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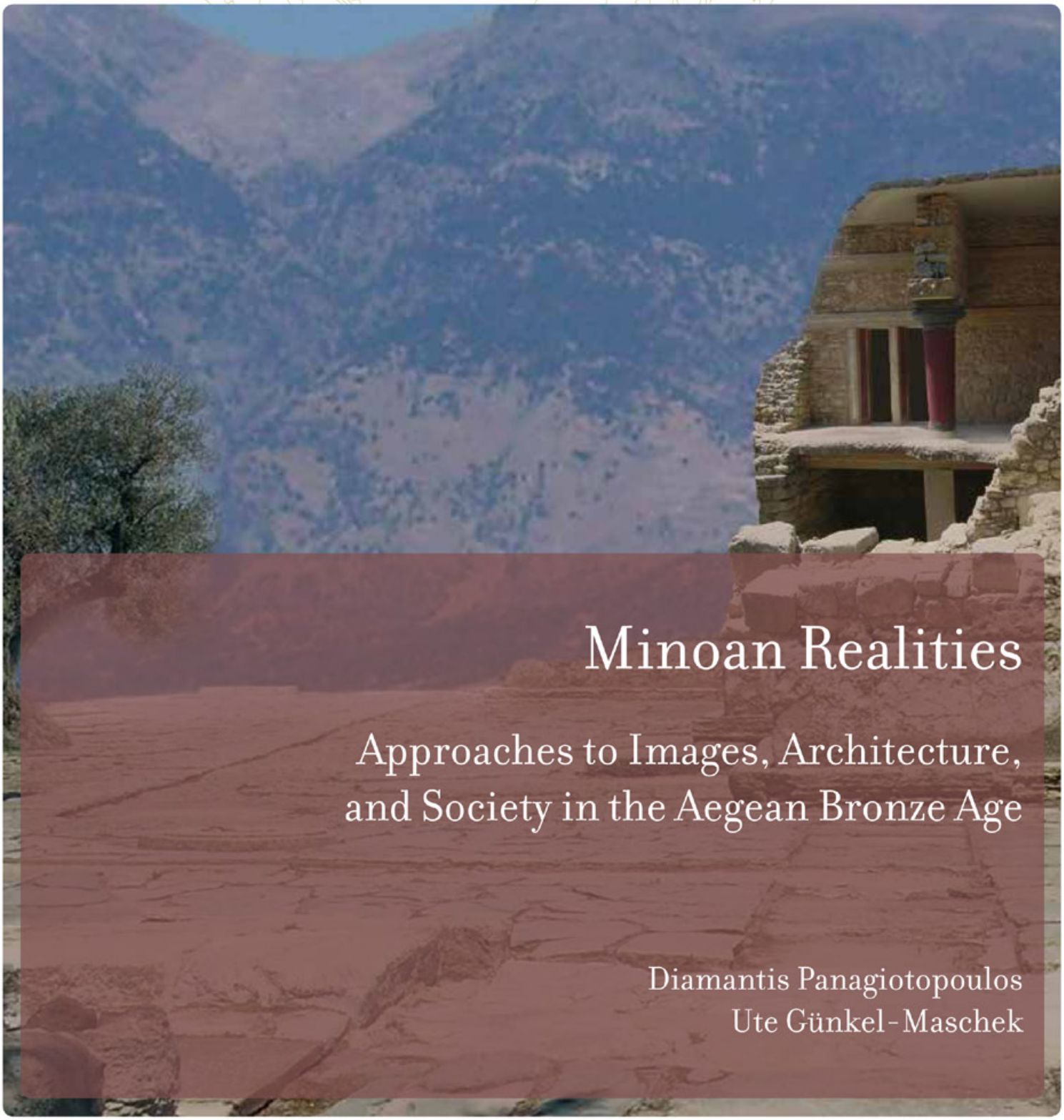

Minoan Realities

Approaches to Images, Architecture, and Society in the Aegean Bronze Age

Diamantis Panagiotopoulos
Ute Günkel-Maschek

UCL PRESSES UNIVERSITAIRES DE LOUVAIN

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Labour Costs and Neopalatial Architecture

A Study of the Buildings at Klimataria-Manares and Achladia and the Palace at Gournia

Maud Devolder*

The existing Neopalatial architectural typology, as presented by McEnroe, is mainly based on a description of the formal and conceptual traits offered by the buildings. As such, a general material and technical simplicity, most often explained as the result of physical determinism, characterises vernacular architecture in radical opposition to the so-called *polite* architecture[1]. The main features of this latter style are the presence of architectural units illustrating respect for architectural trends[2], not unrelated to the social status of the users or inhabitants, and the use of ostentatious building materials. The visual impact of such specific choices has been stressed since the beginning of the history of Minoan archaeology, as this is clear from the oft quoted comment of Seager concerning the ashlar façade of Gournia, an edifice considered in more detail further on in this paper. Seager labelled it "a veneer of elegance to impress the passer-by"[3]. Several studies have since considered these *polite* architectural features, their specific traits, their modifications and adaptations, and their diffusion, notably by taking into account the circulation – in Crete but also elsewhere in the Aegean – of itinerant craftsmen and the possible active reactions against specific ideologically-charged architectural units[4].

Beyond the description of the physical traits of Minoan architecture and their role in the classification of buildings into distinct categories, this essay explores a quantitative approach to Minoan architecture, based on a study of the labour costs generated by the erection of a series of buildings. This approach, sometimes dubbed 'architectural energetics', offers a series of estimates of the time necessary to accomplish the diverse architectural tasks involved in building an edifice. The clearing and levelling of building sites, the supply of materials – whether through collection or extraction –, their transport and finishing, the erection of walls and the making of ceilings and roofs can be studied according to the time necessary for their completion, which is usually expressed in man-hours (henceforth m-h). In this study, I first detail some of the specificities of the method and then focus on the implication for Neopalatial architecture, by studying three specific cases. The purpose of this paper is to highlight the insights offered by such a quantitative approach for the built form and the factors at play during its production. I especially focus here on the material and technical choices of the builders, on the setting of costs into their historical context, and on the workforce involved in the building project.

1. Labour costs estimates: standard costs, sampling and volumes

The specificities of Minoan Neopalatial architecture imply first of all the establishment of standard costs adapted to its specific materials and techniques. Such a quantifying method is based on theoretical costs derived from a variety of sources, including tests conducted in experimental archaeology, mostly by anthropologists but also observations of masons and artisans using pre-mechanical era techniques, often coupled with experimentation. Information can also be found in a series of specialized works intended for architects and engineers of the late 19th – early 20th centuries which are based partly on observations, partly on accounts of large building sites. Finally, reports of international institutions supporting agricultural projects in developing countries also provide information[5] especially when it comes to estimating the average times necessary for a person to accomplish a given task for a set volume of material. Earth (used for brick-making

* I thank Prof. J. Driessen for his advice.

