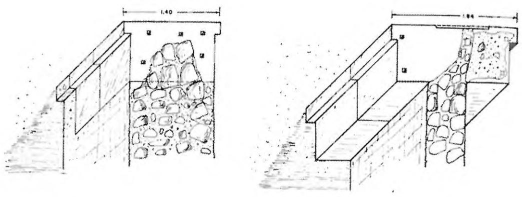
219 – Palace of Malia - Plan of sill in Fig. 218 (by author).

220 – Hagia Triadha - Unexcavated (perhaps blocked) window in light-well of Room 21 - arrow indicates location of mortice (looking north).

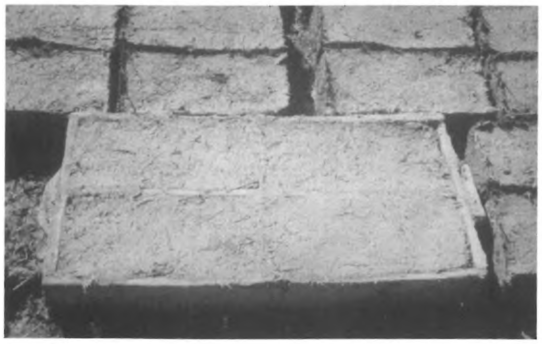
221 – Palace of Phaistos - Top of wall along north-western side of Central Court - note beam bedding and mortises (see also Figs. 62 b and 216 [G]).



222 – Knossos - Temple Tomb - Plan of southern wall of Sepulchre (partly after *Knossos*, plan in Volume IV).

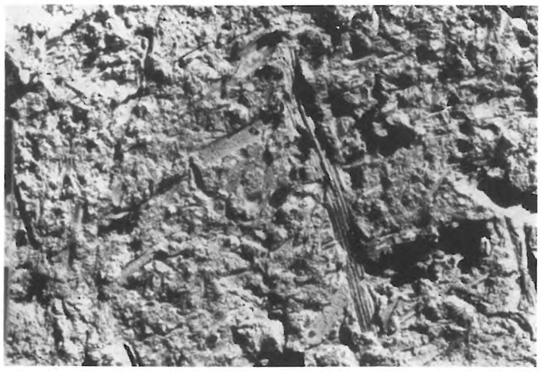


223 – Isometric drawings of pier-jambs in storerooms at Knossos (between Magazines 6 and 7) (left) and Phaistos (between Magazines 35 and 36) (right) (by author).

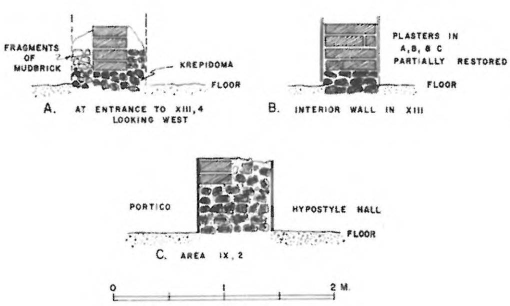


224 – Separate mud bricks (above) and mud in a wooden framework or mold (below) which has not yet been lifted up (courtesy Kenneth Sams).

225 – Kato Zakro - Two Minoan mud bricks (not in situ).



226 – Texture of mud mortar - Note impressions of disintegrated binding material.



227 – Palace of Malia - Three sections of mud brick walls (by author).

228 – Palace of Malia - Southern wall of v, 2.

229 – Palace of Malia - Room iv, 10 - Niche with mud bricks set on edge.

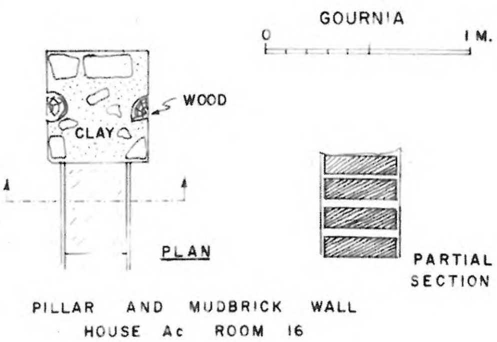
230 – Palace of Kato Zakro - Room L - Intact (A) and fallen (B) sections of mud brick walls (looking south) (see also Figs. 231, 232).

231 – Palace of Kato Zakro - Wall A in Fig. 230. Vertical inked lines indicate joints between separate bricks.

232 – Palace of Kato Zakro - Detail of fallen wall (B) in Fig. 230.

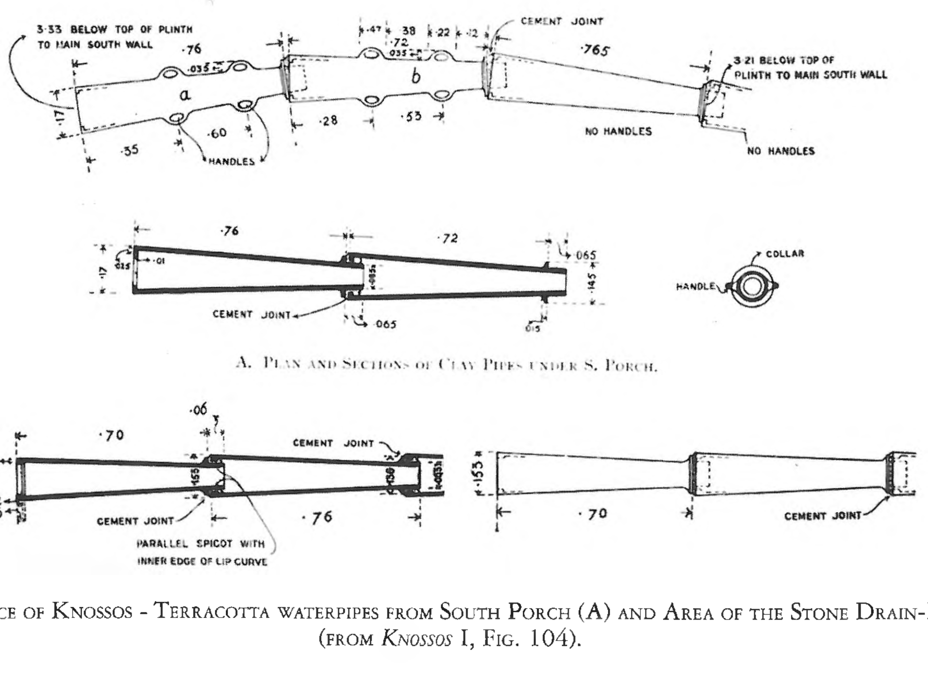
233 – Palace of Kato Zakro - Partitions in Room xxii (looking south).

