CONSTRUCTING MONUMENTS, PERCEIVING MONUMENTALITY & THE ECONOMICS OF BUILDING

THEORETICAL AND METHODOLOGICAL APPROACHES TO THE BUILT ENVIRONMENT

edited by

Ann Brysbaert, Victor Klinkenberg, Anna Gutiérrez Garcia-M. & Irene Vikatou

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List of abbreviations

List of abbreviations based on the Journal Abbreviation Database and the AJA Abbreviations

AborigHist: Aboriginal History
ActaArch: Acta archaeologica
ActaInstiRomFin: Acta Instituti Romani Finlandiae
AJA: American Journal of Archaeology
AM: Mitteilungen des Deutschen Archäologischen Instituts, Athenische Abteilung
AmAnthropol: American Anthropologist
AmerAnt: American Antiquity
AmJHumBiol: American Journal of Human Biology
AmJPhysAnthropol: American Journal of Physical Anthropology
AnnuRevAnthropol: Annual Review of Anthropology
AntW: Antike Welt: Zeitschrift für Archäologie und Kulturgeschichte
ApplErgon: Applied Ergonomics
ArchaeolProspect: Archaeological Prospection
ArchEph: Archaiologike Ephemeris
ArchEspArq: Archivo español de arqueología
AttenPerceptPsychophys: Attention, Perception & Psychophysics
BAR-IS: British Archaeological Reports, International Series
BASOR: Bulletin of the American Schools of Oriental Research
BCH: Bulletin de correspondance hellénique
BICS: Bulletin of the Institute of Classical Studies of the University of London
Boreas: Münstersche Beiträge zur Archäologie
BrJPhilosSci: The British Journal for the Philosophy of Science
BSA: British School at Athens Annual
BSeismolSocAm: Bulletin of the Seismological Society of America
CAJ: Cambridge Archaeological Journal
CurrAnthr: Current Anthropology
EAZ: Ethnographisch-Archäologische Zeitung
EconHistRev: The Economic History Review
EconHistRev: The Economic History Review
EJA: European Journal of Archaeology
EurJSocTheory: European Journal of Social Theory
GalliaPrHist: Gallia préhistoire

JAnthArch: Journal of Anthropological Archaeology
Geoarchaeology: Geoarchaeology-An International Journal
Hesperia: Hesperia. The Journal of the American School of Classical Studies at Athens
JAMT: Journal of Archaeological Method and Theory
JAnthArch: Journal of Anthropological Archaeology
JAR: Journal of Archaeological Research
JArchaelMethodTh: Journal of Archaeological Method and Theory
JAS: Journal of Archaeological Science
JFA: Journal of Field Archaeology
JHS: Journal of Hellenic Studies
JMA: Journal of Mediterranean Archaeology
JMatCult: Journal of Material Culture
JMedievHist: Journal of Medieval History
JRA: Journal of Roman Archaeology
JRAnthropolInst: Journal of the Anthropological Institute
JRSocAntiqIrel: Journal of the Royal Society of Antiquaries of Ireland
MARI: Mari: Annales de recherches interdisciplinaires
MedievArchaeol: Medieval Archaeology
MÉFRA: Mélanges de l'École française de Rome, Antiquité
MelbHistJ. The Amphora Journal: Melbourne Historical Journal. The Amphora Issue
OpAth: Opuscula Atheniensia
Pharos: Journal of the Netherlands Institute in Athens
PJAEE: PalArch's Journal of Egyptian Archaeology of Egypt/Egyptology
PNAS: Proceedings of the National Academy of Sciences of the United States of America
PPS: Proceedings of the Prehistoric Society
Prakt: Praktika tes en Athenais Archaiologikes Etaireias (Πρακτικα της εν Αθηναις Αρχαιολογικης Εταιρειας)
SIMA: Studies in Mediterranean Archaeology
SIMA-PB: Studies in Mediterranean Archaeology and Literature: Pocket Book
SociolTheor: Sociological Theory
SouthwestJAnthropol: Southwestern Journal of Anthropology
StMisc: Studi miscellanei: Seminario di archeologia e storia dell'arte greca e romana dell'Università di Roma
TAPS: Transactions of the American Philosophical Society
WarHist: War in History
WorldArch: World Archaeology

Part One

Theoretical and practical considerations on monumentality

1

Constructing monuments, perceiving monumentality: introduction

Ann Brysbaert

1.1 Introduction

In many societies the construction and conspicuous consumption of large monuments are associated with dynamic socio-economic and political processes that these societies underwent and/or instrumentalised. Their construction and maintenance often involves the input of huge amounts of human and material resources. As a result, such monuments form a useful research framework to investigate their associated societies and the underlying processes that generated different levels of construction, varying from household dwellings to these larger-than-needed structures. Monumental constructions may physically remain the same for some time, but certainly not forever.[1] This is often due to the durability of their chosen materials and size, but also because they were made to commemorate and remind, sometimes well beyond their moment of construction.[2] Therefore, monumentality can be understood as an '… ongoing, constantly renegotiated relationship between thing and person, between the monument(s) and the person(s) experiencing the monument'.[3] Additionally, the actual meaning that people associate with these may change regularly.[4] Although these monuments are embedded in their lives, the contexts within which people perceived, assessed, and interacted with them changed over time. These changes of meaning may occur diachronically, geographically, as well as socially. Through social memory practices, places become persistent through time[5] even when social memory practices change with time;

1 Edensor 2005 and Ingold 2013 describe how buildings can quickly change even their physical appearance and consistency even after the actual construction has been 'finalised', if there ever is such a moment. See McFadyen, this volume, for similar arguments on materials still moving after having been placed.
2 Scarre 2011, 9.
3 Osborne 2014, 3.
4 Osborne 2014, 4.
5 Tuan 1977; Löw 2008; Scarre 2011, 10.

In: Brysbaert, A., V. Klinkenberg, A. Gutiérrez Garcia-M. & I. Vikatou (eds) 2018. *Constructing monuments, perceiving monumentality and the economics of building: Theoretical and methodological approaches to the built environment*. Leiden: Sidestone Press, pp. 21-48.

this ties in with the passage of time, which can also be seen as the journey humans take through the taskscape of dwelling.[6] Realising that such shifts may occur forces us to rethink the meaning and the roles that past technologies play in constructing, consuming, and perceiving something monumental. In fact, it is through investigating the processes, the practices of building and crafting, and the conscious site selection for these activities, that allows us to argue convincingly that meaning may already develop while the monument itself is still being created.[7] As such, meaning-making and -giving may also influence the shaping of the monument in each of its facets: spatially, materially, technologically, socially and diachronically. None of these aspects can be distangled from the other.

Monumentality can be manifested through many different material expressions, in a wide ranges of features, and with the wide multitudes of meanings that these may signal. They come in the forms of temples, palaces, tombs, memorials, military installations, irrigation works, road networks, and many other forms. They do not all emerge from a purely elite-dominated or – sponsored context.[8] Moreover, the multiple messages encoded in people's interactions with the resources they utilised may express prestige, power (*e.g.* through owning and mobilizing resources), durability and eternity, pride, resistance, boundaries, confusion, conflict, and social stratification with inclusion and exclusion of access. Some of the messages encoded in building or decorating monuments can be made very explicit. A good example to consider is the funerary monument of Heinrich Schliemann made of Pentelic marble, taking up a very prominent place in the First Cemetery at Athens, Greece. The tetrastyle monument is directly influenced by the temple of Nike, the latter built as part of the Periclean building programme of the fifth century B.C.E. on the Athenian Acropolis.[9] Not only was the intended association with the Nike Temple of interest, but also the sculpted friezes coiling around the base of the temple. These illustrate Schliemann's large-scale excavations undertaken at Troy, Mycenae, and Tiryns, and these friezes illustrate plenty of the fabulous finds which he uncovered in the process of these rather destructive excavations. Such megalomania expressed itself during Schliemann's life as well. This can be seen in the several luxurious decorations and name-giving in his Athenian residence (now the Numismatic Museum of Athens); it was built by one of the most prominent architects of that time in Athens, Ernst Ziller, who also designed his grave. The house, named 'Iliou Melathron'[10] contained rooms named after his son (Agamemnon) and daughter (Andromache). The mosaic floors and painted friezes (in Pompeiian style) in several rooms throughout the house showed off his wealth and the treasures he had uncovered. These likely sparked plenty of conversations with his guests, placing him constantly at the centre of attention.[11]

Monumentality does not reside purely in oversized and overly decorated features produced from luxurious and exotic materials, but may also be evoked in very different

6 Ingold 1993, 159.
7 See Lefebvre 1991, 80-85.
8 In any case, elites sponsoring and instigating large-scale buildings would not get very far without their builders, labourers, and farmers feeding everyone.
9 Mark 1993; Hurwit 1999.
10 Referring to Troy as Ilium.
11 Korres 1988, 62-64.

ways. The Mona Lisa painting forms a good example of how something that is not impressive in terms of its size greatly outgrew its 'picture frame' by far due to its reputation as the perfect painting of its time (and well beyond).[12] Even better illustrations of this evoked monumentality come from gold and silver coins as well as their depictions. Some of these contain miniature images of rulers (or gods) on the obverse side, linked with often no more than the *pars-pro-toto* of a monumental building on the reverse. This physical connection implied the same monumental character of the ruler who built it and ordered its illustration on his coinage.[13] The gold and silver likely further emphasized the high degree of wealth associated with 'both sides of the coin' as multiple messages, and may have caused exclusionary usage of the piece itself for certain classes only: in the case of silver coins from Athens, this fact also showed clearly who had access to that silver and how.[14]

Similar processes of associations between rulers and the construction of increasingly larger monuments occurred in the more distant past of Greek history as well. The construction of monumental tombs began from approximately the Late Middle Helladic period (1800-1700 B.C.E.) and onwards in the Peloponnese (Greece), specifically in the Argolid, Messenia, and Achaia. Previously, the best known grave types in the Middle Helladic period, specifically in the Argolid, were either simple pit or cist graves, before much larger and richly furnished shaft graves and chamber tombs begin to appear. While both chamber tomb types continued to be produced, the later tholos or beehive tomb was a monumentalisation in stone of the rock-cut and built chamber tombs.[15] Some of the best known examples are located in and around Mycenae. Nine large tholoi were constructed to the west of the citadel of Mycenae, where many more rock-cut and built chamber tomb cemeteries were found. Each grave type, from simple pit and cist, to shaft grave, to rock-cut and built chamber, to the elaborate tholos involved the input of more and more human and material resources.[16]

As this 'Architecture of the Dead' gathered momentum around the end of the 14th century B.C.E. and into the 13th, a shift also took place with the 'Architecture of the Living'.[17] The first construction phases of the massive citadels at Mycenae and Tiryns can be dated to the 14th century B.C.E. that fostered a dramatic increase in the number and size of building projects, throughout the 13th century B.C.E. With a total length of over 300 m, the walls encircling the Lower, Middle and Upper Citadel of Tiryns were 7 m thick and likely up to 10 m high. The same went on at Mycenae, while the site of Midea was entirely constructed in the 13th century B.C.E. Similar processes went

12 Brysbaert 2016, 3.

13 For example, the silver tetradrachm coin from Knossos with Zeus (O) and the Knossian labyrinth (R), second to first century B.C.E. (Based at the Alpha Bank Numismatic Collection, Kerkyra): https://www.ancient.eu/image/3184/ . For a Roman example: silver coin 681, found in the Athenian Agora, in honour of the Divine Augustus (O), depicting a hexastyle temple from Corinth (R): Kroll 1993, 224, pl. 27.

14 The mines at Laureion were operated by wealthy Athenians and the slaves working in the mines were owned by the lessees of the mining rights: Crosby 1950, 204-205.

15 For the best studies on mortuary evidence in MH-LH periods, see the decades-long work by S. Voutsaki, e.g. Voutsaki 1999; Voutsaki *et al.* 2013; the edited volume by Philippa-Touchais *et al.* 2010.

16 See the work done by Fitzsimons 2011. Also illustrated in Voutsaki *et al.*, this volume, in a nuanced and qualitative way.

17 This shift is discussed in Dabney and Wright 1990.

on beyond the Argolid, more specifically in Boeotia (at Gla and Thebes, likely also at Orchomenos), and in western regions of the Peloponnese: Teichos Dymaion (Achaia), Pylos-Iklaina (Messenia), and in Lakonia (Ayios Vasilios).[18] The largest expansion in monumental construction took place in the second half of the 13th century B.C.E., including the construction of massive still-functioning dams (Tiryns),[19] the large-scale draining of the Lake Copaïs Basin at Gla,[20] and several road network constructions.[21] Especially the last few decades towards 1200 B.C.E. witnessed some spectacular and simultaneous large construction projects.[22] Towards 1200/1190 B.C.E., such construction activities ceased to exist and coincided with the slow-down and the cessation of other craft activities, especially those associated specifically with the palatial elites (writing in Linear B, secondary glass production, ivory carving, and eventually also copper alloy working).