1 McEnroe 1982, 13–14; McEnroe 1990.
2 Driessen 1982.
3 Seager 1909, 296.
4 Driessen 1989–90, 5, 17–22; Hitchcock 1997; Wilson Cummer 1980; Palyvou 1990, 45; Driessen and MacGillivray 1989, 101.
5 Devolder 2009, 198–276.

as well as for mortar and coating), field stones (of various types according to whether they were reworked or not), ashlar, wood (used in wall and roof frameworks) and flagstones (used for paving and in some cases for roofs), were then considered according to the various aforementioned architectural tasks. Although we do have standard costs at our disposal for finishing activities (various coatings and painting), the latter were not applied to our sample because of the varying preservation of the archaeological data which does not permit any systematic comparison. Consequently, only building exteriors were considered. Moreover, the reuse of materials in new structures, amongst which those resulting from site levelling, wall demolition, the material properties – such as stone density –, the loss of material during manufacture and the varying proportions of mortar in the walls which all play a role in the application of standard costs have been omitted here.

A convincing application of the method relies on standards costs relating to the specifics of the considered architecture. The buildings investigated need to be sufficiently preserved and studied in order to allow a precise estimation of their volumes. The degree of architectural elaboration has proven in some cases to be insufficient to allow for a detailed and accurate estimate of construction costs. This is actually the reason why the finishing stage was not considered. The state and recording of the data can vary considerably according to the way the structure was abandoned or destroyed, the conditions under which it was subsequently preserved, and the excavation techniques it was finally subject to. On the basis of criteria, an 'energetic' investigation of the palace at Gournia and of the buildings at Klimataria-Manares and Achladia is here undertaken. The different floors these buildings originally comprised have been taken into account[6]. Some of the data are sometimes based on conjectural information and/or reconstructions, but a range of hypotheses were considered by the said method in order to offer the best conceivable approach to the former appearance of these buildings. Furthermore, the cost estimate takes into account the probable architectural sequence of the edifices, including their possible modifications or additions. Needless to say, it was impossible to take into account all parameters at play in the building project. This fact acknowledged, we should remind that the decimals kept after commas are no pretention for providing absolute labour costs, but the illustration for a wish at coherent calculations.

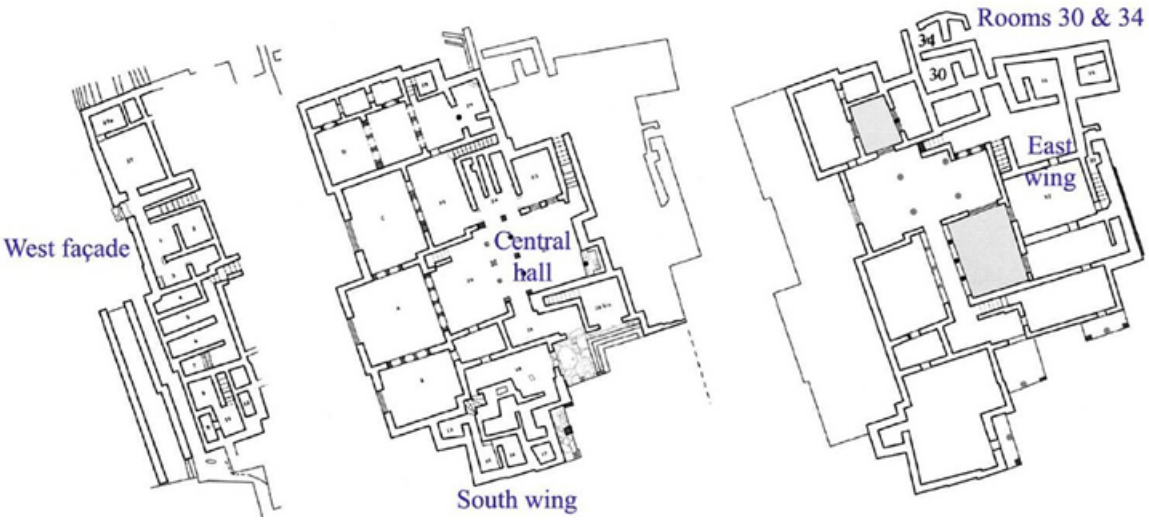


Fig. 1 Plan of the basement, main and upper floor of the palace at Gournia (after Soles 1991, figs. 29, 58 and 67). Written in blue are the parts which were added or remodelled.

[6] The estimates of volumes and precisions concerning details of the application are given in the annex volume of Devolder 2009.

2. Applications

2.1. The palace at Gournia

The construction of the palace of Gournia generated **83,275.68 m-h**, spread over distinct architectural phases. Soles suggests that the initial construction phase of the building took place late in the MM III period, while the modifications of the structure very likely happened during the LM IB period[7]. The latter implied the remodelling of the West façade and the Central hall as well as the addition of the South wing, the East wing and rooms 30 and 34 (fig. 1). The ashlar necessary for the construction of the West façade, the South wing and the Central hall was provided by the quarry at Mochlos, which may have been used only from LM IB onwards[8].

Structural details tend to indicate that at least the remodelling of the Central hall had been completed when the East wing and rooms 30 and 34 were added to the palace[9]. Indeed, the eastern walls of the Central hall support the western walls of the East wing, and these would therefore have been destroyed if they had been anterior to the ashlar remodelling of the hall. Furthermore, the rubble wall in between the alcoves of the Central hall would have been destroyed for the ashlar remodelling, provoking the collapse of levelling materials under the East wing floor into the Central hall. I therefore suggest that the West façade, the Central hall and the South wing, which make privileged use of ashlar, were built or remodelled first, then followed by the East wing, and finally by rooms 30 and 34. As such, the palace at Gournia would seem to represent the most eloquent case of LM IB conspicuous consumption in the architectural sphere. This is exemplified by several other sites in the Isthmus of Ierapetra, but seriously contrasted with the situation illustrated by the domestic architecture in the Gournia town[10]. The costs of the successive construction phases have been estimated as follows:

	Initial phase	South wing	West façade	Central hall	East wing	Rooms 30 & 34
Labour Costs	32,110.71 m-h	18,340.45 m-h	9,144.66 m-h	6.771,45 m-h	15,496.67 m-h	1,411.74 m-h
Surface	1,825.39 m²	222.36 m²	-	-	376.13 m²	113.42 m²
Ratio cost/ ground surface	17.59 m-h/m²	82.48 m-h/m²	-	-	41.2 m-h/m²	12.44 m-h/m²

Table 1 Labour costs of the construction and remodelling phases of the palace at Gournia and, where appropriate, the built ground surface of the addition in question.

It is interesting to see that the building of the South wing generated higher costs than the addition of the East wing, despite its surface being less than two thirds the ground surface covered by the latter. Ratios of labour costs per square meter of ground surface covered by the structure indicate a considerable difference between the distinct building phases. The following graph illustrates the relative importance in each phase of specific materials and techniques (graph 1).