234 – Palace of Kato Zakro - Supports for archives in Room xvi (looking south).

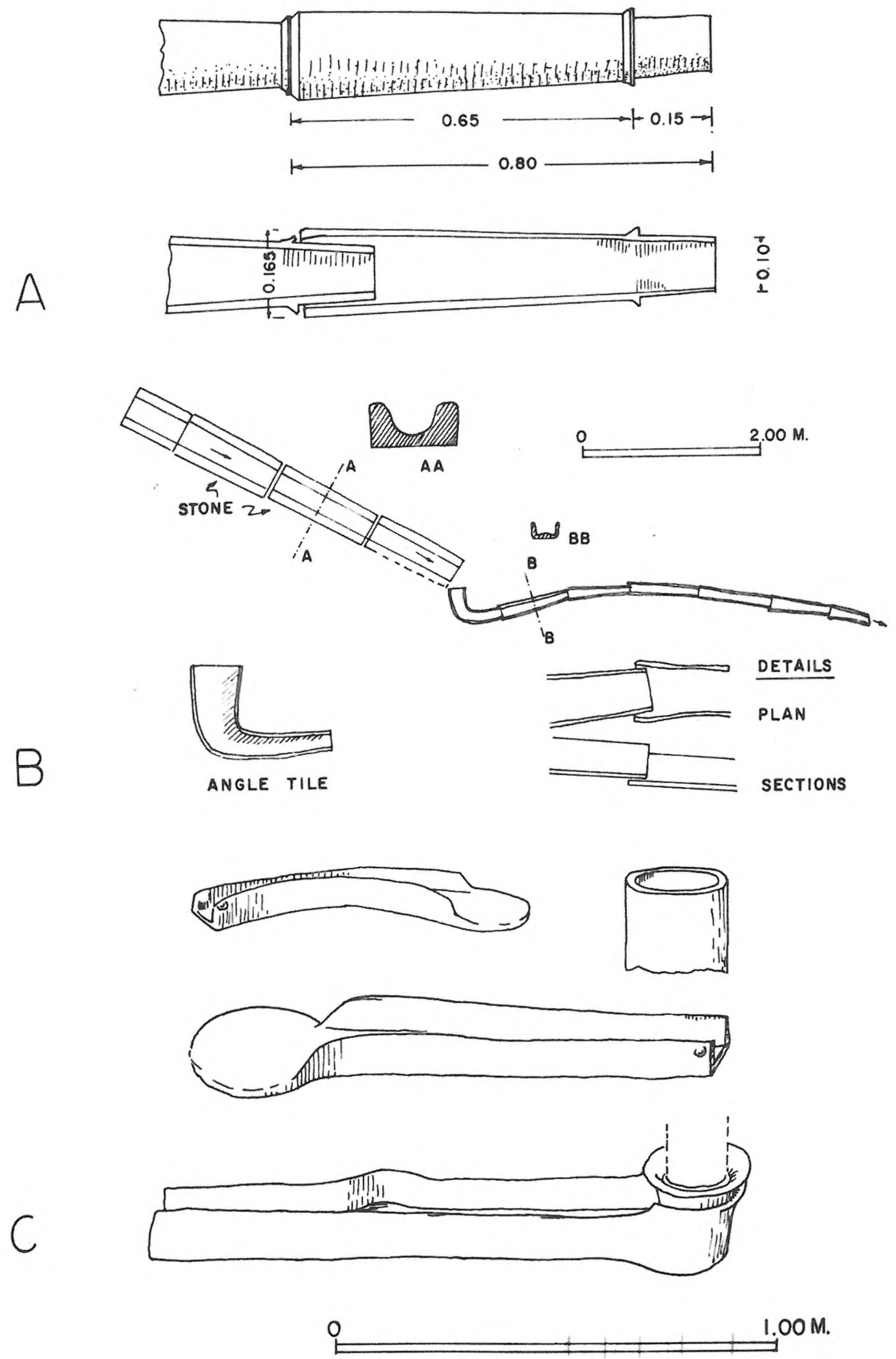


235 – Gournia - House Ac - Plan and partial section of partition wall (by author).

236 – Palace of Phaistos - Room xl - Partially restored partitions of mud brick.

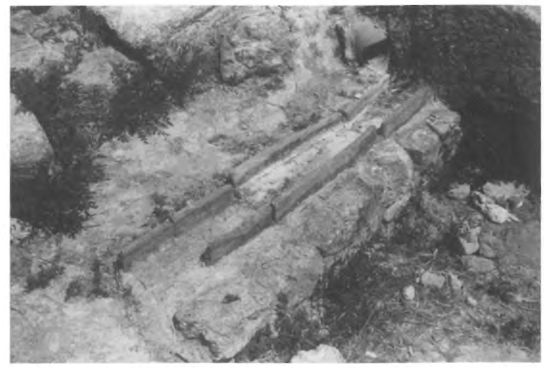


237 – Palace of Knossos - Terracotta waterpipes from South Porch (A) and Area of the Stone Drain-Head (B) (from *Knossos* I, Fig. 104).