1.1.1 The process of making

Of importance to the context of this book is the aspect of making, and the role that 'making' (as a series of processes and social practices) has on the (changing) perceptions of the material culture of monumental architecture in the landscape.[23] We all agree that the Palais du Versailles is monumental in every sense of the word.[24] The 'end product' (if there is such a thing) is immensely impressive in size and it is a clear example of conspicuous consumption. However, its production and human creativity are made obvious when considering the available technologies and materials. Since steam engines would only arrive c. 1850 C.E., Versailles evokes even greater awe, especially in terms of manpower, organisational logistics,[25] and know-how. Equally interesting is the context in which Mycenaean large-scale and long-term building programmes took place from 1400 to 1200/1190 B.C.E. As Maran has convincingly argued, the Mycenaean citadels and other large-scale building works, which were raised in the Argolid only one or two generations earlier, were not perceived by the post-1200 B.C.E. elites in the same way as under the previous palatial elite groups.[26] For example, a post-palatial banquet hall (Building T) of monumental scale was built inside the ruined walls of the most important locale of the earlier palatial elites. This Great Megaron was the seat of the former elite rulership at Tiryns during the Palatial Period.[27] Such a locale-usurping act could indicate that the new elites undermined the previously held statements of power by showing its failure (the ruin) so very blatantly. These post-palatial elites subsequently did build a relatively large megaron again, by selecting the same locale and rooting it in known ancestral powerful presence. However, this was now expressed

18 See Simpson and Hagel 2006.
19 Balcer 1974.
20 Simpson and Hagel 2006; but most recently E. Kountouri *et al.* 2012.
21 Lavery 1990; Lavery 1995; Jansen 2002; Iakovidis *et al.* 2003; Simpson and Hagel 2006.
22 Maran 2010 for a useful summary, especially relating to Tiryns.
23 See Ingold's 1993 use of taskscapes; see more below.
24 E.g. Duindam 2003.
25 For example, to prepare the land and divert rivers, to scout for and extract materials, to transport them to the building site, and all coordination and planning needed once construction was ongoing to avoid major physical and financial bottlenecks at the building site.
26 Maran 2009; Maran 2012.
27 Maran 2000.

through different technological, material and social strategies. Such strategies aimed to imprint the location and means of power upon people's perception under the post-palatial regime. It is perhaps interesting to note that very similar activities went on in the context of other social groups at approximately the same time, for example, among the artisans and their re-use of former workshops in the same locale, also at Tiryns.[28]

Scarre argues that past people perceived the landscape surrounding monuments in a very different way than modern people do.[29] Perceptions, thus, tend to be rather subjective, contextualised, and culture-specific since they express a personal viewpoint, and are based on experiences and expectations which vary for each individual.[30] Even if the actual item is not physically that impressive,[31] it is people's perception of monuments, and the relationships between large-scale architecture and humans, that create the perceptions of something that is more than the usual,[32] something monumental.

Investigating such large-scale building complexes from technical and human investment viewpoints can be adequately approached by means of combining the *multiple chaînes opératoires* of building and employing architectural energetics. The latter is a very useful and diverse method, which translates construction costs into labour time estimates. The method has been tested out in multiple contexts and is currently drawing a lot of renewed attention.[33] Such well-developed field and its associated statistical techniques are indispensible to our efforts to understand the intense relationship between people and their material surroundings while they were building. Osborne's aversion against architectural energetic studies can be understood if and when such studies do not go beyond producing calculations.[34] The same criticism can be levelled at scientific analyses: they are costly and, when not conducted in order to answer archaeological questions, they contribute little more than analytical data. However, combining interpretive processes with econometric or architectural energetics and primary field data offers value to studies on monumental architecture and aspects of monumentality. Additionally, it highlights new facets of the inter-relations between people and materials, and between the processes of building (large-scale) and their surroundings. As such, the purely mathematical dimension of architectural energetics studies receives its deserved place in a socio-political and economic context where these numerical values also become valuable in plenty of different ways.

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28 Brysbaert and Vetters 2010; Brysbaert 2014.

29 Scarre 2002; also Brysbaert 2015.

30 Brysbaert 2016, 2-3.

31 See the coins examples earlier in this paper; also Osborne's 2014 Guennol Lioness statue.

32 As traditionally described by Trigger 1990; see also Torras Freixas, this volume.

33 Just to name a few: DeLaine 1997; Abrams and Bolland 1999; Pakkanen 2009. Due to the renewed interest in architectural energetics and labour rates in archaeological and ethnographic contexts several research groups are currently working towards setting up online databases with all labour rates collected in their respective research projects. Within the context of SETinSTONE, see also the work done by D. Turner, this volume, and his previous research in this field. The most recent *International Congress of Classical Archaeology* (Bonn-Cologne, May 2018) hosted many sessions that discussed labour rates and their implications in answering archaeological questions concerning economic issues in the Greek and Roman worlds (http://www.aiac2018.de/).

34 Osborne 2014.

1.1.2 Meaning and value

The moment something is given a meaning by someone, it receives a place in that person's life and it becomes of value to that person, whether positive or negative. The papers presented in the volume edited by Papadopoulos and Urton discuss 'value' in four somewhat artificial categories: place value, body value, object value, and number value.[35] However, if these categories are connected with artisans' 'communities of practice',[36] the obvious overlaps between these become clear immediately. Let us, for example, look at how labour is valued. In architectural energetics studies, as SETinSTONE carries out (see below), labour is taken as a measurable form of energy expenditure that is invested in various phases of the *chaînes opératoires*[37] of constructing. In this sense, one could say that labour, as a form of energy or calories expenditure, can be measured in clock-time, which then is calibrated to an astronomical standard,[38] often called man-days or person-hours. Because of the fact that the cost of labour is based on inferred behaviour, such cost estimates cannot refer to absolute figures only: each task (some of which we may not be aware of) was executed by individuals with skills and even age, gender or physical condition, unknown to us. But, as Abrams and Bolland also state, there was a real cost in person-days in the construction of a building,[39] and this is also the case when this building process is broken up into all of its ***known*** tasks. The emphasis on '***known***' *justifies* why usually minimal figures are provided in architectural energetics studies.[40] Most often, not all the materials of a given construction are preserved and not all tasks performed can be recognized, so minimal numbers are the safest and most justifiable way of approaching the issue. When it comes to monumental constructions that are not fully preserved, their current state of preservation will not diminish the outrageous effect of the total, nor the inferred socio-political powers needed to make it happen. As the materials themselves (*e.g.* multi-tonne blocks often brought from some distance away), and construction techniques (*e.g.* 'Cyclopean' walls at Tiryns) do not usually feature in purely domestic contexts, there is no danger that the full effect intended will be missed through minimal figures. This is especially the case if these figures subsequently are interpreted in their wider socio-political and economic context. That should also take the usual and expected human errors, inefficiencies, and restraints into account. Human beings have physical restraints in what they can do in one day (of about eight or ten hours), whether they are free workers or slaves, and some jobs take more time than others. For example, we can compare the work needed to extract and transport rough boulders, versus well-masoned stones of the same size and weight and whose surfaces need to be worked in various ways before they are transported. In this, it seems logical that the second type of work will take more time, perhaps also more workers, depending on how the work force is organised and can free itself from other duties. Any study, thus, involving the investigation of the socio-technical aspects of building, cannot escape the need to take 'time' and 'workforce composition' into account, since these are completely related to each other in more than one obvious

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35 Papadopoulos and Urton 2012, 3.
36 As understood by Wenger 1998; Wendrich 2012, 2-5.
37 Against a linear understanding of the *chaîne opératoire* concept, Brysbaert 2011.
38 After Ingold 1993, 158-159.
39 Abrams and Bolland 1999, 265.
40 *Contra* assertions by Voutsaki *et al.*, this volume, 175-176.

way. If the time spent on building in a given community is considered together with the social make-up of the labour force and, then is seen in relation to the other members of the community, one can infer important social information about the structure and complexity of this community. The technical and social aspects merge together by such an operation, and time and place are integral components of such discussions. Especially time can only be provided by results produced by quantitative methods such as architectural energetics.

Another way of looking at the value of labour, however, is through the temporality of the taskscape of which the building can be a part, depending on the context. Taskscape is the entire ensemble of mutual interlocking tasks, such as building while also producing food for family and animals, or conducting rituals. It is an array of related activities which are heterogeneous and qualitative,[41] and actually fit well with the concept of cross-craft interaction.[42] For example, we want to build an accessible and well-drained road to transport building materials from A to B. Farmers in mountainous landscapes know how to cut terraces in order to extend their subsistence capacity if need be. It seems, therefore, logical to involve them in building a mountain road to facilitate the transportation of building materials since that road may also allow their produce to be moved easier. The same farmers also tend to know a thing or two about leading agrarian working oxen, useful again in these construction works. The temporality of a taskscape is very social because in performing tasks and doing things, people also attend to one another. 'Bodies, places and things are all active agents in the construction of value…'.[43] Here we do not ask how much it costs but how it feels to do something at that moment in time. According to Ingold, our passage of time is our journey through the taskscape of dwelling, in which tasks carried out by people take their meaning from their position within an ensemble of tasks, done parallel or in series or both, and usually by many people working together.[44] Ingold touches here on two very important aspects: that, while doing things, we are also social beings, and that of time and temporality. The value of labour is social (and qualitative), and not only an economic (quantitative) action. When we carry out tasks, we participate actively within the passage of time and experience its passing a fast or slow, depending on how we feel about the task. For example, we can perceive a task to be highly exciting because it is something new, we are curious learners, and it is done in a group so we learn from each other. A task can also be utterly boring because it is repetitive, and while we may be very good at it (since we have done it often enough), it feels that the day never passes.

While considering the temporality of the taskscape, I want to stress, however, how important it is that we do not and *should not* value time over temporality. Both the quantitative and qualitative ways of studying labour *in context* – which *necessarily* includes clock-time and a spatial setting – are complementary to each other. This approach identifies a meaningful and contextualised understanding of what it meant for people (now and in the past) to work hard to get things done while attending

41 Ingold 1993, 159.
42 See above. Term coined by McGovern 1989, but has since then been applied to a wide diversity of archaeological contexts.
43 Papadopoulos and Urton 2012, 3.
44 Ingold 1993, 158-159.

to other daily-life tasks (*e.g.* rearing a family, feeding them, maintaining their home, participating in social and religious activities, exploring their surroundings). Therefore, it is imperative that labour be measured also in terms of real clock-time, and for that purpose, architectural energetics studies are and remain a crucial method. They offer the counterpoint to purely qualitative methods that are not anchored in time, and thus do not seem fully contextualised.[45]

Value ascription, which is what we do when we call or perceive of something as 'monumental', may differ according to social groups and may be both inclusive and exclusive. For example, the acquisition of exotic goods charged with high intrinsic and symbolic meaning and value may only be possible for a specific elite class. This class may want to attach beauty, rarity, distance, ritual connotations,[46] technological virtuosity and labour intensity, or any combination of these factors, as exclusionary value 'constructors' to the items they acquire. Yet other factors that may construct an object's or feature's value are its age and the trajectory it has 'travelled' in time and space (*i.e.* an object's or feature's rich biography), before it ends up being valued as a new possession.[47] These items may also be linked to socio-cosmological ideas and ideals, which, again, might only be shared among that peer group.[48] As such, the intention of the sponsoring group of any monumental undertaking is crucial in our understanding of people's perception of that monument; but it is not the only factor since it only indicates what the sponsor intended to get out of this. The success of such endeavours also depends on whether and how that intention has been perceived. There are enough modern and past examples to show that resistance against such intentions could run high and may have eventually resulted in boycotting such large-scale demands on human and other investments. A telling example is the planning, initiation and first phases of clearing the ground and the construction of the 'People's House' in Bucharest, Romania. The name of the complex itself is highly ironic considering that the whole construction was literally planned and executed at cost of many people's already poor housing and lives.[49] The entire undertaking was never completed because the Ceausescus were taken prisoners and publically executed well before the building could be in use. The political instability, the long-term and overt abuse of resources by both dictators, and their personal ignorance of their socio-political context, cost them their position and lives as people joined forces to resist and end dictatorial abuse.[50] This example illustrates that power shifts can occur when multiple forces and social groups no longer accept a top down governing system and do not perceive of a structure such as the People's House' at all as it was intended by the persons who commissioned it. At the same time, it may show archaeologists the importance of examining how succesful rulers achieved the needed social consensus when they wanted things done.[51]

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45 Abrams and Bolland 1999, 264-265.

46 After Helms 1993.

47 Cf. Appadurai 1986; Weiner 1985; Weiner 1992; see also the re-settling of the Great Megaron at Tiryns: Maran 2009; Maran 2012.

48 Refocus on building locales and materials employed at Tiryns's Upper citadel: Brysbaert 2015; Maran 2016.

49 Hanganu-Bresch 2003, 15-16.

50 Hanganu-Bresch 2003, 12.

51 Cf. Wolpert 2004.

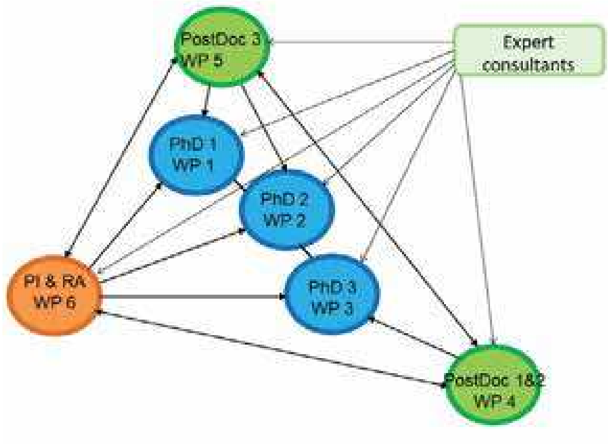

Figure 1.1: SETinSTONE team composition for five years equalling 23.5 person-years of labour input (Graph: A. Brysbaert).