Specific architectural tasks and materials generated relatively important labour costs during the two phases: levelling costs, implied by the adaptation of the bedrock to the basement and main floor in the first phase, and the filling and building of retaining walls in the second phase[11] (fig. 2). The very high percentage of costs

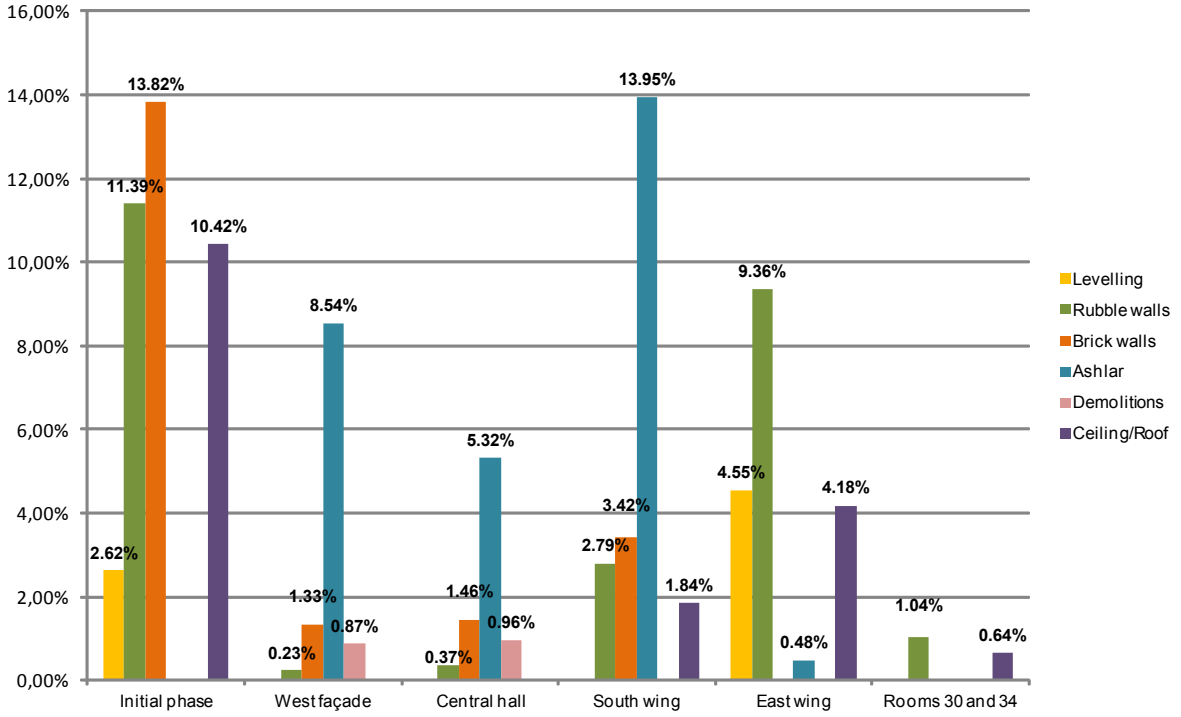
[7] Soles 1991, 21–31.

[8] Suggested by Soles, see Soles and Davaras 1990, 89–90; Soles 1991, 24, 26 and 28, n. 13; Soles et al. 1995, 391; Pike and Soles 1998, 377; Warren 1999, 894–95, 899 and 901–2.

[9] Devolder 2005, 168.

[10] Soles 1991, 31; 2004, 159–60.

[11] Fotou 1990, 59.



Graph 1 Percentage of labour costs for each construction phase of the palace at Gournia.

implied by the use of mudbricks for the upper floors walls is also striking, but we will return to the higher than expected cost of this building material in due course. In fact, it is clearly the ashlar which makes up for most of the costs, representing 28.29% of the total labour costs invested in the palace. The high costs of the structure can therefore for a large part be put down to specific choices in terms of adaptation *of* and *to* the local topography, with especially high levelling costs, and to the presence of an expensive material such as ashlar. Both seem part of a deliberate attempt at conspicuous consumption.

These material and technical choices become even more striking if one considers that, during LM IB, the site reveals a vernacular architecture characterised by the abandonment and subdivision of many houses[12]. Although this marked difference may eventually be tempered by a more refined and precise architectural chronology of the building, it is tempting to suggest a link between the two phenomena. Is it indeed possible that this excessive investment, in the sense that it exceeded the structural needs of the building[13], played a

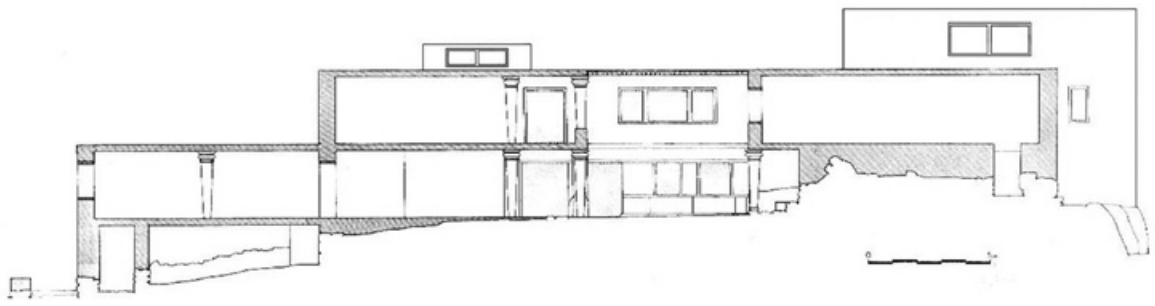


Fig. 2 Section of the palace at Gournia, indicating the levelling prior to the erection of the building on the top of the acropolis (after Soles 1991, fig. 57).

[12] Driessen and Macdonald 1997, 214–15; Devolder 2005, fig. 2.

[13] Trigger 1990, 119: "Its [sc. monumental architecture] principal defining feature is that its scale and elaboration exceed the requirements of any practical function that a building is intended to perform".

specific role in the historical conjuncture of the site? Some have argued that "one would expect an increase in monumental building in times of economic and political stress"[14]. If so, the expensive remodelling of the palace at Gournia may be interpreted in two different, entirely contradictory ways. It could either indicate a flourishing situation at the site during the LM IB period – a conjuncture not unlike the one hypothesized at Mochlos – or it may have served to counterbalance the troubles as suggested by the vernacular architecture elsewhere in town. Also, different architectural phases may illustrate reactions to different contexts, which the chronology of the building and the evolution of the town during the Neopalatial period have not yet allowed to clarify.

Phase	Labour costs	Necessary workforce
Initial phase	32,110.7 m-h	**44.59 individuals**
West façade	9,144.66 m-h	**12.70 individuals**
Central hall	6,771.45 m-h	**9.40 individuals**
South wing	18,340.45 m-h	**25.47 individuals**
East wing	15,496.67 m-h	**21.52 individuals**
Rooms 30 & 34	1,411.74 m-h	**1.96 individuals**

Table 2 Necessary workforce required by each construction phase of the palace at Gournia, considering 90 eight-hour working days.