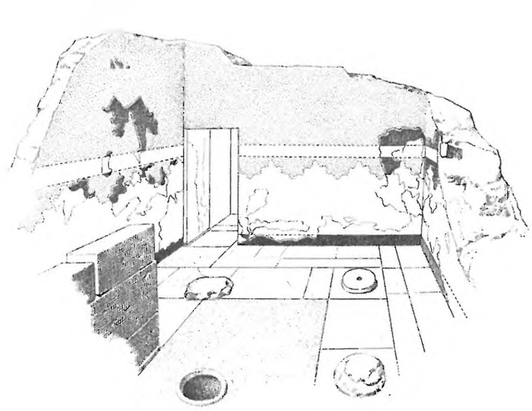
238 – Waterpipes and channels of terracotta from Tylissos (A), Malia (B) and Palaikastro (C) (after *Tylissos* [2] Fig. 14 [A here]; *Maisons* I, Fig. 2 [B here]; Dawkins 1904-1905, p. 289, Fig. 16 [C here]).

239A – PALACE OF KATO ZAKRO - ROOM XI TERRACOTTA DRAINAGE CHANNEL.

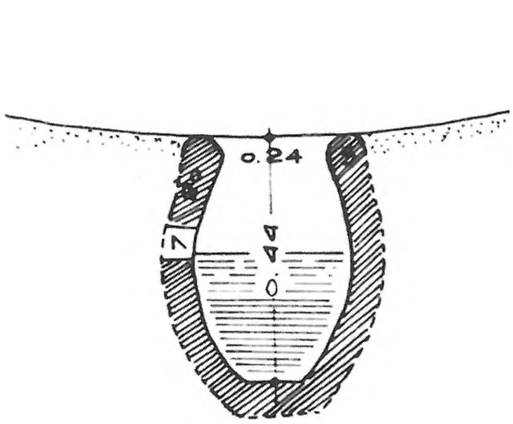


239B – PALACE OF KNOSSOS - SOUTHERN RESIDENTIAL AREA - TERRACOTTA DRAIN.

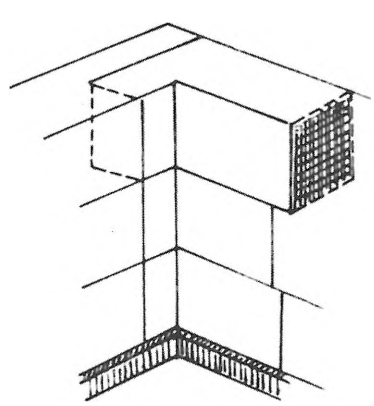
240 – PALACE OF PHAISTOS - ROOM 69 A - MODERN REPLICA OF ANCIENT CATCH-BASIN SET BELOW FLOOR LEVEL.



241 A – HAGIA TRIADHA - NORTHWESTERN RESIDENTIAL AREA - LOOKING SOUTH AT PORTICO AND LIGHT-WELL 54 WITH CATCH-BASIN (FROM HALBHERR *ET AL.* 1977, FIG. 69) (SEE ALSO FIG. 241 B) (BY E. STEFANI).



241 B – CATCH-BASIN IN FIG. 241 A (FROM HALBHERR *ET AL.* 1977, FIG. 70 A).



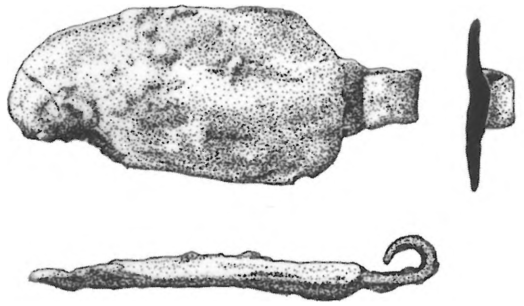
241 C – INTERIOR CORNER CONSTRUCTION AT HAGIA TRIADHA IN LIGHT-WELL 54 (FROM HALBHERR *ET AL.* 1977, FIG. 69) (SEE ALSO FIG. 241 A) (BY E. STEFANI).

242 – Palace of Kato Zakro - Tiles of terracotta, and «tarazza» used for floor-paving in Room IX (see also Fig. 258).

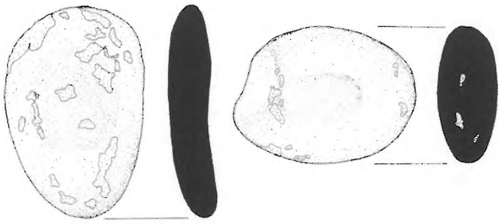
243 – Vasiliki - Detail of wall plastering.

244 – Knossos - Section of thick lime plaster (courtesy Mark Cameron).

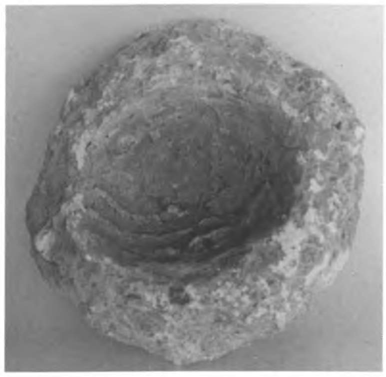
245 – Gournia - Partially restored plaster float of steatite (LM I).



246 – Kommos - Bronze trowel (?) for pointing masonry joints.



247 – Kommos - Palm-sized stone burnishers for plastering. Plaster still adhering is shown in uneven patches. Scale 1:2. (from *Kommos* I [1], Pl. 8.93) (by Harriet Blitzer).



248 – Knossos - Imprints of fingers in a lump of gypsum plaster from a limner's bowl found in a cist in the Long Corridor in the West Wing of the Knossos Palace. (courtesy Mark Cameron).