1.2 SETinSTONE

After the introductory excursion on the themes of the book, I wish to zoom in on various aspects of a case study, as part of the SETinSTONE project (hereafter: SETinSTONE). Based at the Faculty of Archaeology, at Leiden University, SETinSTONE aims to assess if and how monumental building activities in Late Bronze Age (LBA) Greece impacted the political and socio-economic structures of the Mycenaean polities in the period between 1600 and 1100 B.C.E. It also investigates how people responded to changes in these structures, especially around c. 1200 B.C.E., with the demise of palatial Mycenaean civilisation. While many other single factors have been or are being studied,[52] the extent to which long-term and large-scale building programmes in the Argolid may have contributed to socioeconomic and political changes in LBA Greece remains unchartered terrain.[53] SETinSTONE aims to readdress this gap in our knowledge. In architectural energetic terms, approximately 24 years of labour will have been invested (Figure 1.1) into SETinSTONE by 2020 in order to contribute, in various ways, to the role of building and resource (ab)use in the events leading up to the demise of c. 1200 B.C.E.

This research applies a relational approach to monumentality, in which both humans and objects (*i.e.* the monuments) find a place in current archaeological interdisciplinary discourses, together with their surroundings. With very specific questions in mind SETinSTONE was 'constructed' to study the following:

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52 Disqualifying an earthquake as a cause for the 1200/1190 B.C.E. destruction of Tiryns, see Hinzen *et al.* 2018.

53 Many studies have preceded the work of SETinSTONE, including projects studying climatic changes that may have resulted in crises towards 1200 B.C.E., see e.g. the ongoing work by Weiberg and her team on climate issues; Middleton 2010; Middleton 2012 for more comprehensive causes; Jung 2017 on the role of class conflict; general overviews: Bennet 2013; Kramer-Hajos 2016 for Boeotia, and especially Knapp and Manning 2016. None, however, has factored into the equation the long-term and large-scale building activities in the Argolid that took place in an otherwise predominantly agrarian society.

1. What were the minimum input levels of human and material resources in prolonged building efforts in the regions under study, and what happened to these resources?
2. What subsistence and other activities did people undertake in the region and period under study and what resources did they have at their disposal?
3. *If* prolonged building depleted the existing resources towards the LBA Mycenaean 'collapse', how did these local phenomena relate to other regions in the Aegean and East Mediterranean lacking such building activities?

The first two questions touch on the socio-economically and politically organised logistics of the Mycenaean polity hierarchy, present in many regions of late MBA-LBA Mycenaean Greece. These logistics demanded and juxtaposed highly concentrated, long-term and large-scale physical efforts of large segments of the population.[54] Especially monumental efforts in the Argolid and in Attica are highlighted (Figure 1.2): fortifications in Mycenae, Tiryns and Midea, highly impressive tholos tombs, many large chamber tomb cemeteries, a still working dam at Tiryns, and an extensive road network.[55] All of these projects consisted of a formidable resource investment, to the extent that Shelmerdine wondered whether the scale of these eventually contributed to the 'collapse' of Mycenaean the civilisation.[56] As this paper focuses specifically on the architectural segment of SETinSTONE, additional questions arise:

1. What role does 'the act of monumental building' play in constructing the image of the (ideal) ruler, and other social groups?
2. What role(s) did the required resources in prolonged building play? Were they themselves carriers of multiple values in these constructing activities? How can we discern these roles and values?

While large monumental constructions are a logical choice of focus in order to get an understanding of the resources needed and pooled in this region for these specific periods, denying that other and necessary work went on as well is not possible. The most important tasks are the overall late MBA and LBA agricultural and pastoral activities that formed the heavily relied-on subsistence economy of the region; in turn, this heavily relied on the surrounding landscape and its people. People and their animals needed feeding, irrespective of their other activities, and for some, that was their full-time activity: supporting themselves and their household, perhaps making a little surplus to exchange in a day-to-day barter. Available evidence and information on what sustained people in that region during that period, is collected and assessed by SETinSTONE: changes visible over time, especially relating to the wave of massive building, are explained when and if possible. These embedded activities and practices are a very good example of cross-craft interaction and Ingold's taskscape. Thus, the spread sheet model concept, used by Abrams and Bolland[57] in the context of archi-

54 Both the active population, i.e. those at work in construction, for example, or in other industries, and the support population: families, farmers, tool makers: see Brysbaert 2013.
55 Wright 1978; Iakovidis 1983; Küpper 1996; Loader 1998; Simpson and Hagel 2006, among others.
56 Shelmerdine 1997, 566. Also De Fidio 2001, 16, n. 12, n. 49; Galaty and Parkinson 2007, esp. 14-15.
57 Abrams and Bolland 1999, 282-284, figure 9.

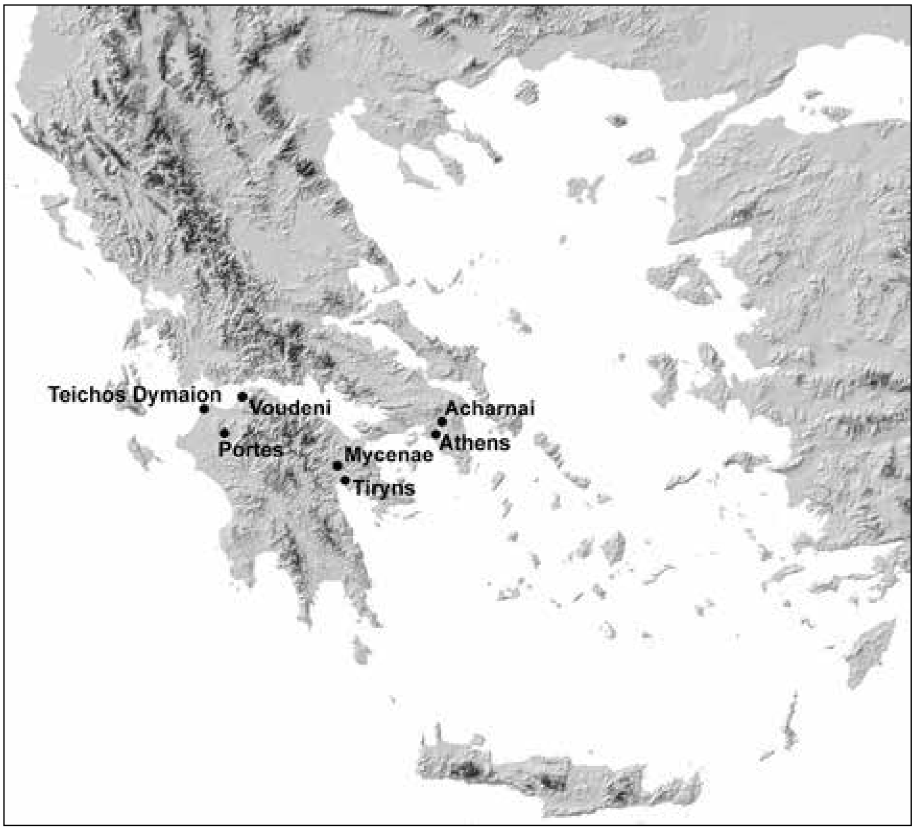

Figure 1.2: Map of Greece indicating the sites on which SETinSTONE is active (Anavasis editions/Hans Birk, adapted by A. Brysbaert).

tectural energetics, can perhaps be expanded here in order to include activities in support of and lateral to the building activities themselves.[58] Agrarian activities such as crop rearing, animal husbandry, pastoral activities, fishing, crafting (*e.g.* making tools, household dwellings and barns, pottery and other sedentary necessities), all can find a place in such spread sheets or similar workable models. While the spreadsheets tend to have an economic reason for being drawn up, their interpretation provides data to assess the equally needed qualitative values of these embedded labours that formed the backbone of late MBA – LBA Mycenaean societies and polities.

As mentioned earlier, the study of any type of monument, especially giving meaning to the efforts done for these, can only be fully understood when contextualised. This needs to include their surrounding topography and be connected by means of the necessary infrastructure. Questioning how places relate to each other essentially asks about how people move, work and interact with each other in this landscape context. In that sense, stones of megalithic size are not extracted for convenience but

58 I see the spreadsheet model as a useful tool to illustrate complex sets of activities and processes that may, in part, be running at the same time, or not, in one or many *chaînes opératoires*. It is, however, the social interpretation of the spreadsheets that become meaningful in the end.

Figure 1.3: Map of the region near Tiryns, indicating (in red) the various red limestone outcrops, the Tiryns citadel (blue large), and the tholos tomb (blue small). (Original image ©2018 Microsoft, satellite view, adapted by A. Brysbaert and I. Vikatou).

for their added value, the latter likely embedded in the landscape from which they were extracted and subsequently in the building in which they were incorporated. Extracting megaliths was purely intentional (by some) and the efforts invested (by others) need to be seen in this context.

A local map (Figure 1.3), indicating quarried areas of several building stones, especially the red limestone near Tiryns, shows several potential extraction spots, none of which have been securely dated by excavations. They indicate the extraction spots mentioned by Varti-Matarangas *et al.* (*i.e.* from the hill of Profitis Ilias and the hill near Profitis Ilias),[59] but it is unclear which Profitis Ilias hill was meant. Additionally, this red limestone of varying quality seems to crop out in several other locations south, east, and north of Tiryns too; especially noteworthy are the outcrops of Aria, and Ayios Georgios, north of Tiryns. All these outcrops fall within a radius of 1-2 km from the citadel of Tiryns and, therefore, all could be possible quarry candidates. It was, however, recent fieldwork at the Tiryns tholos tomb, dating to the 15th century B.C.E., that suggested a more definitive picture.[60] Earlier observations made clear that if the red limestone extraction place is located at the large Profitis Ilias hill, it sat just above and around the Tiryns Tholos tomb (Figure 1.4a).

Additionally, a strong level of intervisibility was noted between this tomb and the Tiryns citadel at least from the moment the citadel was being constructed, if not well before that. We should not forget that earlier (monumental) structures dominated the Tiryns citadel outcrop too, for example, the Early Helladic II Rundbau and its

59 Varti-Matarangas *et al.* 2002, 478-481: esp. lithofacies D and E, and referring to several hills including Aria, the hill of Profitis Ilias and the hill adjacent to the latter.

60 There are two tholoi in Tiryns close together and may both date roughly to the same time, see Papadimitriou 2001, 70. The second one has not been published and will, therefore, not be discussed any further. We thank the Eforate of Antiquities of the Argolid for permission to document the Tiryns Tholos, work that was carried out in the spring of 2018, and will be published elsewhere.

Figure 1.4a: The well-preserved Tholos tomb of Tiryns set in the foot of the large Profitis Ilias hill (Photograph: I. Vikatou).

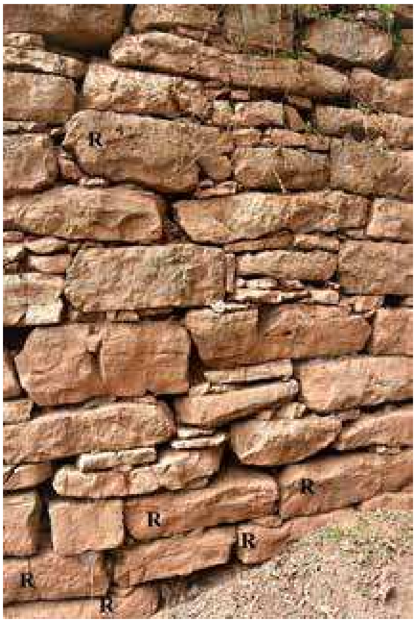

Figure 1.4b: the red limestone employed in the lower courses of the left stomion side (Photograph: A. Brysbaert).

subsequent Tumulus atop the Tiryns outcrop.[61] Maran also ties in to this locale the predecessor of the Great Megaron in Tiryns (former redated to Late Helladic III A1/III A2). [62] The date of this predecessor must be about 100 years after the Tiryns tholos, while the far less impressive Maison du Chef likely dated to the LH I phase. The potentially more monumental remains of the predecessor of the first Megaron, containing painted plaster remains and spreading over two terraces with connecting stairs, dated to LH IIB,[63] thus closer in time to the Tiryns tholos. Their location on the outcrop may have provided another intervisible link between the two locales at that time.

But why the emphasis on this intervisibility? In earlier work I expressed the strong possibility that the use and choices of several types of stones at Tiryns were consciously made and went well beyond their pure functionality.[64] Its conglomerate use, beautifully

61 On the Rundbau: Müller 1930, 86-87. It was destroyed c. 2200 B.C.E. around the same time as the Corridor House at Lerna, just across the bay and visible from the Tiryns outcrop; Maran 2016, 160. A tumulus was built over the Rundbau (in late EH II-EH III and likely still clearly recognisable until at least the Shaft Grave period) and protected the Rundbau structure from immediate decay: Maran 2016, 153, 165-166, 169 who also suggests that the Tiryns Tumulus may have been visible still at the time when the first Megara were constructed. According to him, the Rundbau too was meant to be seen and impress, even from across the Nauplion bay: Maran 2016, 160.

62 Maran 2001, 23.

63 Maran 2001, 24-28.

64 Brysbaert 2015.

illustrated and discussed by Maran,[65] had already been explained well before, but it provoked me to look at the other stones too, especially in conjunction with the geological paper by Varti-Matarangas *et al.*[66] It became quickly clear that the red limestone was not of the best quality and yet, it was incorporated, in different phases of the Tiryns citadel walls complex, in large quantities and block size. Its quarries, recognised but unclearly described by the geologists, were all within an easy 1-2 km reach, with the large hill of Profitis Ilias as the geologists' favourite. I am convinced that this can now also be substantiated (but not to the exclusion of other quarry locations of this stone), because of the meaning of this stone, its usage history and locations, and its potential references to its ancestral ownership.