Beyond new insights into the architectural traits of the building and the relationship of its own history to local conjuncture, labour costs make it possible to investigate the importance of the human factor in the interpretation of the building project. As such, the Neopalatial population on the site has been estimated at around 5,420 individuals[15]. Considering that between 20 and 33% of a normal population may be considered as a potential workforce[16], this implies that between 1,084 and 1,804 individuals were available, regardless of the type of mobilisation, to build the palace. If we consider the difficult times the town may have been facing on the eve of its destruction by fire at the end of the Neopalatial period, it may well have meant that this potential workforce was considerably reduced. But even if less manpower was available, it is interesting to consider these numbers in comparison to the workforce necessary for each phase. To estimate the latter, several parameters need to be set. One of these is the length of the working day, which is here estimated as eight hours[17], though this may have varied according to the tasks accomplished[18]. Another is the potential duration of the entire building project. Several studies have stressed that larger projects were generally carried out in a limited time-frame, in order to reduce the exposure of damage-prone walls. As a consequence, work was usually carried out during the dry season. Similarly, the months during which fields require little or no work were often those used for such building activities. Comparative studies based on examples in Central America, Greek antiquity and Western Africa suggest a period of between two and five months[19]. These

[14] Driessen 1995, 71.

[15] Based on estimates by Branigan 2001, 15–16 and tables 3.3. and 3.4; Watrous and Blitzer 1999, 906.

[16] Abrams 1987, 493: "The labor pool […] might have ranged from 20 percent of the total population – only adult males or household heads – to approximately 33 percent of the total population – adult males plus some portion of adult females and subadult males".

[17] Erasmus 1965, 283.

[18] Aaberg and Bonsignore 1975, 46.

[19] Abrams 1987, 490: "A wide range of ethnographies […] indicates that within agrarian societies, construction is predominantly if not exclusively scheduled for the agricultural off-season (excluding of course situations requiring immediate repair). Within the Copan Valley today, construction is scheduled for the dry agricultural off-season […] a period of approximately 120 days. […] This figure, however, is too high, since the four operations within the overall process of construction are to some degree sequential; that is, there is a necessary temporal delay between component operations. Thus I will reduce the duration of work to a 60-day period for most of the tasks in construction". On the basis of interviews with artisans from Copan, Honduras, Abrams (1994, 43) stretches his estimate: "First, construction in Copan is generally undertaken during the dry season, from January to May. The reasons are rather predictable: dry conditions provide for dry materials and better working conditions, and the agricultural off-season provides the necessary time for scheduling house construction". For the Batammaliba (Togo and Benin), Blier (1987, 19) argued: "House construction is generally

concern societies where architecture is mostly an unspecialised activity and where those forming the labour pool must also attend to their own affairs, agricultural for the most part, as was very likely the case in the Aegean[20]. According to the labour costs estimated and considering these parameters, the necessary workforce can be reconstructed as in table 2.

Where the later phases are concerned, some of these works (West façade, the Central hall and the South wing) may have happened simultaneously so the necessary workforce may have been combined. In any case, the number of individuals involved in the building project would always have been lower than those available on the site. If an excess in invested energy can be observed in the construction or modification of the palace at Gournia, it is more a matter of materials and technical choices than an excessive demand on the population of the site. It cannot even be excluded that some of the participants of the building project were foreign to Gournia, especially if the town was not large enough to support a permanent class of craftsmen able to accomplish the most skilful tasks, such as required by ashlar manufacture and construction. And although reasonable and plausible in their own demographic context, these seemingly considerable costs appear, however, as excessive if one regards the development of the rest of the town in LM IB.

2.2. The buildings at Klimataria-Manares and Achladia

The buildings at Klimataria-Manares and Achladia, together with sites such as Zou and Aghios Georghios Tourtouloi, are situated in the socio-politically and economically debated landscape of the hinterland of Petras[21]. They have been the object of recent investigations by E. Mantzourani and her collaborators, who provide detailed architectural accounts and reconstructions which help to appreciate the role of these buildings in a regional context.

The Klimataria-Manares edifice is an isolated structure located on and along the Stomion river and has been dated to MM IIIA–LM I[22]. A mole built on its east side suggests the building actively participated in a network providing goods and persons towards Petras, the central point of the region, although it cannot be excluded that Klimataria controlled the passage by river[23]. Storage rooms were identified but it is not possible to say whether commodities were brought in from the area or whether they were produced at Klimataria-Manares[24].

The construction of the building at Klimataria-Manares generated labour costs of **10,981.37 m-h**. Levelling activities only account for a mod-

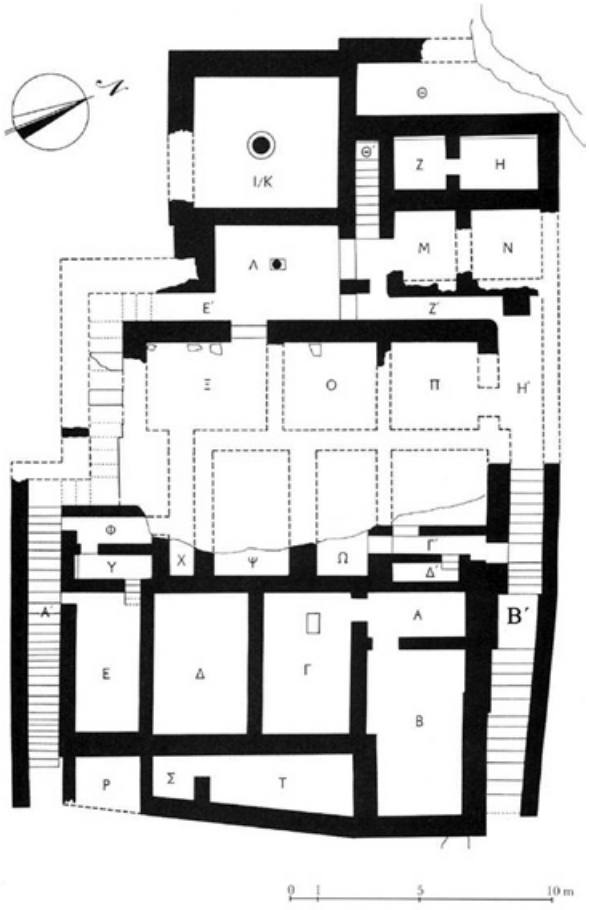


Fig. 3 Plan of the building at Klimataria-Manares (after Mantzourani and Vavouranakis 2005, fig. 13).

undertaken each year between the dry season months of December and February". In Greek antiquity, "[…] a fourth-century record from Eleusis shows that heavy transport from the quarries, in one instance at least, was done during July and August, the driest time of the year"; see Burford 1963, 33.