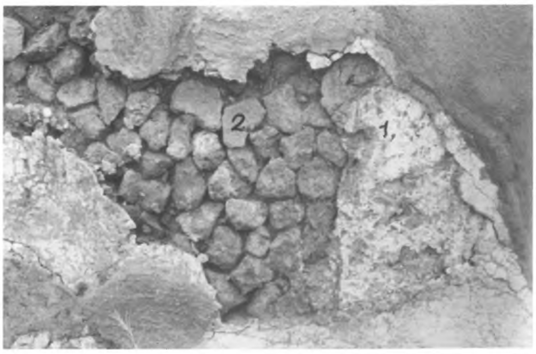
249 – Knossos - Fragmentary LM III bowl partially filled with plaster (courtesy Mark Cameron).

250 – Knossos - Profile of lump of plaster (courtesy Mark Cameron).

251 – Knossos - Holes of square wooden dowels in fragment of wall-plaster (courtesy Mark Cameron).

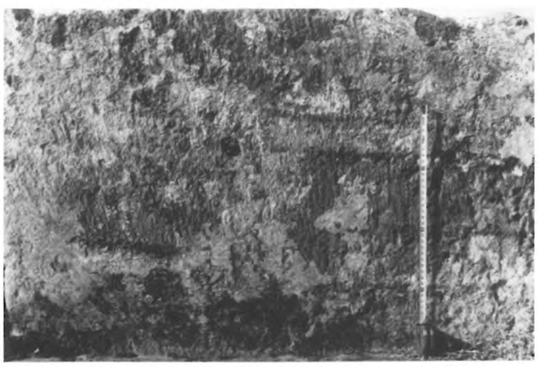
252 – Tylissos - Back face of wall plaster. Note impressions of straw binder.

253 – Tylissos - House C - Coarse mud plaster with impressions of straw binder in Corridor B.

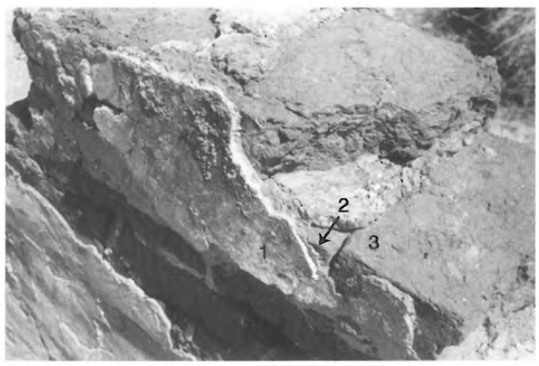


254 – Malia - Hypostyle Crypt - Fine lime plaster (1) applied on backing of small stones (2).

255 a – Palace of Malia - Layers of plaster on wall in Room xxiv, 1.

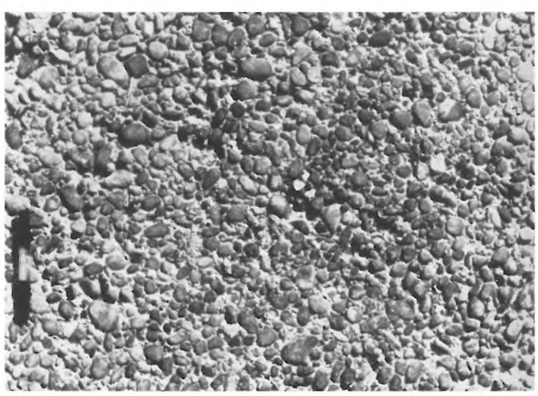


255 b – Palace of Malia - Detail of block of West Façade. Note very thin plaster layer still adhering to wall surface.



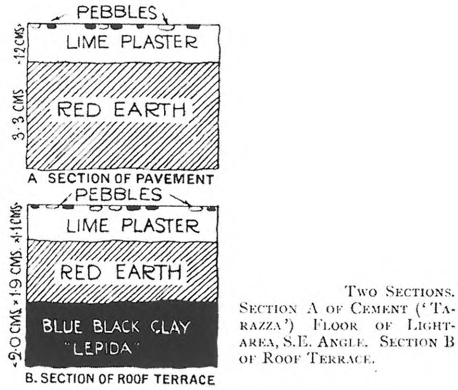
256 – Palace of Malia - Corridor C-C' - Detail of wall showing lime plaster (1), mud plaster backing (2) and mud brick (3) in blocked doorway.

257 – Palace of Malia - North Court - Remains of plaster water-channel.