Located on the rocky outcrop of the Tiryns citadel was a clear vertical axis, representing various time scales. This axis was present both materially through its building stones but also symbolically through the reuse of the same location over time, as has already been established.[67] Not only was the Tiryns citadel outcrop a good vantage point in the entire region – visible overland *and* from the sea[68] – the rock itself was and remained an important and connected locale. Building on the same spot was no coincidence and done intentionally. It was spatially and temporally connected to a heroic past, and its associated ancestral claim to rulership was made obvious through that material vertical axis and associated social memory practices.[69] Especially the red limestone fulfils a very useful practical and symbolic function in emphasizing the temporal axis.[70] But, can the same be said for the use of the conglomerate material which came from near Mycenae, about 15-18 km away?[71] Conglomerate stones at Tiryns with visible working traces on them[72] do not, in my view, represent a vertical material and symbolic axis of communication and social memory, as the red stone does. Instead, it constructs a spatially horizontal one, a link to Mycenae's presence in the near distance, and to its overlordship which needed to be recognised[73] and respected. It does not refer to the depths of the outcrop and its associated past: because it does not have to, and it cannot. Mycenae's domination was a much more recent fact, and was likely associated with the remodelling of the Megara atop the citadel since the 14th century B.C.E. I argued in 2015 that this domination may have even been silently contested by Tirynthians through their well-chosen and intended red stone usage therein. And how to express allegiance to the *real* ruler of Tiryns better than through the same play of stones? I argue here that yet another axis may be recognised, one that can be both spatially and temporally horizontal *and* vertical: its material presence and its symbolic meaning and value. This axis can be recognised in the much earlier usage of the red limestone at the 15th century B.C.E. Tholos tomb at Tiryns (Figure 1.4b). Constructed more or less at the foot of the large Profitis Ilias hill (Figure 1.4a), easy access to this red limestone for the tomb builders and its sponsor was clear. The person buried

65 Maran 2006, 81-83, plate 12.
66 Varti-Matarangas *et al.* 2002.
67 Esp. Maran 2006; Maran 2016; Brysbaert 2015.
68 Maran 2010, 724.
69 Tuan 1977.
70 Brysbaert 2015.
71 See Maran 2006, plate 12 and Brysbaert 2015, figure 8, table 3.
72 Especially markings of the so-called pendulum saw, see now Blackwell 2018.
73 See the exact same dimensions, to the cm, of the megaliths employed at the Great Gate at Tiryns and the Lion Gate at Mycenae, with only the lock difference, befitting of two different 'houses'.

there was certainly of elite descent considering the size and construction of the tomb, one of the earliest of this type in the region. A conglomerate lintel was not employed here yet,[74] and Mycenae did not have similar ties perhaps to Tiryns at this earlier stage. Very likely, the person buried at Tiryns also possessed the land in which he was buried so he must have posessed the red limestone outcrop too and used it for his tomb.[75] Is it then too far-fetched that, when the 14-13th century B.C.E. citadel wall builders employed the red limestone, they likely went back to where it was used originally, to get some more? And as they did so, their actions justified the then ruling elites *own* status as rulers, by employing stones owned by Tiryns' ancestral ruler or ruling family, who was buried in this very outcrop. The four pillar bases in the Central Court of the Great Megaron at Tiryns, then, take on a specific meaning in reflecting who was still considered the truly recognised ruler of Tiryns. Yet, they were covered in plaster to avoid any troubles with contemporary powerful neighbours, such as Mycenae. As such, one could argue that the people of Tiryns used the stones to connect to the land over long periods of time, and to show where they belonged, whom they felt allegiance to, and how they wanted to be remembered. The landforms themselves certainly played a role in this connecting as well, and people likely connected to the landscape in many more ways than seeing it just as a place from which to extract resources, which is how we tend to see our surroundings nowadays.[76]

Through various axes of communication and access, the Tirynthians may have accepted overtly its place in the local hierarchy with Mycenae as the main power in the Argolid. Covertly it remained its own boss, backed by its strong past location of the Rundbau and Tumulus,[77] and through the possessions of their powerful ancestral rulers. These were materially embedded at the heart of the structures of the living, the hearth of the Great Megaron on the Upper Citadel. The Mycenaeans, thus, did not only shift their focus from an 'architecture of the dead' to that of the living.[78] Just as the ancestors of Grave Circle A at Mycenae were incorporated by the 13th century B.C.E. fortification wall into the citadel's power circumference, so did Tiryns enclose its ancestral powers within its Citadel, and as close by as the Great Megaron itself. Another nod to its ancestral power was how the builders played with their materials, although we will never know whether they did so upon command, or by themselves. Either way, identity building and aspects of belonging to that land were clearly expressed through the stones. The entrance to the western staircase has been illustrated already[79] and recently also the so-called corbelled shrine entrance, just inside the Main Entrance and north of the Great Gate, was recognised to have exactly the same stone colour decoration too (Figure 1.5). Both entrances also face east and were part of the last large remodelling phase of the citadel walls. These decorative effects must have caught the

74 In contrast to the contemporary tholoi near Mycenae.

75 See for a similar argument for the chamber tombs and landholdings at Mycenae: Shelton 2003, 35.

76 Cf. Scarre 2011, 11-13.

77 Maran 2016, 168-169 does not see a direct architectural marking of the EH Rundbau in the 14-13th century B.C.E. Mycenaean Palatial citadel constructions while, to me, it is obvious through the very specifically chosen use of stone, see Brysbaert 2015. While new traditions of social memory may have been created, according to Maran 2016, 168-169, they do not exclude earlier ones but actually tie in with these, a fact he does recognise for the next period connection to Building T.

78 As mentioned earlier in this paper and emphasized by Dabney and Wright 1990; see also Fitzsimons 2011.

79 Brysbaert 2015, 83, figure 9.

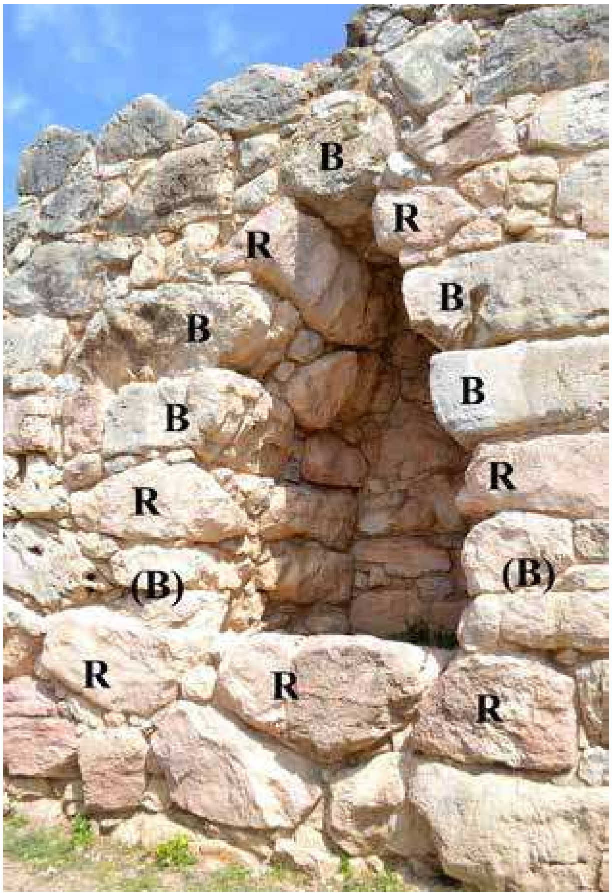

Figure 1.5: Decorative coloured stone arrangement at the Tiryns citadel shrine, just inside the Main Entrance and north of the Great Gate (See Papadimitriou 2001, 27, figure 19 (small niche east of nbr 50 on figure 19)) (Photograph: A. Brysbaert).

eyes of new visitors, and since at least two places with stone colour-play have now been recognised, this leaves the argument of 'pure coincidence' well out of the picture and assigns initiative to the builers themselves.

Building and remodelling the Tiryns citadel and its constituent parts over several centuries involved the incorporation of different stones. These drew in, materially and symbolically, the different parts of the ruler's political realm and its people, through them being builders or/and being inhabitants of the land which provided its required food supplies. As such, building at this scale may have either cemented the existing relationships with the local lords on which they could rely to supply work forces,[80] or, it may have consolidated their strong bonds with their ancestral rulership and past, or both. Using local stones rather than stones from Mycenae also likely consolidated not just their alliance to Mycenae, but also their own social identities. The latter involved the interaction between ruling families *and* builders and with each other, possibly through yearly feasts to renew alliances,[81] through employing local human and stone resources, and possibly their animals too. A complex

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80 As expressed in Brysbaert 2015.

81 Wright 2004; see also archaeologist's habits of organising a 'glenti' at the end of an excavation season for all parties as a way to thank everyone's efforts and to forge next year's renewed potential for such efforts together.

web of alliances and social group interactions at play at LBA Tiryns became materialised through the stones, which were collected and worked by those that belonged to the land from which the stones originated too. Thus, researching the construction of monuments and how monumentality may have been perceived ultimately builds a much richer image of people's taskscapes. The papers in this volume illustrate this as richly as one can interpret the taskscape itself.

1.3 The construction labour of this book

This book is the fruit of labour investment that spans about two years. It is the result of the first SETinSTONE workshop (9-10 December 2016)[82] and, after discussions between some of the participants of the workshop, the idea formed to bring more people together with common interests in these themes. The EAA session in Maastricht (2-5 September 2017)[83] brought together papers on several Mediterranean and other regions together, showing how widespread this strand of research extends. The recently held 19th AIAC 2018 conference at Bonn-Cologne (21-27 May 2018) proves this point amply. Finally, I also would like to draw attention to a volume which is about to appear[84] but to which I had no access prior to writing this introduction. I would imagine from its title that its papers will be very complementary indeed with the ones in the present volume. Architectural energetics and labour cost studies, and the archaeology of ancient economies (of building) certainly are back in fashion. Whether this is a good trend remains to be seen, because it would be all too easy[85] to produce databases and clouds full of labour ratios and costs linked to materials. The essential question remains: what do we want to achieve with the labour of collecting these data? Does it serve a larger goal? One would hope so, considering it also did in the past, as many of the papers in this volume illustrate well.

For convenience's sake, the papers in this volume have been grouped under three subtitles even though most papers fall under more than one. The volume varies widely in regional and chronological focus and forms a useful manual to studying both the acts of building and the constructions themselves across cultural contexts. A range of theoretical and practical methods are discussed, and several papers illustrate that these are applicable to both small or large architectural expressions, making these useful for scholars investigating urban, architectural, landscape and human and other resources in archaeological and historical contexts. The ultimate goal of this book is to place architectural studies, in which people's interactions with each other and material resources are the key, at the intersection of and embedded in both landscape studies and material culture studies, where it belongs.

After this introduction, Chris Scarre's paper on *Mounds and monumentality in Neolithic Europe* illustrates how widespread and diverse in form and size these features

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82 Full programme: http://setinstone.eu/wp-content/uploads/2016/11/SETinSTONE_workshop_I_program.pdf

83 Session 272: Construction economies of the past. New approaches to their societal, political and long-term impact. Comparing archaeology across regions and periods, organized by A. Brysbaert and A. Gutierrez Garcia-M.

84 McCurdy and Abrams, in press.

85 As J. Osborne 2014 already alluded to, but plenty of papers, even in this volume, contradict these fears.

are in the archaeological record of many places, depending on their cultural settings. By their very nature, mounds can fulfill a variety of objectives: they impress and commemorate but they can also serve to cover things, such as the remains of the dead. In forming an act of closure, they may protect the living from the powerful and dangerous things that are buried with the deceased and also mark the end of active mortuary deposition. Mounds do not only cover, but also raise; their elevation can be both practical and symbolic. Mounds can thus provide a platform for special rituals. In focusing especially on the prehistoric burial mounds of western Europe, Scarre's paper explores the symbolism of the mound, the visibility of the mound within its broader landscape, and the materials and processes involved in their construction.

In her paper, Kalliopi Efkleidou discusses issues relating to the experience of Mycenaean monumental architecture which have, so far not been widely or extensively discussed when compared to building techniques per se, and how monumentality relates to status-building. Through examples drawn from the Late Bronze Age sites of Mycenae and Tiryns in Greece, she focuses on the mechanisms through which architecture can relate and communicate specific views on the existing, the imagined, or the desired social order. In exploring their design, construction, and aspects of people's experiential engagement with these monuments, she demonstrates that architecture was strategically used as a medium for socio-political display and the negotiation of group identities. But this was not only for the elites themselves. Efkleidou, in fact, illustrates how the architecture's permanent character allowed it to function as a long-term and perpetual medium for the members of all communities to display, affirm, and negotiate their place in the existing social order, something that resonates very well with the active role of artisans seen in building at Tiryns, for example.

Lesley McFadyen's paper focuses on the Neolithic unchambered long barrows in south Britain. She postulates that materials and forms shift through time, that they are immanent in unfolding practices, and that the materials themselves allowed for specific kinds of shape shifting. As such, it is the form that follows from materials rather than vice versa. In studying architecture that one cannot re-enter, she investigates how the form emerges through the process of construction, and the effects of that practice on those participating in the building activities. She encourages us, archaeologists, to consider the kinds of body dynamics and politics involved in a more dependent building practice, what she calls an 'unequal architecture'. These practices were of short duration, the architecture was physically inaccessible and it lacked a stable form. The combination of these characteristics meant that inequality could not be repeatedly played out through an engagement with an architectural object. Through these observations, McFadyen asks how one should understand social relationships negotiated on such inner terms?