20 Halstead and Jones 1989; Osborne 1996, 51.

21 Tsipopoulou and Papacostopoulou 1997; Platon 1997.

22 Mantzourani et al. 2005, 743; Tsipopoulou and Papacostopoulou 1997, 210 and 214.

23 Mantzourani et al. 2005, 761 and 763; Platon 1952, 636.

24 Platon mentions the discovery of several pithoi, some of which had a typical MM III rope decoration, see Platon 1952, 637.

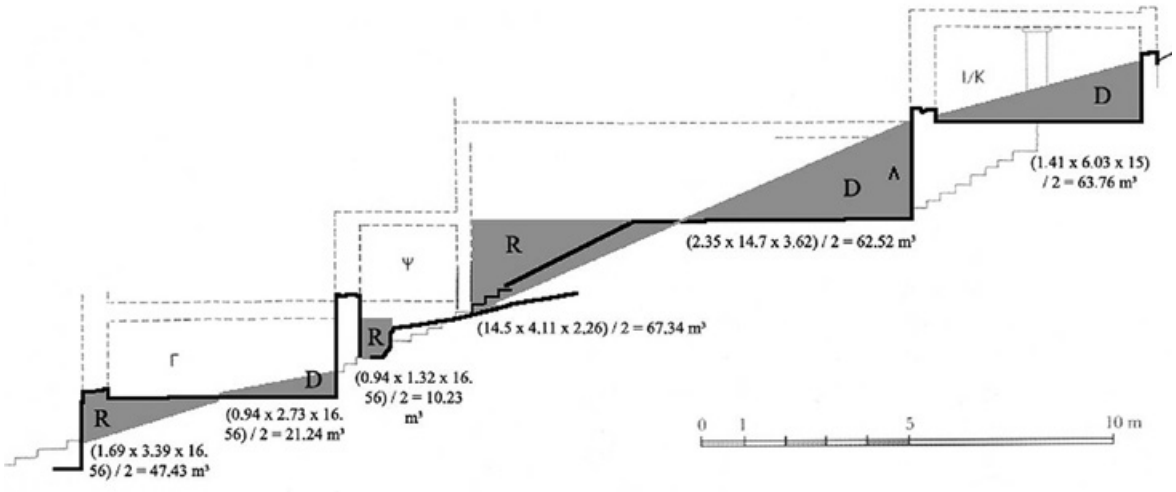
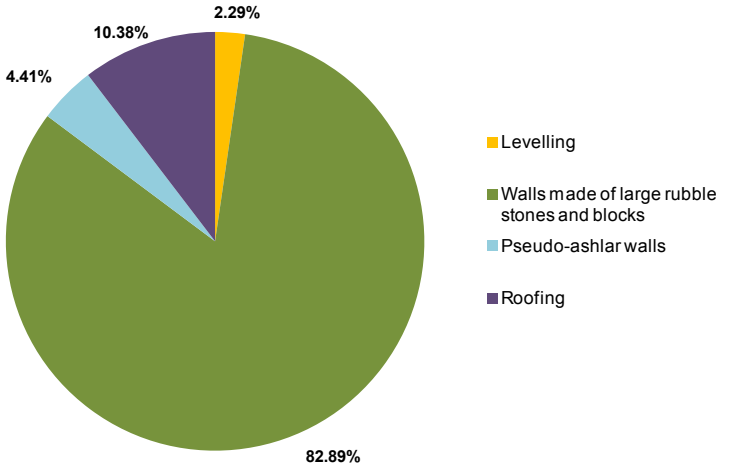


Fig. 4 Schematic view of the estimated cleared (D) and filled (R) volumes for adapting the building of Klimataria-Manares to the slope (after Mantzourani et al. 2005, fig. 9).

erate part of the total costs[25] (2.29 %, graph 2 and fig. 4). These limited levelling works were compensated by the use of large amounts of unworked large rubble and blocks for masonry (82.89 %, graph 2), probably because the setting of the edifice over four main terraces required sturdy walls. Indeed, many of these walls are one meter or more in width. Pseudo-ashlar walls, worked blocks of which implied labour costs for collection and manufacture far below those represented by ashlar, account for only 4.41% of the total construction costs of the building (graph 2). This rather modest elaboration was placed in a visually prominent position in the building, at the lower entrance which could be reached via the north-eastern, lateral staircase (B′, fig. 3). Although the building's labour costs indicate a strong investment in structural efficiency, the masons nevertheless invested some time in a somewhat status-loaded material, though moderate both in elaboration (the blocks were only roughly worked) and quantity.

The 'villa' at Achladia, in contrast to the building at Klimataria-Manares, may have been part of a settlement, as is suggested by the walls which appear in the agricultural fields around the building[26]. The structure examined here is Building A, located on a low hilltop but with a commanding view of the region[27]. It was built in MM IIIB or LM IA[28] and it cannot be excluded that its function changed between LM IA and B, since it is possible that the original reception rooms M and B were transformed into dining or storage areas[29]. Indeed, the number of storage and cooking vases



Graph 2 Proportion of the materials and techniques involved in the construction of the building at Klimataria-Manares.

[25] Mantzourani et al. 2005, 749 and 754.
[26] Tsipopoulou and Papacostopoulou 1997, 210 and 214; Platon 1997, 187.
[27] Mantzourani and Vavouranakis 2005, 101.
[28] See N. Platon (1959, 212) for a MM IIIB dating of the initial construction of the building, while L. Platon (1997, 194) suggests LM IA, on the basis of the architectural particularities of the building. Although the pottery corroborates a LM IB destruction of the building, as suggested by L. Platon, the date of the construction remains uncertain.
[29] Mantzourani and Vavouranakis 2005, 113.

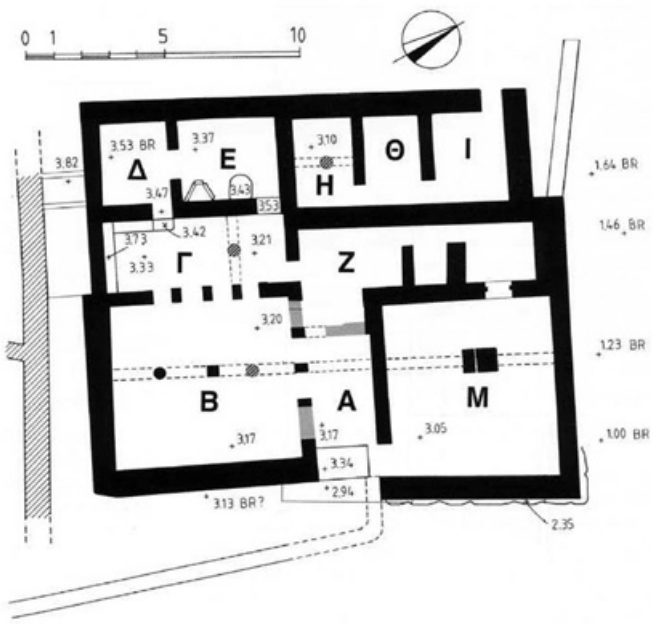


Fig. 5 Plan of the 'villa' at Achladia (after Mantzourani and Vavouranakis 2005, fig. 5).

discovered during the excavation of the structure suggest a mainly domestic and agricultural function. Thanks to a prior levelling of the site, the building could be given a modular plan and the orientation of the entrance towards the south-east protected it from fierce north and north-west winds. These features, as well as the presence of an architectural elaboration, with multiple doors and columns, stress the quality of this countryside 'villa'[30] (fig. 5).