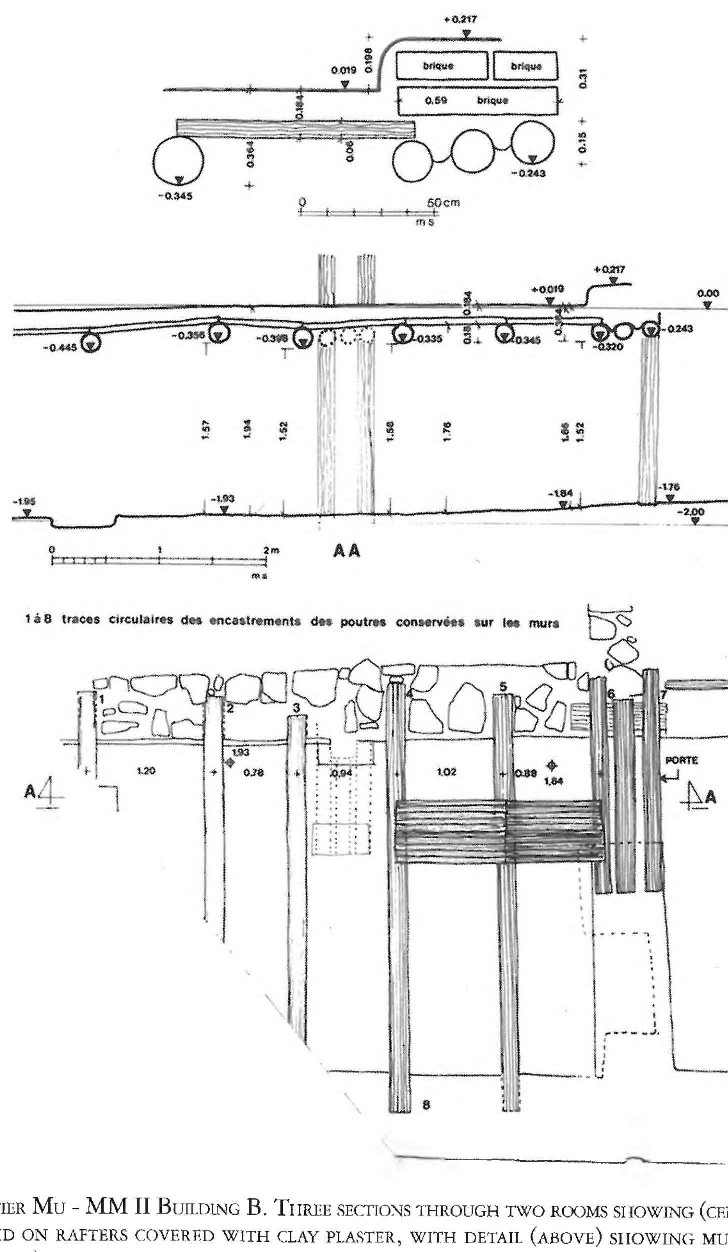


258 – Palace of Kato Zakro - Detail of worn tarazza floor in Room ix (see also Fig. 242).

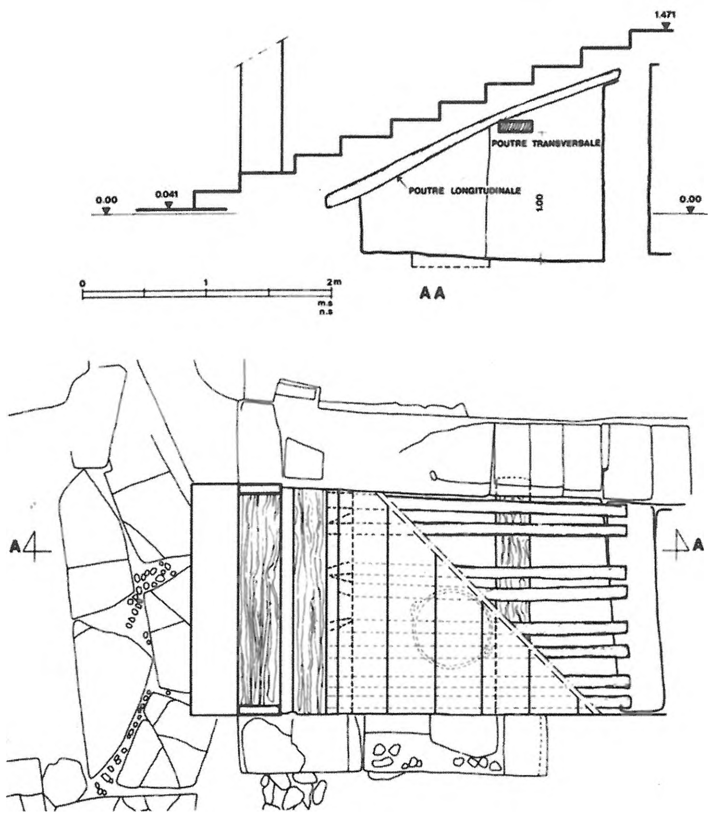
259 – Palace of Kato Zakro - Side-view of partially preserved tarazza floor in Room LXI.



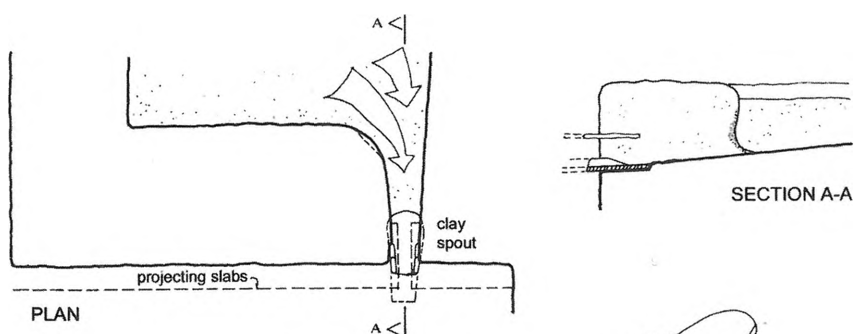
260 – Knossos - Schematic sections of tarazza floors (from *Knossos* II, Fig. 185).