Of the papers with practical methodological approaches to studying architecture, Yannick Boswinkel investigates the usefulness of surveying sites for architecture where stretches of walls are below two meters or where the majority of the remains comprise individual building blocks out of context. This approach is in contrast to the traditional way of surveying the ruinous architecture of monumental structures, or nearly complete buildings. A team of the *'Ancient Cities of Boeotia Project'* has been documenting the architectural remains from Hyettos, Haliartos, and Koroneia, where a large variety of architectural remains were found. Some of these formed just a heap of rubble, but occasionally monumental *in situ* structures or foundations were also encountered. Most of the documented Koroneia material consisted of generic material in the form of both roughly hewn and well-dressed stone blocks. Boswinkel's research focused on trying to identify the specific structures or specific zones of the city from which these blocks derived, in order to understand to what degree his highly detailed approach could aid in identifying structures of potentially monumental size. His paper shows the usefulness of such a survey and a detailed approach for this kind of material, since it helps to determine whether monumental structures can be recognized in its individual pieces, or only by the sum of its parts.

Jari Pakkanen presents a wide range of practical applications of several 3D techniques currently employed and the millimetre-precise recording of architectural remains, both on land and under water. As the developer of the use of intense reflectorless total station drawing method, he shows how, over time, one can move away from stone-by-stone documentation of the entire monument, to a much faster combined method whereby the minor loss of precision outweighs by far the speed reached by 3D photogrammetry. For large complexes, drone photography can shorten the time needed in the field. Full 3D documentation of existing features allows for more precise reconstructions and subsequent analyses of the architecture. Moreover, these techniques are very time- and cost-effective. Previously inexperienced students can be trained through short field courses to a professional standard, making the methods and their employment well within the reach of most project's budgets. The examples given, Kyllene harbour, Pleuron reservoir, and Naxos shipsheds (Sicily), are complex case studies. Nevertheless, his years of practical field experience demonstrate the flexibility in approaching the issue, all through successfully documented case-studies.

Elisavet Sioumpara's paper presents an overview of the Mycenaean Acropolis remains, some of the least known on the Rock in the heart of Athens. She outlines what has been preserved and in revealing these fragments in detail, she explains the equally complex excavation and research history of these remains. This is especially valuable, since the focus of most Acropolis research sits squarely with the better known and more visible Periclean building programme of the fifth century B.C.E. However, since Archaic and later builders took the Mycenaean remains into account during their building activities, the importance of the earlier remains are clear. Although the PhD by S. Iakovidis provided the major documentation of the Athenian Acropolis Mycenaean remains, 3D scanning has also been carried out. Yet, the Mycenaean remains were never the focus of further study. As part of the SETinSTONE project, the combined method of reflectorless total station with 3D photogrammetry is described in detail to show how the methods are useful, not only for the labour cost studies for SETinSTONE, but also for future studies on the Rock.

The paper by Sofia Voutsaki, Youp van den Beld and Yannick de Raaff aims to reconstruct the labour input in the tombs from the cemetery of Ayios Vasilios in southern Greece. On the bases of these analyses, they reconstruct changing social and kin relations in the Early Mycenaean period (1700-1450 B.C.E.) there. They argue that the initiation of building projects is an important component in the transformation of reciprocal, segmentary, kin-based social networks into asymmetrical, centralized and competitive political entities. Starting with a healthy critique on specific aspects of architectural energetics methods, they suggest and apply a more qualitative method to several of the graves of the Ayios Vasilios cemetery. Their method accounts for the division of labour and the circulation of resources that undergo radical change in this period and are expressed in these mortuary practices. The tombs show substantial labour input used for the quarrying, transporting and rough working of different types of stone. In studying variation in the size and construction of the tombs and their associated labour input, they aim to understand better the social strategies of distinction or conformity, exclusion or inclusion. It is generally accepted that changes in grave types are part and parcel of the transformation of the mainland societies, with the emergence of social asymmetries and political hierarchies.

Daniel Turner's paper focuses on preindustrial logistics of construction and the potential for a comparative method. The former relies on accurate measurements of the construction and defendable rates at which the work likely proceeded. Selecting rates from previous studies, such as ethnographic reports, historical sources, or experimental replication, whether within the same region and time period or not, is often obstructed by their scattered occurrence within the literature. If present, these figures are often secondarily cited, and left hardly commented on or unexplained. Turner asserts that future labour studies would benefit from a quick-reference guide of task rates in order to avoid perpetuating this weakness. He sets this in motion by developing such a reference for manual earthmoving. Task rates are combined with the dimensions of a built feature, and the volume of earth is considered from material procurement, transportation, construction, and elaboration characteristics, and includes variables for region, technology, and source. Prehistoric rates cannot be easily recovered, but in employing convincing ranges in manual labour efficiency, predictions remain possible when based on analogous rates from experimental archaeology, ethnography, and history. Turner illustrates this through case studies from the UK, USA, and Ireland. Key in comparative work is the question of acceptable labour ranges based on the used tools and materials, and he states the need to carry out such work for stone, wood and other materials, as well as for transport means and construction techniques.

Maria Torras Freixa's paper on the ancient city of Teotihuacan (0-650 C.E.), re-evaluates the context in which the city achieved its monumentality and the political and socio-economical processes that triggered the large-scale building projects. The city's centre was dominated by three monumental temple pyramids: the Moon Pyramid, the Sun Pyramid and the Ciudadela with the Feathered Serpent Pyramid. Until recently, these were considered to belong to the earliest building stages (0-200 C.E.). However, only the Moon pyramid was started that early and was very modest in size, while all three became monumental in a very short period, between 200-250 C.E., which implied a huge contemporary labour input. In employing building sequences, size, techniques, materials, decoration, orientation of the pyramids, their location within the settlement, and their dedication caches, Torras Freixa shows the existence of an urban master plan initiated in the Tzacualli phase (0-150 C.E.). This plan was reconfigured in the Miccaotli phase (150-200 C.E.), and monumentalized in the Early Tlamimilolpa phase (200-250 C.E.). The changes in orientation and the introduction of human sacrifice show an increase in authority coupled with the emergence of new symbolic discourses. In that sense, rethinking monumentality in Teotihuacan is a first step to understand political and socio-economic issues in the city's configuration.

Janet DeLaine's paper investigates the role of economic factors in the exercise of choice in Roman construction at Ostia in the Roman heartland, where construction often involved materials from further afield and complex technologies. Like for Rome itself, Ostia seemed to have been built up mostly of permanent materials and on a grand scale. Through employing architectural energetics, she assesses the levels of counter-economic choices made at Ostia as deliberate expressions of conspicuous consumption, and the power to command workforces to execute such work. Her case studies (the Mausoleum of Cartilius Poplicola; the Horrea in via degli Aurighi), and three peristyle colonnades of different types (the Horrea of Hortensius, the palaestra of the Baths of Neptune, and the *porticus post scaenam* of the theatre), all focus on the differential use of materials and construction techniques. Through these analyses, DeLaine considers several cost-affecting factors. The results regarding the transport for local materials, labour for the production of construction elements, and their putting in place are combined in the latter two examples together with the requirements for special equipment (*e.g.* lifting machines). Her conclusions highlight the tension between strategies for minimising construction expenses and the requirements of the patron's self-presentation.

Moving to the provinces, Anna Gutiérrez Garcia-M. and Maria Serena Vinci discuss the dual nature of the Roman town of Tarraco (Tarragona, Spain): as colony and capital of the largest Roman province in the western Mediterranean. In the Early Imperial Age, Tarraco experienced intense building activities that radically modified its architecture and urban layout. From the Augustan period, the landscape of the town was modelled to a degree of monumentality commensurate with its political status. Two public areas developed: one as the centre of the Republican and Augustan colony, and one where the architectural complex of the Provincial Forum was erected. The large temple presiding over the latter became the symbol of sacredness of the imperial power and a means for the political representation of the local elites. These two areas are ideal case-studies for the dynamics that revolve around the setting up of large-scale building programmes and the complex economic construction system. By looking into the abundant archaeological record (architectural remains, the El Mèdol quarry, remarkable quarry marks on blocks), the authors aim to better understand the organisation of the building industry. They identify the impact that it had on the overall economy of the town while contextualizing it within its geographical and socio-political environment.

Cathalin Recko's paper illustrates methods for measuring and calculating the required materials used in the Temple of Isis (Pompeii, Italy). A detailed presentation of the operational chain of brickwork is presented in this paper. While contributing to research on labour as an indicator for the economic value of ancient construction, Recko's paper also focuses on the potential of comparing this data in different settings. Estimating labour costs based on pre-industrial sources led to approaches to quantifying and valuating ancient construction. However, the underlying mathematical principles of calculating form, size, and the amount of materials on which to base architectural comparisons for buildings with different functions, are limited. Recko presents different options and levels of precision in the mathematical methods, keeping in mind different perspectives and research questions. Questioning which public building or building type would require the most labour, skill, and time has the strongest potential to give valuable insights into a city's building economy. As such, she aptly illustrates what the Temple of Isis can tell us about the Pompeiian brick industry in context. Economic factors, the design itself, together with the ideological and the socio-cultural background of the builder and the city itself all influenced the choices of building materials.

Finally, Jacopo Bonetto and Catharina Previato's paper reconsiders the city walls of the Latin colony of Aquileia, Italy. As one of the best preserved architectural complexes, dating to the earliest phase of the colony founded by the Romans, the city soon became the most important and the richest of Northern Italy. The defensive walls, provided with gates and towers and almost entirely made of fired bricks, were 3 kilometres long and encircled 40 hectares. Through data collected during recent archaeological excavations and by experimental analyses, the authors analysed the different steps of the construction processes of these city walls. In quantifying the amount of building materials employed, the time and the means of their supply and production, the number of workers involved, and the time required by the building activities, their aim is to define the socio-economic impact of the construction processes. Subsequently, they analyse these results in view of the historical context in which these activities took place, during the Roman conquest of Northern Italy. Additionally, they also test the overall strengths and weaknesses of quantitative analyses on ancient buildings.

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2

Mounds and monumentality in Neolithic Europe

Chris Scarre

2.1 Introduction

Burial mounds of various ages, morphologies and materials are among the most widespread features of the archaeological record. They are present indeed in every inhabited continent. Although they require investment of labour, sometimes on a significant scale, mounded burials are not restricted to farming societies. One of the very oldest to have been investigated is the low eight-metre cairn at L'Anse Amour, raised by hunter-fisher-gatherer communities of coastal Labrador in the seventh millennium B.C.E.[86] At the opposite end of the spectrum are massive examples such as the keyhole tombs of Japan, the largest of them some half a kilometre in length, associated with the emergence of a powerful centralised state in the fourth and fifth centuries C.E.[87] The mounded tomb hence encapsulates a wide range of chronologies, social contexts, internal arrangements, and external forms.

That variety could be taken to indicate that burial mounds do not in any real sense constitute a coherent phenomenon. On the other hand, the very ubiquity of the burial mound suggests that it responds to widespread patterns of funerary practice and belief. Indeed, burial mounds offer a number of specific affordances and constraints. They cover and conceal, hiding from view whatever they contain. They impose a distance, or physical estrangement, between whatever may be held within or covered by the mound, and the viewer who is placed outside it. Mounds also by their very nature rise above the ground, sometimes providing a raised platform for ceremonial, but in all cases, they create a visible mark on the landscape. They reach towards the heavens, a quality that may sometimes have cosmological significance. In common with other substantial monuments, they are also statements of social power. Large mounds dominate the viewer, forcing onlookers to lift their gaze upwards, a feature emphasised by

86 McGhee and Tuck 1975.
87 Mizoguchi 2013, 273-280.

In: Brysbaert, A., V. Klinkenberg, A. Gutiérrez Garcia-M. & I. Vikatou (eds) 2018. *Constructing monuments, perceiving monumentality and the economics of building: Theoretical and methodological approaches to the built environment*. Leiden: Sidestone Press, pp. 49-64.

Moore in his study of *isovistas* in South American ceremonial architecture, drawing upon the work of Japanese landscape architect Tadahiko Higuchi.[88]

Western Europe has an extensive inventory of prehistoric burial mounds, ranging in date from the Earlier Neolithic to the Roman conquest. In the absence of ethnographic or documentary evidence, the meaning and significance of these structures have to be deduced from a close reading of the archaeological evidence coupled with insights from other regions and periods. Archaeological evidence documents their architectural character and the role of mounds as closure to earlier activities, but only by considering the broader background can their symbolic dimension be addressed. Let us deal with each of these issues in turn, focusing on the Neolithic burial mounds of western Europe but looking further afield where appropriate.

2.2 The mound as architecture

Monuments such as burial mounds are an expression of the agency of those who built them, whether that was a small-scale farming or foraging society, or the centralised labour resources of an early state. They exceed the requirements of any practical functions.[89] The constructional process itself is significant. Recent decades have seen a better understanding of internal structure and the specific techniques that were employed. In some cases, prehistoric burial mounds have been shown to be complex and sophisticated in their design and execution. Others may have been more informal, but the engagement of individuals and communities in the creation and elaboration of a burial mound is crucial to their interpretation.