Since Mantzourani and Vavouranakis suggest different hypotheses as to the reconstruction related to the possibility that the upper walls were made of bricks or rubble[31], I here offer several hypotheses concerning the costs of the 'villa' at Achladia. In total, six estimates are suggested in table 3. Costs vary **between 9,630.52 and 11,521.15 m-h**.

Though this material is generally the object of some disrespect, bricks walls surprisingly generated significantly higher costs than rubble walls. These costs seem to result from the fact that the mixing of the raw materials gathered for the bricks and their final shaping demanded more input and such tasks were unnecessary for the making of rubble walls. As expected, the layout of the 'villa' required important levelling works representing between 22.43 and 26.83% of the total labour cost of the structure, according to the various reconstruction hypotheses proposed by Mantzourani and Vavouranakis. A voluminous backfill and the construction of walls in sturdy masonry supporting it in the north-east corner of the building account for most of the construction costs (graphs 3 and 4).

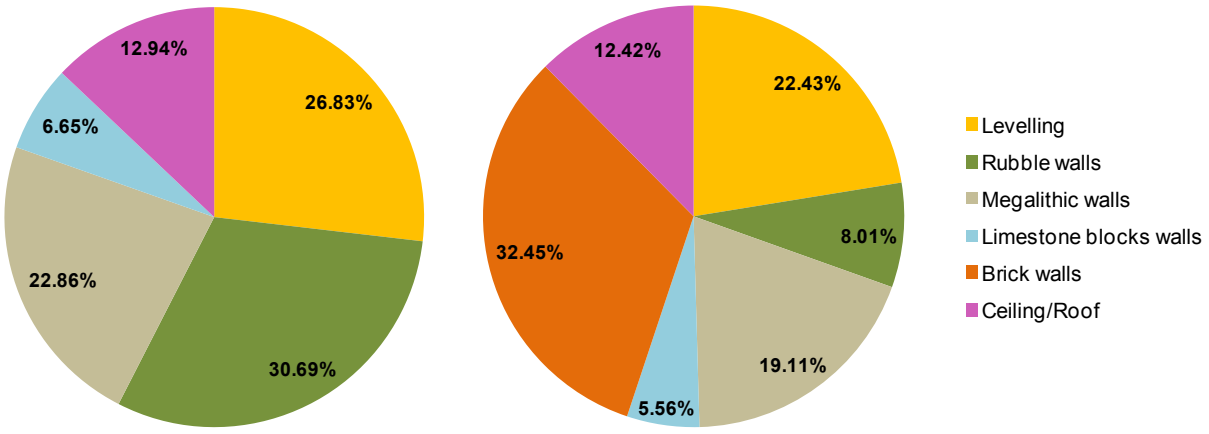
The costs of the buildings at Klimataria and Achladia are therefore the result of specific choices that are mostly concerned with the adaptation of the building to the local topography, in one case by time-consuming levelling. At Achladia, though the levelling had a strong impact on the total construction costs, it allowed for a free modular planning of the structure[32], absent at Klimataria-Manares where the structure was rather adapted to the topography by distribution of the rooms on distinct terraces supported by sturdy masonry. This corroborates the observation made by V. Fotou when she distinguished between structures whereby the plan was adapted to the specificities of the ground and those which saw the terrain adapted to a preconceived, elaborate plan. This distinction would then indicate whether the building belonged to a different architectural category[33]. It is true that, beyond planning, the building at Achladia does indicate some deliberate attempts at producing quality architecture, in which the absence of the most proliferated *polite* architectural features may be linked to the relative isolation of the 'villa' from the main Neopalatial centres. If we take the geographical extent of the so-called palatial features on the island[34] into consideration, isolation may perhaps not have been the main reason why this building remained relatively modest, and it is interesting to stress that its total costs remain in the same range as those of the building at Klimataria-Manares.

An investigation of the human factors at play within the production of these buildings is not an easy task because in one case the structure is isolated and in the other case data are lacking on the size and available population of the Neopalatial settlement. We therefore need to consider this question from a different perspective

[30] Mantzourani and Vavouranakis 2005, 101–3; Fotou 1990, 65 and fig. 29; Platon 1959, fig. 1.
[31] Mantzourani and Vavouranakis 2005, figs. 13, 14 and 16.
[32] Preziosi 1983, 332–35.
[33] Fotou 1990, 72–73.
[34] Driessen 1989–90.

Achladia					
Hypothesis 1		**Hypothesis 2**		**Hypothesis 3**	
Levelling					
2,584.22 m-h		2,584.22 m-h		2,584.22 m-h	
Ground floor rubble walls					
923.62 m-h		923.62 m-h		923.62 m-h	
Megalithic walls					
2,202.08 m-h		2,202.08 m-h		2,202.08 m-h	
Limestone blocks walls					
641.37 m-h		641.37 m-h		641.37 m-h	
Ceiling					
715.55 m-h		715.55 m-h		715.55 m-h	
Upper floor rubble walls	**Upper floor brick walls**	**Upper floor rubble walls**	**Upper floor brick walls**	**Upper floor rubble walls**	**Upper floor brick walls**
2,542.81 m-h	3,738.76 m-h	2,032.38 m-h	2,988.17 m-h	2,358.11 m-h	3,467.1 m-h
Roof		**Roof**		**Roof**	
715.55 m-h		531.3 m-h		621.83 m-h	
Total	**Total (1b)**	**Total (2a)**	**Total**	**Total**	**Total**
10,325.2 m-h	**11,521.15 m-h**	**9,630.52 m-h**	**10,586.31 m-h**	**10,046.78 m-h**	**11,155.77 m-h**

Table 3 Estimate of the labour costs of the 'villa' at Achladia according to the different reconstruction hypotheses (after Mantzourani and Vavouranakis 2005, figs. 13, 14 and 16). In blue, the costs considered in graphs 3 and 4.



Graphs 3 and 4 Proportion of the materials and techniques involved in the construction of the 'villa' at Achladia, hypotheses 2a (to the left) and 1b (to the right), as described in table 3.

than that in the study of the workforce involved in the construction of the palace at Gournia. On the basis of the parameters mentioned before – i.e. a building program of 90 eight-hour working days – we can estimate the workforce necessary for raising the buildings at Klimataria-Manares and Achladia (table 4). This would be 15.25 individuals for the former and between 13.37 and 16 individuals for the latter, again following the different reconstruction hypotheses considered. These numbers allow us to consider whether the structures were built by their own inhabitants or whether the workforce necessarily implied an input from a larger area, which could indicate that these buildings functioned in a wider regional network. If we follow Abrams in assuming that between 20 and 33% of the population was likely to participate in the construction, this implies a contributing population of between 45.75 and 76.25 individuals in the case of Klimataria-Manares, and a population of between 40.11 and 80 individuals in the case of the 'villa' at Achladia.