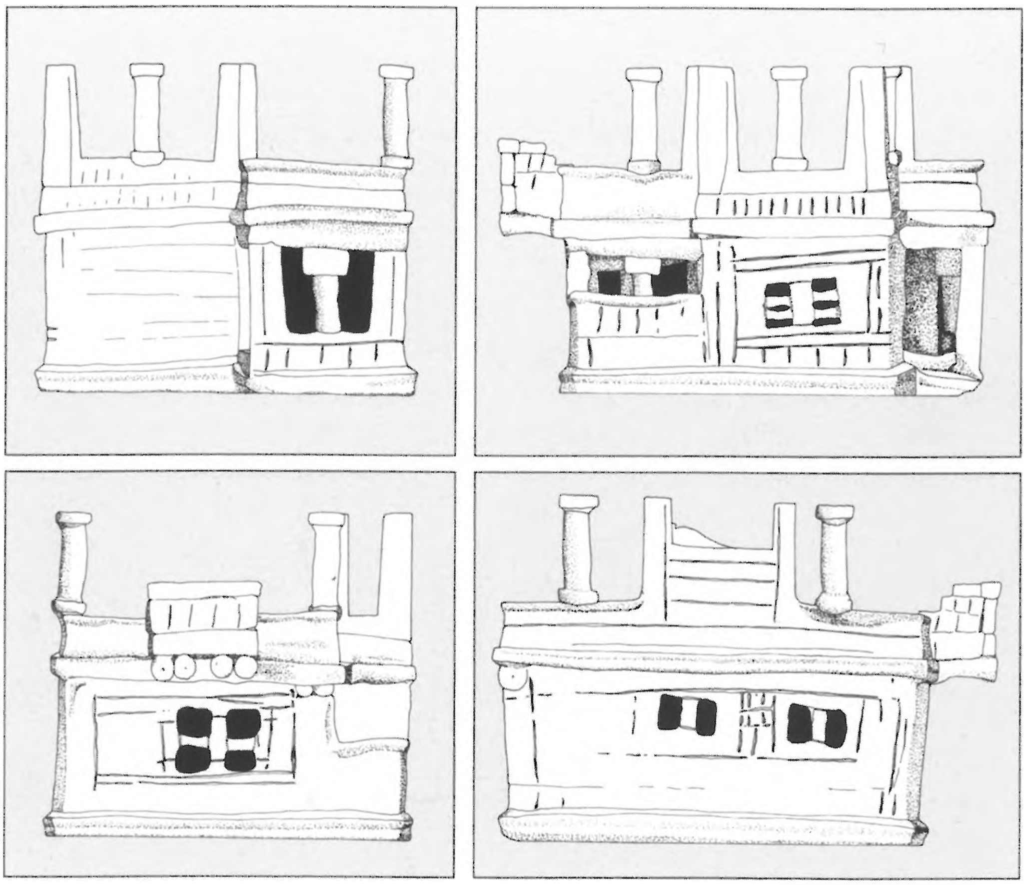
261 – Malia - Quartier Mu - MM II Building B. Three sections through two rooms showing (center) positions of thin lengths of wood laid on rafters covered with clay plaster, with detail (above) showing mud brick used to raise floor level, and (below) reflected plan of ceiling construction (note doorway) (from Schmid 1996, Figs. 43-44).



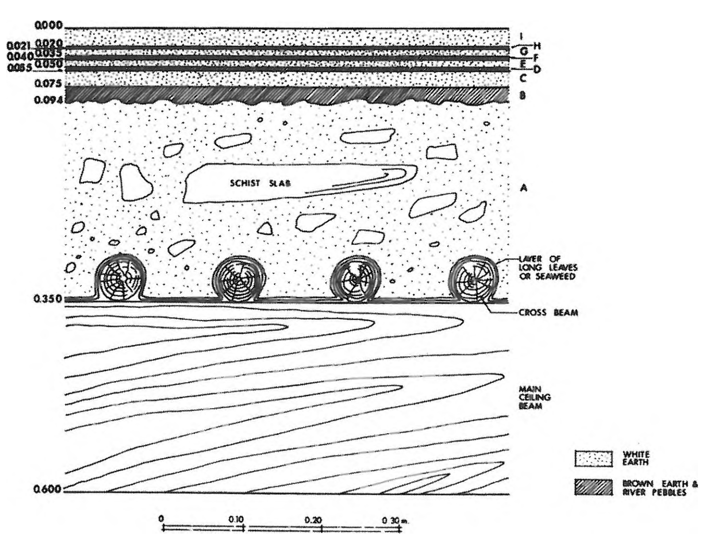
262 – MALIA - QUARTIER MU - MM II BUILDING A. PLAN (BELOW) WITH SECTION (ABOVE) SHOWING USE OF ROUGH-CUT BEAMS IN STAIRWAY IN WHICH THE LOWER TREADS WERE PLASTERED CLAY AND THE TOP TWO WERE PLANKS (FROM SCHMID 1996, FIG. 45).