The crucial advance in the archaeological study of European prehistoric burial mounds came with the realisation that the mounds were important in themselves, and not simply as coverings for the graves, chambers, or funerary deposits that they contained. Early antiquarian interest focused on digging into burial mounds to expose and recover their contents. In England, large numbers of barrows were emptied in this way. In extreme cases, several mounds might be 'opened' in a single day.[90] It was only in the later 19th century that attention began to be extended to the mounds themselves. In Britain, the total excavation of the unchambered long mound of Wor Barrow in 1893-1894 C.E. marked the beginning of a new and more systematic approach.[91] During the 20th century such rigorous excavations have become widespread both in Europe and beyond. This has given rise to the 'architectural' analysis of mounds and cairns.

In the case of European Neolithic burial mounds, one outcome of these new approaches has been the demonstration of their cumulative character. Many mounds in their current form are clearly the product of several phases of modification and addition. Internal chronologies have been increasingly well documented by 20th and 21st century excavations that have focused specifically on burial mounds as architectural objects in their own right. In some cases, earlier phases have been almost entirely erased by

88 Moore 1996, 104-108; Higuchi 1983.
89 Trigger 1990, 109.
90 Marsden 1999; Daniel 1975, 153-154.
91 Ashbee 1970, 5.

Figure 2.1: Complex internal structure of the Neolithic long mound of Péré C at Prissé-la-Charrière in western France. Excavations by Luc Laporte, Roger Joussaume and Chris Scarre. Photo: Chris Scarre.

later construction. An excellent example is the passage tomb of Dombate in Galicia.[92] This consists of a tall chamber constructed of overlapping orthostates (frequently, as here, seven in number) accessed by a much lower passage, and the whole structure is enveloped by a circular earthen mound. Excavation in 1987-1989 revealed, however, that this large extant burial chamber had replaced an earlier smaller tomb alongside it, of which only fragments or snapped bases of the nine orthostates remained.

Still more complex is the sequence revealed at Prissé-la-Charrière in western France (Figure 2.1). This 100-metre long mound, still surviving in places to a height of 4 m, preserves a complex of internal dry-stone walling, external kerbs, three burial chambers, and flanking quarry ditches.[93] Excavation has revealed a structural sequence beginning with a small megalithic chamber at the western end. This was enlarged in stages to a 'short' long mound 28 m in length entirely enclosed within a rock cut ditch. That early monument was given external coherence by a dry-stone wall without any breaks or entrances. Its external appearance would have suggested an intended finished product – an active burial chamber decommissioned and hidden away within a regularised rectangular cairn. After a relatively short interval, however – probably only a few decades – the encircling ditch was backfilled, and a much longer mound built, 100 m in length, entirely enclosing the earlier structure and once again concealing it from view.

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92 Bello Diéguez 1993; Bello Diéguez 1997; Cebrián del Moral *et al.* 2011.

93 Laporte *et al.* 2002; Scarre *et al.* 2003; Cousseau 2016; Laporte *et al.* in press.

In effect, the sequence at Prissé-la-Charrière appears to comprise at least two, and possibly more, 'finished' monuments, the first of which was rapidly incorporated within a larger monument. Even the 'finished' monument may not have been intended to stand intact for a prolonged period. However impressive when first built, a long mound of this kind would quickly have taken on a dilapidated appearance unless it was regularly patched and repaired. It is indeed open to question whether the builders were intending to create a 'monument' – a memorial designed to last for a considerable period – or something instead of an altogether more transitory nature.

The complexity of the internal structure at Prissé-la-Charrière is by no means unique. In northern Europe, excavation of Scandinavian passage graves has revealed the complexity of the construction around the central chamber.[94] In several cases, massive quantities of crushed flint were packed around the chamber – between 20 and 30 tonnes of it at Kong Svends Høj.[95] At Birkehøj, instead of crushed flint, the builders constructed a rubble wall outside the chamber and filled the intervening space with pebbles.[96] These deposits were sealed by a capping of clay (where available), or a layer of loam or earth. The purpose was to prevent rainwater penetrating the interior of the chamber, and in some cases, drainage was further assured by the digging of a ditch or channel in the ground surface immediately outside the bases of the orthostats. It has been suggested that the various different solutions to creating a waterproof chamber define the existence of a series of 'architectural schools'.[97] The social context of construction is especially intriguing since these passage graves number in the hundreds yet all of them appear to have been built within the space of two or three centuries.[98] The high level of technical knowledge involved in the construction of so many tombs in such a relatively short period implies either specialist tomb-builders or an efficient transmission of knowledge and expertise among north European Neolithic societies. The level of expertise required continues to be subject to debate, an issue we shall return to below.

2.3 The mound as closure

The preceding discussion has focused upon passage graves, where a stone-built chamber (of megalithic or dry-stone construction) was covered by a mound or cairn, and continued access to the chamber was enabled by the provision of a passageway leading to the chamber from the edge of the mound. This is in contrast to the majority of burial mounds – in prehistoric Europe and elsewhere – where the raising of the mound marked the end of funerary deposition, as the original burial chamber or grave was sealed beneath it. In these cases, the construction of the mound was essentially an act of closure, sealing and preserving the earlier remains.[99]

This has already been illustrated by the example of Prissé-la-Charrière, where the initial burial chamber at the western end of the long cairn was taken out of use by the

94 Dehn *et al.* 2000; Dehn *et al.* 2004; Dehn *et al.* 2013; Midgley 2008, 43-107.
95 Dehn *et al.* 1995.
96 Dehn *et al.* 2004.
97 Midgley 2008, 107.
98 Scarre 2010.
99 Last 2007.

construction of the 'short' long mound and encircling rock-cut ditch. What began as an active place of burial became a blank static monument, testimony perhaps to the burials that had already been deposited there, but that no longer formed a focus of new funerary activity.[100] A similar process can be found at other Neolithic chambered cairns. At Ile Carn, for example, on the northwest coast of Brittany, the late fifth millennium chambered cairn with three passage tombs was ultimately sealed away within a large circular cairn, 30 m in diameter, edged by a continuous dry-stone kerb.[101] The same process, the transformation of an active burial place to a mute memorial, would indeed have occurred at any of the many Neolithic monuments where a closed chamber was covered by a mound. We may refer to them all as mounded tombs, but it is clear that mounds were sometimes added to burial chambers only after funerary activity – in the sense of the deposit of human remains – had ceased.

At some sites, the sequence may have been relatively rapid; at others, prolonged and played out over several centuries. Several Neolithic chambered tombs in northern Europe give evidence that the mound – or at least its outer part – may not have been added until the Early Bronze Age. This was observed over a century ago by Swedish archaeologist Oscar Montelius when discussing the T-shaped passage grave of Prestgården in Halland, southwest Sweden (Figure 2.2). Excavated in 1881 C.E., the initial mound reached only the lower surface of the capstone. It was capped by a layer of stones. During the Earlier Bronze Age, two oak coffin burials were placed on this surface, immediately adjacent to the capstones of the passage grave, and a large mound of rubble raised above them. This, in turn, was covered by a large earthen mound, containing three Later Bronze Age graves.[102] It appears to have been this sequence above all that led Montelius to conclude that many passage graves were only completely covered by mounds as a result of Bronze Age additions.[103] Tårup in Denmark provides a more recent illustration of such a sequence. A megalithic chamber, perhaps originally free-standing, was enclosed within an initial Neolithic turf mound 15 m across, then buried by a much larger Early Bronze Age mound 57 m in diameter with an encircling ditch.[104] Elsewhere in northwest Europe, too, Neolithic burial monuments were augmented by Bronze Age additions. At Mound of the Hostages in Ireland, the Neolithic passage tomb in its stone cairn 17.5 m in diameter was sealed in the Early Bronze Age by a larger earthen cairn, 20 m in diameter. In this case, access to passage and to the original burial chamber was retained, and burials were deposited at this period in both the chamber and in the overlying mound.[105]

Early Bronze Age burial mounds built *de novo* are frequently very complex in their history and internal structure.[106] A period of centuries might intervene between the initial burial activity and the completion of the mound. This is shown for example at Amesbury G.71, a chalk barrow 6 km east of Stonehenge.[107] When excavation began

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100 Laporte *et al.* 2002; Scarre *et al.* 2003; Laporte *et al.* in press.
101 Giot *et al.* 1987.
102 Montelius 1899, 122-123.
103 Montelius 1899, 124.
104 Holst 2006.
105 O'Sullivan 2005; Scarre 2013.
106 Bourgeois 2015; Garwood 2007; Garrow 2014; Last 2007.
107 Christie 1967; Barrett 1988.

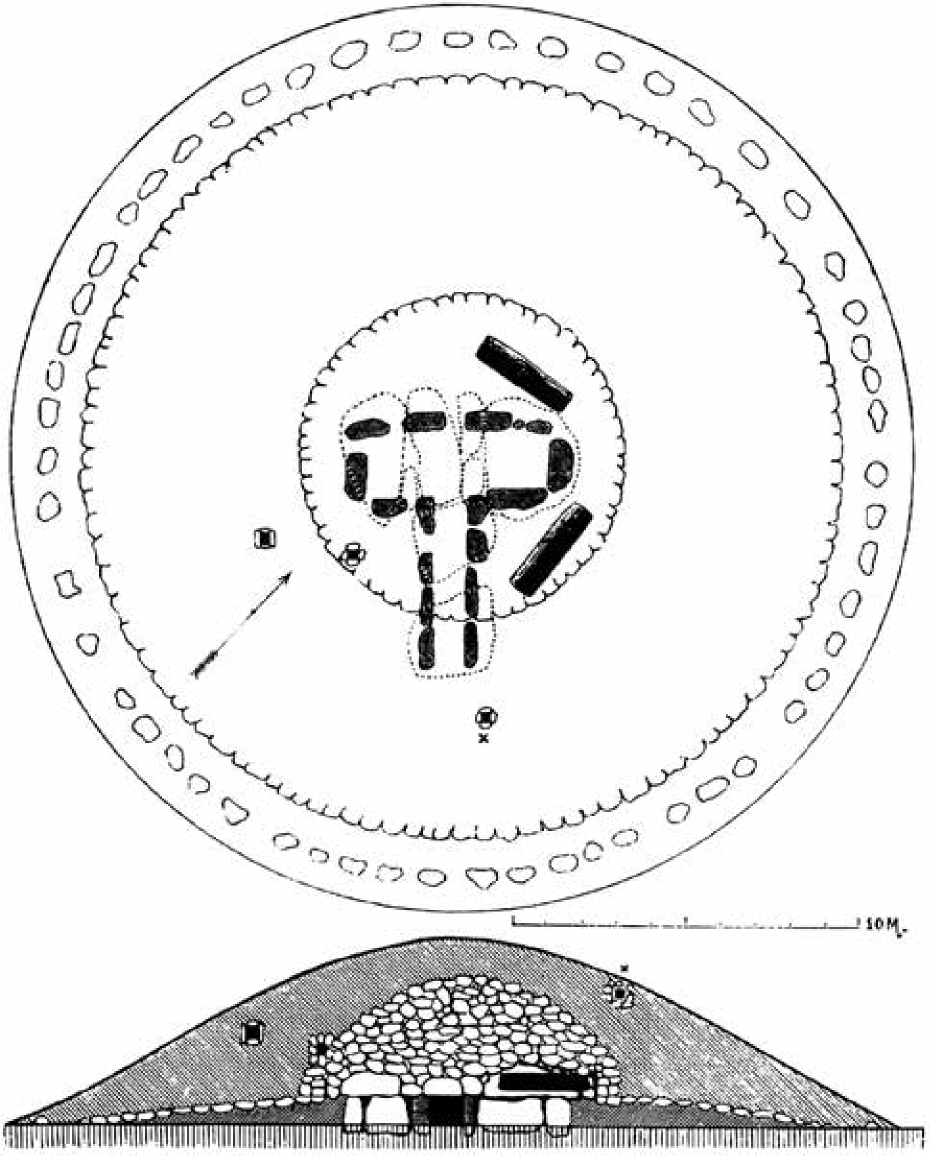

Figure 2.2: Plan and cross-section through the burial mound of Prestgården at Eldsberga in Halland, Sweden, excavated in 1881. The low Neolithic mound rose only as high as the underside of the capstones of the megalithic chamber. At different stages in the Bronze Age there were added, successively, a stone-built cairn containing two oak coffin burials, and an earthen mound containing three stone cists with cremations. Source: Montelius 1899, Fig.164.

in 1961 it measured 30 m in diameter and survived to a height of 2.5 m above the surrounding chalk downland. The visible monument was, however, only the final phase of a complex sequence that began within a circular ditch 7 m in diameter enclosing a ring of wooden stakes and a disturbed grave. In the next phase, a deep pit was dug to receive a second inhumation. The grave pit was enclosed within two rings of stakes, but both grave and stake circles were subsequently covered by a low turf mound edged by flint nodules, with a shallow ditch outside. Subsequently, that initial turf mound was truncated and several new burials were inserted, both cremations and inhumations. Those, in turn, were covered by a level platform of earth and chalk on which a bonfire was lit, before being sealed beneath the final turf mound (containing further inhumations and cremations). The entire sequence spanned probably four or five centuries.[108]

An interesting feature of Amesbury G.71 and other Early Bronze Age barrows is the role of colour in generating or enhancing visual impact. Although the final mound consisted largely of turf, there was evidence in a number of places that it had been capped by a layer of chalk.[109] That would have given it a brilliant white appearance and made it a highly conspicuous monument. The symbolic potential is clearly apparent, and more complex patterns of colour symbolism have been suggested for Early Bronze Age burial mounds elsewhere in Britain.[110] Ethnographic reports document the intentional use of differently coloured soils by recent mound-building communities. In southern Chile, the soils used to build the Araucanian mounds were specifically linked to different sectors of the landscape and were the property of individual lineages who participated in mound construction.[111] Here the coloured soils were buried and hidden as the mound rose in height; they were internal features. The colour of materials reminds us, nonetheless, that the eroded grass-covered appearance offered by many prehistoric burial mounds today masks a more striking and deliberate visual impact when they were first built.[112]

2.4 The mound as symbol

Colour, both internal and external, would have offered important symbolic potential to prehistoric mound-building societies. More frequently discussed is the symbolically charged parallel in architectural form between funerary and domestic spaces. This is most commonly seen in the form of the burial chamber. As long ago as 1838 C.E., Swedish archaeologist Sven Nilsson compared the megalithic chambered tombs of northern Europe to the winter huts of 'Esquimaux' of Greenland and North America, noting not only parallels in their form and dimensions but also suggesting that some had been used as burial places.[113] The theme was developed by Oscar Montelius, who again compared megalithic chambered tombs to traditional houses, this time citing the Lapps of northern Norway.[114] The concept of the tomb as a house of the dead is of course very widespread. Classic examples from southern Europe include the rock-cut *Domus de Janas* of Late Neolithic Sardinia or, from a later period, rock cut Etruscan tombs such as those at Cerveteri.[115] These European examples take their place among an extensive series of tombs-as-houses ranging in date from prehistoric times to the present day.