	Expected workforce for a 90-day building program (individuals)
Klimataria-Manares	15.25
Achladia (hyp. 2a – min.)	13.37
Achladia (hyp. 1b – max.)	16

Table 4 Estimates of the expected workforce for a 90 eight-hour working day building program for the buildings at Klimataria-Manares and Achladia (two hypotheses).

By correlating roofed space and population in 18 case studies, Naroll has suggested an estimate of 10 m² of living (roofed) space per individual[35]. Whitelaw has pinpointed some of the methodological weaknesses of Naroll's reconstruction, stressing notably that "there is no simple relationship between people and the space they inhabit"[36]. The size of the house may indeed better mirror the wealth of the inhabitants than their actual number[37]. Even if we assume that the buildings at Achladia and Klimataria-Manares fulfilled other than purely domestic functions, we have no other indication about the size of the contributing group which inhabited the building than Naroll's estimates. Interestingly, the area occupied by living space in the Klimataria-Manares building is 242.61 m² whereas that in the Achladia 'villa' is 309.02 m² (hyp. 1) or 269.27 m² (hyp. 2). This means that in no case could the inhabitants have provided the necessary workforce, whether this was made out of 20 or 33% of the population[38] (table 5).

The lack (or discrete character) of elaborate architectural elements in these structures would seem to exclude the possibility that they were built by itinerant craftsmen. It therefore seems more likely that the inhabitants of the settlement (in the case of Achladia), from the region (in both cases) or from some particular social network provided the necessary workforce. It is, for the moment, difficult to go further into an analysis of the details of the workforce mobilisation, and although specific payments for the masons cannot be excluded, it is important to remember the role these edifices played in a wider economical and socio-political network and landscape. Both buildings seem indeed to have participated actively in the production of agri-

	Population corresponding to the expected workforce (individuals)		Estimated number of inhabitants based on Naroll's estimates (individuals)
	Considering workforce as 20% of population	Considering workforce as 33% of population	
Klimataria-Manares	76.25	45.75	24.26
Achladia (hyp. 2a – min.)	66.85	40.11	26.90
Achladia (hyp. 1b – max.)	80	48	30.90

Table 5 Estimates of the number of individuals corresponding to the expected workforce, compared to the potential inhabitants of the buildings at Klimataria-Manares and Achladia.

35 Naroll 1962.
36 Whitelaw 2001, 16. See also Cameron 1999, 201 on the many factors likely to have an impact on room size.
37 Whitelaw 2001, 19, referring to Kramer 1982, 116–38, 170–81.
38 Abrams 1987, 493.

cultural commodities and their circulation in the hinterland of Petras. Whether the individuals in charge of the respective sites had a privileged access to the material and human resources of some network which allowed them to support important building programs, or whether the community was forced to collaborate in the making of its architectural environment, because it took rewards from it, are questions which are for the moment hard to settle. The study of labour costs generated by these building projects does in any case lend some support to the argument for an external origin of the workforce, as suggested for the palace at Gournia.

The application of the 'energetic' approach to these three cases has illustrated the possibility of elucidating specific behaviour involved in building projects. The objective appreciation of the labour costs generated by their construction – especially in the case of the palace at Gournia – has shown the energetic impact of excessive material and technical choices (such as ashlar and levelling), at the same time demonstrating that these were feasible in terms of available workforce. The method allows statements to be made on the involvement of users and local population in the construction, linking building programs with demographic evolution and evaluating their impact on the settlement or region. In this way, it contributes to a better understanding of building programs in the context of local and regional social networks and historical developments.

References

Aaberg, S., and J. Bonsignore. 1975
"A Consideration of Time and Labor Expenditure in the Construction Process at the Teotihuacan Pyramid of the Sun and the Poverty Point Mound." In *Three Papers on Mesoamerican Archaeology*, edited by J.A. Graham and R.F. Heizer, 40–78. *Contributions of the University of California Archaeological Research Facility* 24. Berkeley: University of California Press.

Abrams, E. 1987
"Economic Specialization and Construction Personnel in Classic Period Copan, Honduras." *AmerAnt* 52(3): 485–98.

Abrams, E. 1994
How the Maya Built Their World. Energetics and Ancient Architecture. Austin: University of Texas Press.

Blier, S.P. 1987
The Anatomy of Architecture: Ontology and Metaphor in Batammaliba Architectural Expression. Cambridge: Cambridge University Press.

Branigan, K. 2001
"Aspects of Minoan Urbanism." In *Urbanism in the Aegean Bronze Age*, edited by K. Branigan, 38–50. *Sheffield Studies in Aegean Archaeology* 4. London: Sheffield Academic Press.

Burford, A. 1963
"The Builders of the Parthenon." In *Parthenos and Parthenon*, edited by G.T.W. Hooker, 23–35. *Greece and Rome Suppl.* 10. Oxford: Clarendon Press.

Cameron, C.M. 1999
"Room Size, Organization of Construction, and Archaeological Interpretation in the Puebloan Southwest." *JAnthArch* 18:201–39.

Devolder, M. 2005
"Hâte-toi de bâtir la demeure, hâte-toi d'édifier le palais." *Creta Antica* 6:165–86.

Devolder, M. 2009
"Composantes et interactions sociales en Crète néopalatiale (1700–1450 av. J.-C.). Investigation des données archéologiques." Ph.D. diss., University of Louvain-la-Neuve.

Driessen, J. 1982
"The Minoan Hall in Domestic Architecture on Crete: To Be in Vogue in Late Minoan IA?" *ActaArchLov* 21:27–92.

Driessen, J. 1989–90
"The Proliferation of Minoan Palatial Architectural Style: (I) Crete." *ActaArchLov* 28–29:3–23.

Driessen, J. 1995
"'Crisis Architecture'? Some Observations on Architectural Adaptations as Immediate Responses to Changing Socio-Cultural Conditions." *Topoi Orient-Occident* 5:63–88.

Driessen, J., and A. MacGillivray. 1989
"The Neopalatial Period in East Crete." In *Transition. Le monde égéen du Bronze Moyen au Bronze Récent. Actes de la deuxième Rencontre égéenne internationale de l'Université de Liège (18–20 avril 1988)*, edited by R. Laffineur, 99–111. *Aegaeum* 3. Liège: Université de Liège, Histoire de l'art et archéologie de la Grèce antique.

Driessen, J., and C.F. Macdonald. 1997
The Troubled Island: Minoan Crete Before and After the Santorini Eruption. Aegaeum 17. Liège and Austin: Université de Liège, Histoire de l'art et archéologie de la Grèce antique, and University of Texas at Austin, Program in Aegean Scripts and Prehistory.