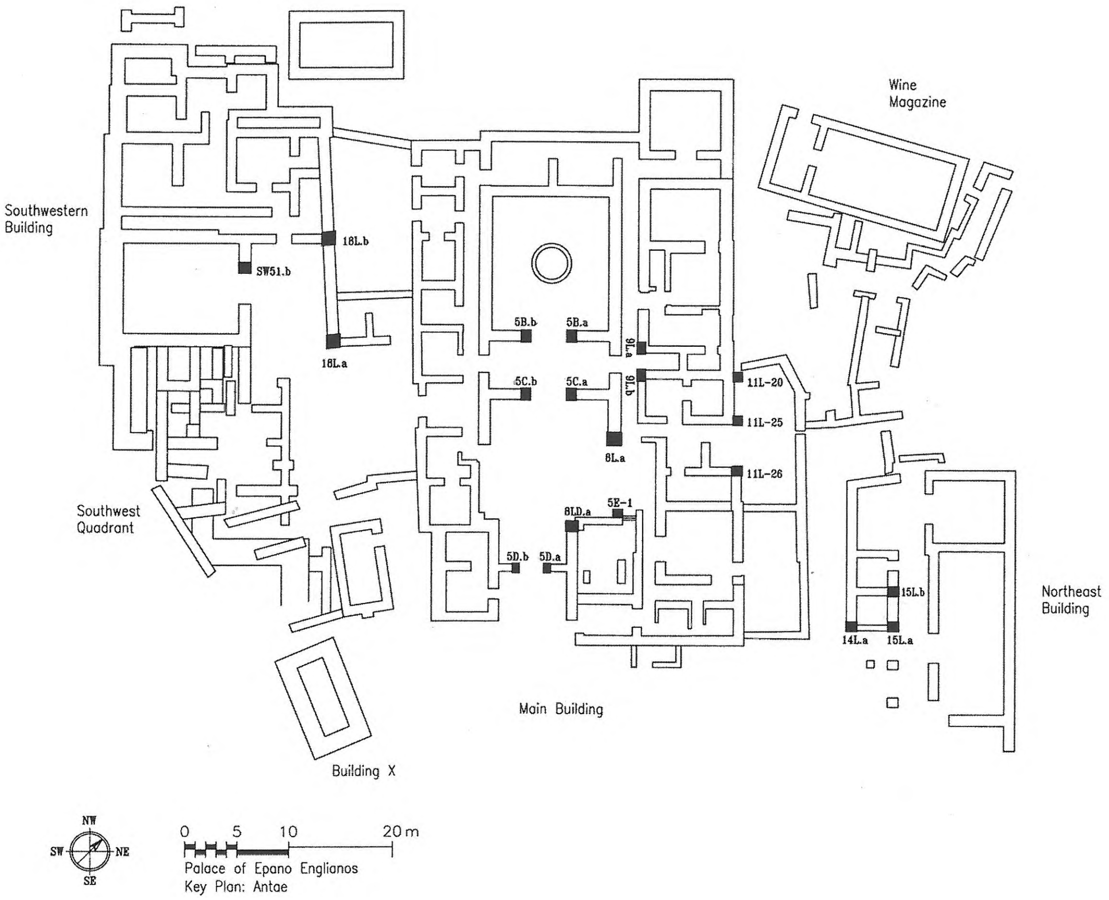
263 – AKROTIRI, THERA. DETAILS OF A WELL-PRESERVED THERAN ROOF WITH A SPLAYED TERRACOTTA SPOUT AND PROJECTING STONE SLABS, FROM A BUILDING NEXT TO THE SOUTH HOUSE (FROM PALYVOU 2005, FIG. 185).



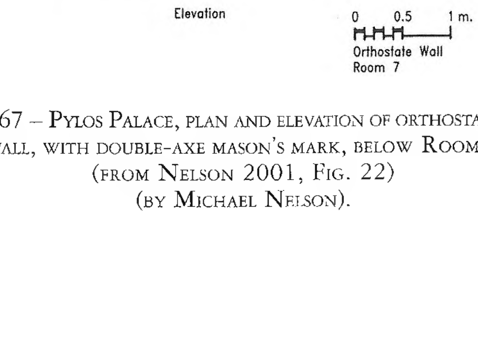
264 – House model from Archanes (from Lebessi 1976, Figs. 4-7) (by K. Iliaki).



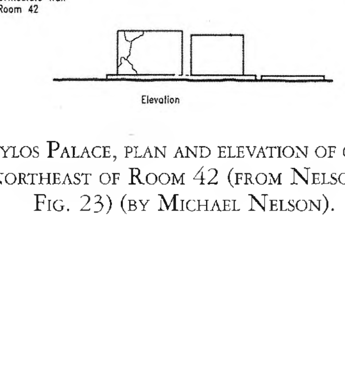
265 – Akrotiri, Thera. Section of a fallen roof fragment with multiple renewals from the West House.



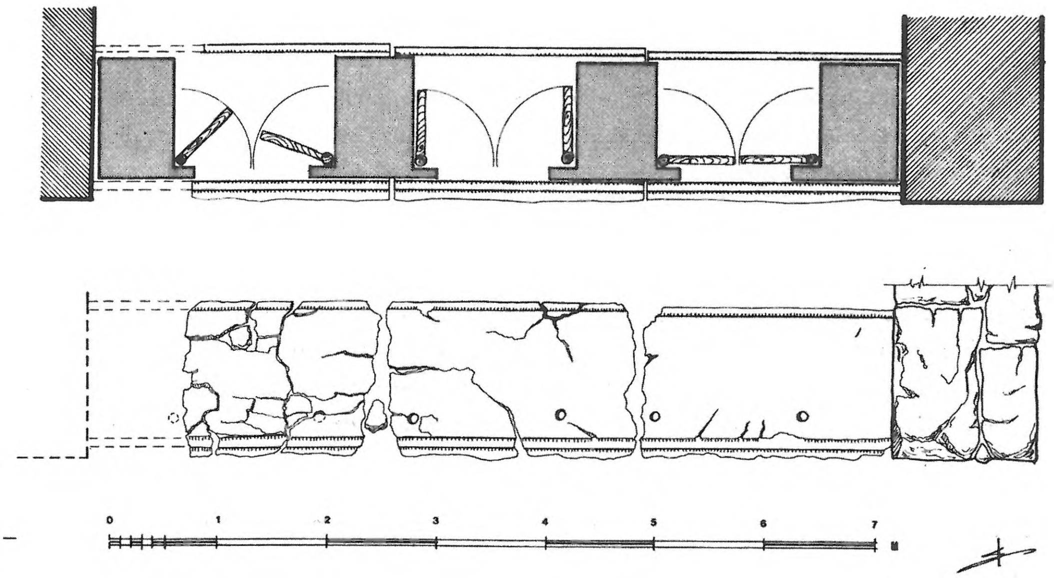
266 – PLAN OF PYLOS PALACE, SHOWING LOCATIONS OF PIERS AT WALL CORNERS AND WALL-ENDS (*ANTAE*) (FROM NELSON, 2001, FIG. 7) (BY MICHAEL NELSON).