108 Christie 1967.
109 Christie 1967, 347.
110 Owoc 2002; Owoc 2004.
111 Dillehay 2007, 267.
112 Scarre 2006.
113 Nilsson 1838.
114 Montelius 1874.
115 Robin 2016; Prayon 1986.

Nilsson and Montelius drew their parallels from the form of the chambers. In the early and mid 20th century, however, European prehistorians began to make a different comparison, between the forms not of the chambers but of the mounds. This concerned above all the long mounds of northern Europe, and the longhouses of the early farming Bandkeramik communities. Thus, Ernst Sprockhoff compared the typical long mound of northern Germany in its original form to a long house with low-ridged roof and a decade later Childe drew attention to parallels in plan between trapezoidal long houses at Brzesc Kujawski and trapezoidal Kujavian long mounds.[116] The parallel takes a curious twist in the case of Barkaer in Jutland, where a pair of long mounds, reduced to a height of little more than a metre, were initially interpreted by the excavator as a pair of timber long houses.[117] A similar case is Niedzwiedz in Poland, where again what came to be recognised as a long mound was initially interpreted as a long house.[118]

More elaborate forms of symbolism are also documented. Beyond Europe, the representational significance of the mound design is most graphically illustrated by the effigy mounds of southern Wisconsin and eastern Iowa in North America. Some 15,000 mounds were built in Wisconsin, mainly during the Mature period of the Late Woodland stage (700-1100 C.E.).[119] Most are conical or linear in shape, but around 3,000 of them are classified as 'effigy mounds', deliberately modelled in the form of birds or animals. The majority cover burials, usually placed in pits dug into the land surface beneath them. The mounds themselves can achieve substantial size – over 100 m in length – but they are rarely more than a metre or so in height. The emphasis therefore is on their ground plan rather than their elevation.

It has been argued that the animals represented by the effigy mounds were associated with particular social units or clans. In the Four Lakes area of Wisconsin, ten recurring animal forms may have been clan symbols: they include birds (eagle, goose, the mythical thunderbird), quadrupeds (bear, wolf, deer) and reptiles (snake). These creatures could also have had cosmological significance, depicting as they do inhabitants of all three natural realms – sky, earth, and water. Creatures of the sky may have evoked the upper world, those of water the lower world.[120]

Alongside this cosmological symbolism is an important social dimension. The effigy mounds were built by mobile foraging communities, and the clustering of mounds may indicate places of seasonal ceremonials, where communities came together in summer to reassert social cohesion and engage in shared ritual activities: 'mound building, burial of the dead, and other rituals that emphasized commons, kinship, and ancestry'.[121]

That interpretation of the North American effigy mounds draws on the ethnography of the historically documented Oneota who are presumed to be the direct descendants of the effigy mound builders.[122] Other examples from beyond Europe illustrate how ethnographic associations with living or recent communities can provide insight into the deeper meanings that even simpler mound shapes may have held.

116 Sprockhoff 1938; Childe 1949.
117 Bradley 1998, 4-9; Liversage 1992, 20-22.
118 Turek 2016, 2.
119 Birmingham 2010; Boszhardt 2012.
120 Birmingham 2010, 35-38, 111-113.
121 Birmingham 2010, 11.
122 Birmingham 2010, 13-15; Boszhardt 2012.

This can be illustrated by burial mounds in the southern Brazilian highlands, where modern Jê communities are structured into moieties that are expressed in burial traditions.[123] The practice has been traced back to the proto-Jê period (1000-1700 C.E.) when cremation burials were placed in mound and enclosure complexes. Mound interment was first recorded by Europeans in the 17th century and continued into the 20th century. The enclosures are defined by a shallow ditch and low bank, sometimes with a single circular mound occupying a central position within it, in other cases with several mounds across the interior. Excavations at MEC1 at Abreu Garcia revealed that there were sixteen cremation deposits divided between the northeast and southwest halves of the mound, leaving the central axis clear. The burials in the two halves of the mound were strikingly different: those to the northeast had been placed within the body of the mound, or in two cases in pits cut into the underlying earth. Those to the southwest were more elaborate and with one exception were buried in a row of four deep rock-cut pits (one each in pits B, C, and D; five together in pit A). There is hence a 'stark contrast between the formal bedrock cut pits of the southwestern half and the dispersed interments in the northeast'.[124] That distinction may reproduce the opposition between the dominant Kamé and subordinate Kairu moieties in the ethnographic record.

In the southern Jê case it is not the mound itself that is the symbol, but the patterning of the burial practices within and beneath it. The complexity of burial arrangements at individual prehistoric mounds in Europe alerts us to the possibility that similar social distinctions may have been expressed there also. Ethnographic examples may not provide direct answers, but they encourage us to think beyond the material.

2.5 Architecture and design

This digression into more recent mound-building traditions (previous section) has taken us some distance beyond the European Neolithic examples that are our focus. It has illustrated, however, the wider social and cosmological references that might have been embodied within their outward form and internal structure. At the same time, the detail that has been revealed by recent excavation of European mounds and cairns offers the possibility of a new and more direct reading of their construction. It has led to new discussions about the way the work may have been planned and organised, and its social context.

As we have seen, the apparent finality and monumentality of the burial mound masks a constructional history that was sometimes complex and prolonged. Detailed observation increasingly enables constructional sequences to be deciphered and the various intermediate stages to be identified. Good examples from southern Britain include Hazleton North and Ascott-under-Wychwood where the modular structure of the chambered long mounds may relate directly to the process of construction itself, reflecting the coming together of different kin-groups or communities.[125] Study of the internal arrangements of these mounds has given rise to the concept of 'quick architec-

123 Iriarte *et al.* 2013; Robinson *et al.* 2017.
124 Robinson *et al.* 2017, 247.
125 Saville 1990; Benson and Whittle 2007.

ture', where construction was a participatory process in which fluidity and instability were an important component.[126] This is consistent with the contingent, temporary character of the internal structure of several excavated examples of southern British long mounds.

At Maeshowe in Orkney, the successive concentric structures revealed within the mound have been interpreted in a different way, as technologies for 'wrapping' the central burial chamber by which the monument was successively reproduced.[127] There was, perhaps, no anticipated final form, foreseen from the outset, merely a process of addition.

In other contexts, other models may be invoked. Monuments that began in one form were modified, extended, or even erased to produce something entirely different. That applies not only to different phases of mound construction but also to other features such as the graves and stake circles beneath Early Bronze Age mounds, or indeed the formerly free-standing monoliths frequently incorporated within Neolithic burial chambers in Brittany and other regions.[128]

For certain groups of burial mounds, however, the technical complexity that is evident may not be so obviously consistent with small-scale, localised expertise. In Scandinavia, for example, it has been suggested that 'specialists, perhaps even travelling master craftsmen' may have been responsible for the large numbers of passage graves built to standardised plans in a relatively brief time span.[129] In western France, too, the specialist skills of the builders have been highlighted by recent analysis of the drystone construction of monuments still preserved to a height of several metres.[130] It has been argued, likewise, that Irish passage tombs must have been built to a preconceived plan.[131] The careful selection and deployment of materials implies a high degree of skill and experience, especially in the case of technically demanding features such as corbelled vaults.

Yet, although expertise will have been required in many cases, even much larger mounds may have been within the capacity of local communities. This includes Silbury Hill, the largest prehistoric mound in Europe. It has been estimated that it would have required four million work hours to build the massive chalk mound.[132] The apparent magnitude of the undertaking, however, must be balanced against the evidence from the Bayesian analysis of Accelerator Mass Spectrometry radiocarbon dates that indicates that construction may have been spread over 50-100 years. If the raising of Silbury Hill was indeed a prolonged process it may not have required large numbers of people at any one time but could have been accomplished by a local community over an extended period.[133]

The level of expertise and the scale of the social engagement remain open questions, which depend upon underlying assumptions about the character of Neolithic

126 McFadyen 2007, 27; McFadyen this volume.
127 Cummings and Richards 2017.
128 L'Helgouach 1997; Díaz-Guardamino Uribe 2010; Scarre 2011; Bueno Ramírez *et al.* 2016.
129 Dehn 2016.
130 Cousseau 2016.
131 Powell 2016.
132 Startin 1982.
133 Field *et al.* 2013, 236-237.

societies that are difficult to evaluate. The growing evidence for mobility at this period does indicate, however, that traditions and expertise might easily have been passed between quite distant communities by movements of people, whether individuals or groups. Such mobility has been directly documented within the burial assemblages of megalithic tombs.[134] Similar patterns have been demonstrated for later periods; at the Magdalenenberg in southwest Germany, where in a Hallstatt princely grave, the central chamber was accompanied by 126 individual burials arranged concentrically within the enclosing mound. Strontium isotope analysis indicated a diversity of geographical origins for these accompanying burials, some of them clearly from beyond the local area.[135]

Burial mounds in prehistoric Europe were hence not exclusively linked to local communities. They embodied broader constellations of knowledge and expertise that tied them into traditions that extended beyond the individual region and reflected larger-scale interactions. They also incorporated varied architectural histories, and projected (or concealed) a diversity of ritualised and symbolic expressions. Many of them today survive only as low grassy knolls, ploughed out remnants, or ephemeral signatures visible on aerial photographs. They nonetheless represent a widespread and recurrent pattern of investment in monumental architecture, frequently linked to the disposal or commemoration of the dead, that finds expression not only in small-scale societies such as these, but in the impressive tomb-building traditions of early state societies.

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134 Sjögren *et al.* 2009; Neil *et al.* 2016, 2017.
135 Oelze *et al.* 2012.

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3

Architectural conspicuous consumption and design as social strategy in the Argolid during the Mycenaean period

Kalliopi Efkleidou

3.1 Introduction

Most approaches to Mycenaean architecture can be considered to fall within the scope of formal and functional approaches, focusing on the form of spaces and buildings as well as on their predominant function (domestic, workshop, cult etc).[136] While these perspectives constitute a substantial part of the defining qualities of architecture, architecture is not only this. It is widely accepted now that architecture is shaped by and itself shapes human movement and interactions.[137] As such, architecture plays an important role in shaping human relations and, ultimately, human social identities.[138] As a result, several studies in the past decade have strongly suggested that a change in perspective is necessary to better understand the relationship between Aegean Bronze Age architecture and the people who interacted with it.[139]

Architecture is a field of practice in which the built environment is not only shaped, but is also inscribed with meanings and transformed from 'space' into 'place'.[140] The process of inscribing onto or invoking meaning from the built environment takes place during events such as the actual building of a structure or during use of it, and even by people interacting with it as visitors and/or spectators.[141] These meanings, formed by thoughts, memories, concepts or stories invoked upon interaction with a particular construction, can be manifested thereafter through tangible features of the built envi-

136 Darcque 2005; Hiesel 1989; Kilian 1981; Kilian 1987; Kilian 1990b; Kilian 1992; Mylonas-Shear 1968.
137 Moore 1996; Tschumi 2000; Thomas 2007, 10-12.
138 Lawrence and Low 1990.
139 Maran 2006a; Maran 2006b; Thaler 2006; Brysbaert 2013; Brysbaert 2015; Brysbaert 2016.
140 See Tuan 1977; Basso 1996; Tilley 1994; Bradley 1998.
141 See Lefebvre 1991, 80-85.

In: Brysbaert, A., V. Klinkenberg, A. Gutiérrez Garcia-M. & I. Vikatou (eds) 2018. *Constructing monuments, perceiving monumentality and the economics of building: Theoretical and methodological approaches to the built environment*. Leiden: Sidestone Press, pp. 65-86.

ronment, such as the use of particular raw materials vested with symbolic value, or be intangible and implicitly invoked.[142]

This constant interaction of people with their built environment entails that people continuously embed meanings into architecture and, in turn, architecture conveys these meanings onto people, shaping their thoughts and interactions. Such a conceptualization of the built environment is key to understanding the impact of architecture on Mycenaean societies.

The risk for archaeologists is to develop a rigid methodology to identify those elements in architecture that trigger people's reaction and invocation of meanings embedded, and to explore how these triggers were perceived and experienced. Despite this, a phenomenological approach to architecture allows for a deeper understanding of the impact of architecture on societies, especially of the importance of architecture as a means to establishing, reproducing and negotiating social identities.[143] This attempt, however, is plagued by the dearth of material remains, especially of those belonging to the Aegean Late Bronze Age domestic architecture of the southern Mainland Greece. As a result, the case studies discussed in this paper derive from an area that has been substantially explored, the Argolid in Southern Greece, and from sites extensively studied and discussed in the literature, the palatial citadels of Mycenae and Tiryns during the Late Bronze Age (hereafter LBA, c. 1600 – 1100 B.C.E.).