Erasmus, C. 1965
"Monument Building: Some Field Experiments." *Southwestern Journal of Anthropology* 21: 277–301.

Fotou, V. 1990
"L'implantation des bâtiments en Crète à l'époque néopalatiale: aménagement du terrain et mode d'occupation du sol." In *L'habitat égéen préhistorique. Actes de la table ronde internationale, Athènes, 23–25 juin 1987*, edited by P. Darcque and R. Treuil, 45–73. *BCH Suppl.* 19. Athens: École française d'Athènes.

Halstead, P., and G. Jones. 1989
"Agrarian Ecology in the Greek Islands: Time Stress, Scale and Risk." *JHS* 109:41–55.

Hitchcock, L.A. 1997
"The Best Laid Plans Go Astray: Modular (Ir)regularities in the 'Residential Quarters' at Phaistos." In *TEXNH. Craftsmen, Craftswomen, and Craftmanship in the Aegean Bronze Age, Proceedings of the 6th International Aegean Conference, Philadelphia, Temple University, 18–21 April 1996*. Vol. 2, edited by R. Laffineur and Ph.P. Betancourt, 243–50. *Aegaeum* 16. Liège and Austin: Université de Liège, Histoire de l'art et archéologie de la Grèce antique, and University of Texas at Austin, Program in Aegean Scripts and Prehistory.

Kramer, C. 1982
Village Ethnoarchaeology. Rural Iran in Archaeological Perspective. New York: Academic Press.

Mantzourani, E., G. Vavouranakis, and C. Kanellopoulos. 2005
"The Klimataria-Manares Building Reconsidered." *AJA* 109:743–76.

Mantzourani, E., and G. Vavouranakis. 2005
"Achladia and Epano Zakros: A Re-Examination of the Architecture and Topography of Two Possible Minoan Villas in East Crete." *OpAth* 30:99–125.

McEnroe, J.C. 1982
"A Typology of Minoan Neopalatial Houses." *AJA* 86:3–17.

McEnroe, J.C. 1990
"Significance of Local Styles in Minoan Vernacular Architecture." In *L'habitat égéen préhistorique. Actes de la table ronde internationale, Athènes, 23–25 juin 1987*, edited by P. Darcque and R. Treuil, 195–202. *BCH Suppl.* 19. Athens: École française d'Athènes.

Naroll, R. 1962
"Floor Area and Settlement Population." *American Anthropology* 27:587–89.

Osborne, R. 1996
"Classical Landscape Revisited." *Topoi Orient-Occident* 6:49–64.

Palyvou, C. 1990
"Architectural Design at Late Cycladic Akrotiri." In *Thera and the Aegean World III. Proceedings of the Third International Congress*. Vol. 1, edited by D.A. Hardy, Ch.G. Doumas, J.A. Sakellarakis, and P.M. Warren, 44–55. London: Thera and the Aegean World.

Pike, S., and J.S. Soles. 1998
"A Petrographic Characterization Study of Bronze Age Sandstone Quarries in East Crete and its Application to Minoan Archaeology." *AJA* 102:377.

Platon, N. 1952
"Μινωϊκή έπαυλη Σητειας." *Prakt*:636–39.

Platon, N. 1959
"Ανασκαφή Αχλαδιών Σητείας." *Prakt*:210–19.

Platon, L. 1997
"The Minoan Villa in Eastern Crete. Riza, Achladia, and Prophetes Elias, Praissos: Two Different Specimens of One Category?" In *The Function of the 'Minoan Villa'. Proceedings of the 8th International Symposium at the Swedish Institute at Athens, 6–8 June 1992*, edited by R. Hägg, 187–202. Stockholm: Paul Aströms Förlag.

Preziosi, D. 1983
Minoan Architectural Design. Formation and Signification. *Approaches to Semiotics* 63. Berlin: Mouton Publishers.

Seager, R.B. 1909
"Excavations on the Island of Mochlos, Crete, in 1908." *AJA* 13:273–303.

Soles, J.S. 1991
"The Gournia Palace." *AJA* 95:17–78.

Soles, J.S. 2004
"New Construction at Mochlos in the LM IB Period." In *Crete Beyond the Palaces: Proceedings of the Crete 2000 Conference*, edited by L. Preston Day, M.S. Mook, and J.D. Muhly, 153–62. *Prehistory Monographs* 10. Philadelphia: INSTAP Academic Press.

Soles, J.S., and C. Davaras. 1990
"Theran Ash in Minoan Crete: New Excavations on Mochlos." In *Thera and the Aegean World III.* Vol. 3, *Chronology. Proceedings of the Third International Congress, Santorini, Greece, 3–9 September 1989*, edited by D.A. Hardy and A.C. Renfrew, 89–95. London: The Thera Foundation.

Soles, J.S., S.R. Taylor, and C.J. Vitaliano. 1995
"Tephra Samples from Mochlos and Their Chronological Implications for Neopalatial Crete." *Archaeometry* 37:385–93.

Trigger, B.G. 1990
"Monumental Architecture: A Thermodynamic Explanation of Symbolic Behaviour." *WorldArch* 22(2):119–32.

Tsipopoulou, M., and A. Papacostopoulou. 1997
"'Villas' and 'Villages' in the Hinterland of Petras, Siteia." In *The Function of the 'Minoan Villa'. Proceedings of the Eighth International Symposium at the Swedish Institute at Athens, 6–8 June 1992*, edited by R. Hägg, 203–14. Stockholm: Paul Aströms Förlag.

Warren, P. 1999
"LM IA: Knossos, Thera, Gournia." In *MELETEMATA. Studies in Aegean Archaeology Presented to Malcolm H. Wiener as He Enters His 65th Year*. Vol. 3, edited by Ph.P. Betancourt, V. Karageorghis, R. Laffineur, and W.-D. Niemeier, 809–903. *Aegaeum* 20. Liège and Austin: Université de Liège, Histoire de l'art et archéologie de la Grèce antique, and University of Texas at Austin, Program in Aegean Scripts and Prehistory.

Watrous, V.L., and H. Blitzer. 1999
"The Region of Gournia in the Neopalatial Period." In *MELETEMATA. Studies in Aegean Archaeology Presented to Malcolm H. Wiener as He Enters His 65th Year*. Vol. 3, edited by Ph.P. Betancourt, V. Karageorghis, R. Laffineur, and W.-D. Niemeier, 905–9. *Aegaeum* 20. Liège and Austin: Université de Liège, Histoire de l'art et archéologie de la Grèce antique, and University of Texas at Austin, Program in Aegean Scripts and Prehistory.

Whitelaw, T.M. 2001
"From Sites to Communities: Defining the Human Dimensions of Minoan Urbanism." In *Urbanism in the Aegean Bronze Age*, edited by K. Branigan, 15–37. *Sheffield Studies in Aegean Archaeology* 4. London: Sheffield Academic Press.

Wilson Cummer, W. 1980
"Itinerant Aegean Builders." *TUAS* 5:3–14.