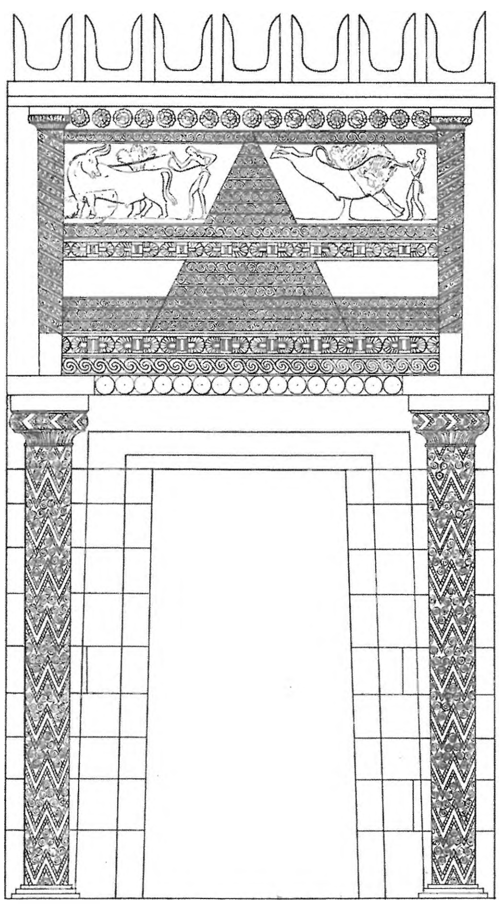
267 – PYLOS PALACE, PLAN AND ELEVATION OF ORTHOSTATE WALL, WITH DOUBLE-AXE MASON'S MARK, BELOW ROOM 7 (FROM NELSON 2001, FIG. 22) (BY MICHAEL NELSON).



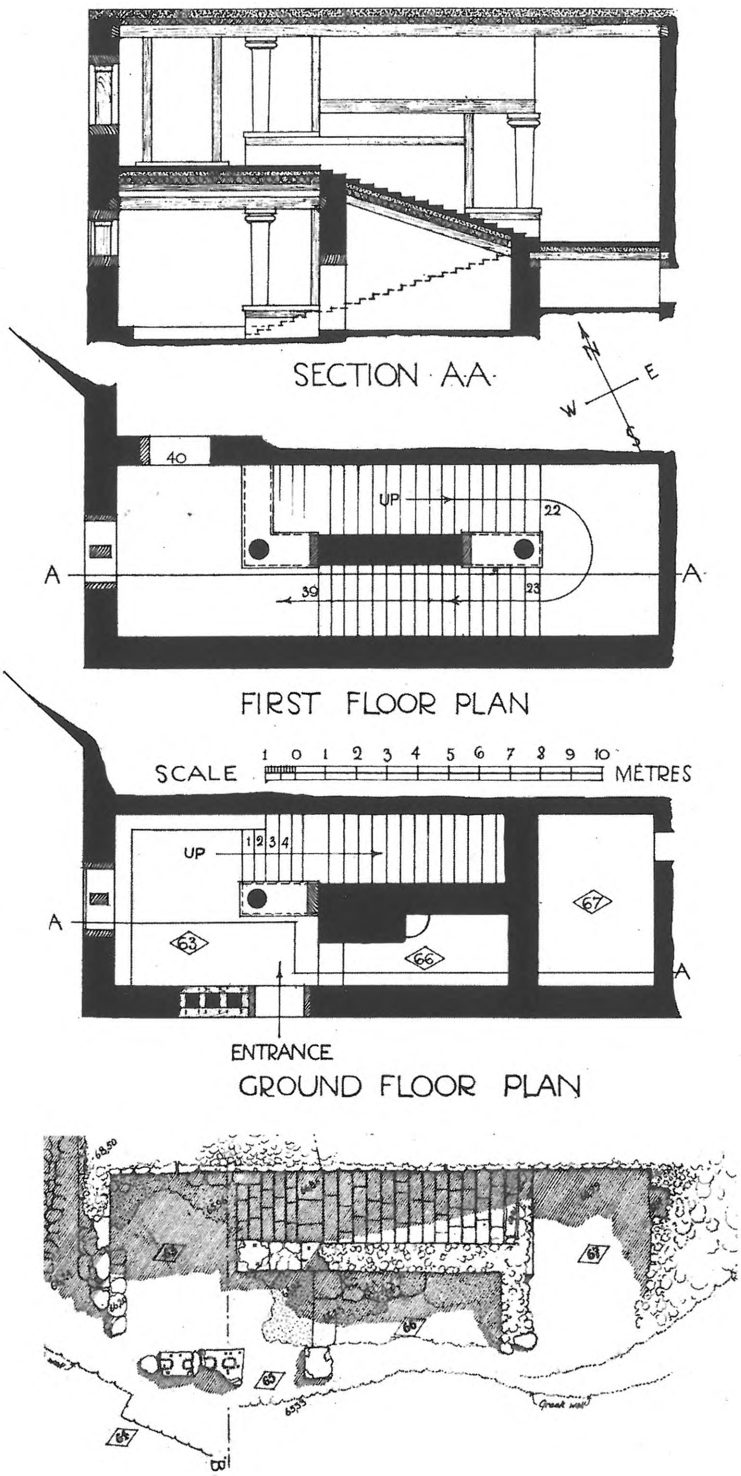
268 – PYLOS PALACE, PLAN AND ELEVATION OF ORTHOSTATE WALL NORTHEAST OF ROOM 42 (FROM NELSON 2001, FIG. 23) (BY MICHAEL NELSON).



269 – Gla. Restored (above) and state plans of hard limestone threshold slabs with bored holes for pivots (below) at *polythyron* entrance into Room 3 (from Iakovides 1989, Fig. 22) (by Sp. Iakovides).



270 – Mycenae. Treasury of Atreus Façade (from Marinatos and Hirmer 1973, Fig. 34) (after Sp. Marinatos).



271 – Mycenae. Palace. Restored Grand Starcase leading up to Mycenae Palace (from Wace *et al.* 1921-1923, Fig. 34) and (below) state plan of same area (from Wace *et al.* 1921-1923, State Plan) (plans by Piet de Jong and Leicester Holland, respectively).

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