In the following discussion, the notions of architectural conspicuous consumption and design are theoretically presented as the 'tools' employed by past sponsors of architecture in order to structure its perception by the people who interact with it, and to convey specific sets of meanings. Next, case studies from the LBA sites of Mycenae and Tiryns are discussed within this framework to ascertain the extent to which these tools were known and used, who their sponsors and audience were, what kind of messages would have been aimed to convey, and if they were successful.

3.2 Architectural conspicuous consumption and design and the shaping of social identities and order

In architecture, especially in monumental constructions, characteristic practices dubbed as *architectural conspicuous consumption* can be summed up as follows: spending for constructions that are larger in size, use materials that are expensive, rare or more difficult to work with or transport than ordinarily, and demand a larger workforce, such that they exceed the needs of their sponsors or users.

Practices of conspicuous consumption have traditionally been associated with the social performance of consumption or, to put it better, the wasteful spending, of goods and services to create the impression of one's higher standing.[144] Such practices have long since been identified in the rich funerary assemblages of the shaft graves at Mycenae and have been considered as the method *par excellence* for rising elites to establish and demonstrate their higher standing and political power.[145]

142 See Rapoport 1982, 55-120, 177-195.
143 Moore 1986.
144 See Veblen 1899; Mauss 1967.
145 Voutsaki 1995; Voutsaki 2001.

When exploring the relationship between architecture and the production of society, thermodynamic approaches have emphasized size and quality of construction as triggers for past and present people to invoke the 'cost' of investment and make assumptions for the economic and socio-political status or 'power' of the sponsors of various monumental constructions.[146]

A challenge, however, to the premise that *conspicuous consumption equals power* lies in the difference between reality, intended meanings, and actually conceived meanings.[147] Architectural conspicuous consumption and monumentality need not always be 'read' or accepted as legitimate indicators of power and social potency.[148] One needs to acknowledge, further, that there is scarcely only one way to 'read' a structure and the meanings embedded in it. Each society or individual has its own way of experiencing and understanding the world, which is related to one's habitus[149] or to the conditions under which different people interact with the built environment.[150] Thus, there is always the question to be explored of *who* directs messages through architecture to *whom,* and how reliable these messages are for past people and present researchers to make inferences on the social identities and order that are being projected.

Successful communication through architecture is not guaranteed simply through architectural form; it relies also on the manner through which people experience, perceive and understand the built environment.[151] To date, there is significant ethnographic and anthropological scholarship building on how architecture maps and reproduces social relations through control of space use and movement.[152] Several archaeological studies, moreover, have systematically explored the importance of vision and sight lines.[153] Vision, however, is only one of the human senses that are actually important in the perception of the environment. Other senses, namely, hearing, smell, touch, and kinesthesis are equally involved as people move through the landscape – between or inside structures – and interact with other people and spaces. It is at this level of perception that *architectural design* plays a significant role in making meanings more concrete and in directing specific sets of meanings to selective audiences.

Architectural design refers to the way spaces are arranged, pathways and gates are constructed, and materials are used. Of interest to the present study is the ability of architectural design to dramaturgically stage a 'performer-spectator interaction', to stage how people move about in space (mode of walking, speed), to activate and guide people's senses towards particular images, sounds, smells, textures, to control and manipulate people's emotions and how the latter are projected towards others.[154] Architectural features such as staircases and gates are especially well-adapted to creating a dramatic effect in their capacity to control visual and physical accessibility within a succession of spaces, and alternatingly creating and relieving tension and concepts pertaining to peo-

146 Trigger 1990, 122-124.
147 Osborne 2014, 7.
148 See Colloredo-Mansfeld 1994; Wolpert 2004; Trigg 2001, 104-106.
149 See Bourdieu 1977.
150 See Halbwachs 1967; Connerton 1989; Pauketat 2007; Fisher 2009.
151 See Colloredo-Mansfeld 1994, 849; Lefebvre 1991, 221-224.
152 See Cunningham 1972; Bourdieu 1977; Bourdieu 1989; Rapoport 1982; Moore 1986; Hodder 1990.
153 See Bradley 1993; Bradley 1998; Bradley 2000; Tilley 1994; Tilley 1996.
154 See Goffman 1959.

ple's self- and group-identities.[155] Consequently, an exploration of the experience of the built environment could allow scholars today to speculate on how people understood and perceived architectural structures and how, through their interaction with the built environment, they perceived their own identities and place in the world.

3.3 A brief history of the period

The end of the Middle Bronze Age (hereafter MBA, c. 2000-1600 B.C.E.) in the Argolid marks the beginning of a long period of social transformations that culminated in the formation and legitimation of a rigid multi-tier social hierarchy with the *wanax*, the king (Linear B *wa-na-ka*, cf. ἄναξ), at its head.[156] Inherent to this social transformation was a profound change in the worldviews and established social rules that had, gradually and implicitly, started to form at significantly earlier times than that. During the MBA, funerary evidence suggests that people's personal identities were grounded on their group identity.[157] Individual tombs placed in groups in close proximity to contemporary houses (Asine, Lerna),[158] presumably their own, seem to indicate the importance of belonging to a wider group and its hearth. The appearance, already in the MBA II, of a restricted number of tumuli burials, however, seems to indicate the attempts of small groups of people to differentiate themselves from the rest of their community (Asine and Argos in the Argolid).[159] The claim for their differentiation was evidenced by a multitude of grounds relative to their funerary practices: (1) the tumuli were destined for burial of only a limited number of dead; (2) they lay away from their hearths and communal space; (3) burials were placed below a low earthen mound that demanded investment from the deceased's descendants to construct and maintain; and (4) they demanded a more costly funerary protocol that must have involved the organization of a funerary procession to carry over the dead from their home to the burial ground. The performative qualities of the funerary procession, the funeral itself, and the peri-funeral rituals would have made opportune occasions for group display and socio-political status negotiations.[160]

Towards the end of the period, however, the items placed within the graves to accompany the dead increased not only in number or variety, but also in 'wealth'. Even though 'wealth' is a notion difficult to define in the context of past societies for which there are no written documents, it appears that by that time, choices in raw materials, decoration, and their provenance started to play a powerful role in establishing and displaying one's personal achievements in war, in hunting, in securing access to overseas exchange networks and to prestige objects.[161] Since only a few seem to probably have had such access to exchange networks and ownership of prestige goods, it became apparent to Aegean scholars that the placement of these objects inside the graves (and, in reality, their withdrawal from circulation) was an act of *conspicuous consumption*, a

155 Janson and Tigges 2014, 96-97.
156 Shelmerdine 2011; Shelmerdine and Bennet 2008.
157 Voutsaki 2010.
158 Nordquist 1987; Milka 2006; Milka 2010.
159 See Voutsaki *et al.* 2011; Philippa-Touchais 2010.
160 Efkleidou forthcoming.
161 Voutsaki 2012.

'waste' of labour investment and objects, that could only have taken place with the aim to impress the rest of the community with their 'wealth'.[162] At the same time the architectural design of the graves changed. Voutsaki has argued that the design of the new graves was adapted to the wish of this small group of people to change the mortuary rituals, to adopt graves for multiple burials taking place over a long period of use.[163] It is my contention that the adaptation of the architectural design was further conceived to accommodate for the new values that the emerging elites wanted to establish: room for individual wealth display, without casting aside the importance of group membership or the establishment and confirmation of a long line of descent, and the protection and legitimation that would have come from the ancestors.

The wealth placed inside the shaft graves at the two grave circles of Mycenae marks a time when a shift towards placing importance onto personal achievements along with group membership started to increase. This increased investment in the wealth placed inside the graves, as well as in the size and construction of the graves, has since formed the basis of our reconstructions of the social antagonisms that led to the formation of the rigid hierarchical order that is now known to have characterized Mycenaean palatial societies.

3.4 Architectural conspicuous consumption in the Mycenaean world

Practices of architectural conspicuous consumption are quite easy to identify in Mycenaean architecture. At least two sets of architectural remains will be discussed here, but the agents, the meanings and the audiences involved should not necessarily be considered the same for both.

The first set of remains involves the burial remains of the end of the MBA until the end of the LBA II period (c. 1700-1400 B.C.E.), when the introduction of two new types of burial receptacles takes place in the Argolid, namely, the shaft grave and the tholos tomb. Until that time individual burials took place inside pit, cist, or pithos graves.[164] The graves were generally small (on average not larger than 2 m^3)[165] and their construction would have been possible on local resources and with use of familial or extended kin labour or with work parties whose labour could have been recruited from friends and neighbours through reciprocal participation in various work efforts.[166]

Even though it would have been some investment for the descendants of the deceased to procure the raw materials as well as to feed the necessary work force, the investment would have been significantly smaller than that needed for the new LBA types of the shaft grave or the tholos tomb. The shaft grave was designed with a deep and wide shaft dug into the earth, at the bottom of which the burial chamber was constructed with built stone walls and a roof of wooden planks. The tholos tomb was

162 Wright 1987, 173-179; Wright 1995, 69-71; Wright 2006a, 11-13, 16-18; Voutsaki 1995; Voutsaki 1998, 45-46; Voutsaki 1999; Voutsaki 2012.
163 Voutsaki 1998, 45; Voutsaki 2012, 166, 170.
164 Cavanagh and Mee 1998, 23-40.
165 Fitzsimons 2011, 80.
166 See Colloredo-Mansfeld 1994.

designed as a subterranean construction with a dromos corridor leading into a circular stone-built burial chamber through a *stomion* entrance.[167]

Their sturdy construction, designed for use over a long period of time and for multiple generations, their prominence and their ubiquity in the settlements made them monumental compared to what would have been the norm until then. Several studies[168] of architectural energetics have successfully demonstrated the geometrically increasing work-force, period of time, and cost necessary to complete these building projects. Elements of conspicuous consumption should also be recognized in the gradually increasing use of symbolically charged raw materials, such as the use of conglomerate stone, and demanding types of masonry, such as ashlar masonry, or the internal and/or external decoration of the tombs' facades with colourful wall-paintings.[169]

What made it more 'wasteful', however, was the fact that these structures were designed from the beginning to remain hidden from view after the finalization of their construction and after each burial episode.[170] This practice, put in context reminds us that people tend to forget the size of an investment and lose interest with familiarity. Keeping these types of tombs underground and hidden for long time was what probably kept the memory of the initial investment intact. The practice, moreover, of periodically re-opening them for short periods of time probably helped in keeping the memory strong even with those people who had not initially witnessed the construction themselves.

One cannot deny the economic and probably socio-political investment behind these monumental structures. The recruitment of the necessary work-force and perhaps skilled technicians must have demanded negotiations and the promise of some *quid pro quo*. Furthermore, the consecutive adoption and limited use of the two tomb types within a relatively long period of 300 years and the increasing level of construction size and difficulty in the quality of decoration and in resources investment is likely associated with competitive social practices among a small number of social groups that had acquired the financial means but not the desired social rank. By the end of the LBA II period, the conspicuous consumption evident in the architecture and the grave goods of the tombs of the newly-formed elite was emulated by a continuously increasing part of the community at Mycenae, in the use of the chamber tomb. Along with the new types of tomb and the new forms of wealth display, the funerary rituals, and attitudes towards the manipulation of the dead were transformed in such a way as to highlight the importance of group identity and ancestry in strong association with personal achievements and wealth. This wealth, however, was not only measured in the amount of prestige goods one possessed, but, also, in its association with the group's ancestors and line of descent through deposition in ancestral tombs. This novel mode of social status appraisal revised the previous MBA mode of establishing status through group affiliation and ascription and became the dominant mode for confirming the rank of any person in the community.[171] This process, however, took place over a long

167 Pelon 1976.

168 Wright 1987; Cavanagh and Mee 1999; Fitzsimons 2006; Fitzsimons 2007; Fitzsimons 2011; Fitzsimons 2014.

169 Wright 1987; Cavanagh and Mee 1999.

170 Laffineur 2007.

171 See Veblen 1899, 84-85.

period of time necessary as one cannot immediately equate the manifestations of architectural conspicuous consumption with a self-evident expression of power.

Architectural conspicuous consumption is further manifested in the monumental building programmes of the Mycenaean period at Tiryns, Mycenae and Midea involving the construction of the palaces and the cyclopean fortifications of the respective *Acropoleis* dating to the 14th and the 13th century B.C.E. The cyclopean fortifications were monumental in their conception and construction planning, in size (megalithic), in masonry (un-plastered cyclopean blocks), in resources (procurement of raw materials and recruitment of labour force among whom a number of specialized masons) and, as such, in actual economic investment.[172] The fact that the size of these fortifications was exceedingly large, probably beyond the demands for warfare at that time, makes them certainly a by-product of conspicuous consumption.

The monumentality of cyclopean fortifications has traditionally been interpreted as communicating the power – political and economic – of the elite and the wanax. Excessive consumption, however, does not automatically entail social status and respect, especially when there are conflicting attitudes towards appropriate display of wealth.[173] This is especially problematic in the case of the fortifications at Mycenae and Tiryns. As Maran[174] has pointedly remarked, earlier MBA communities, were not accustomed to living in settlements bounded by any type of fortification. What is more, the fortifications at Mycenae and Tiryns were not designed to protect the entire community, since the lower towns outside the *Acropoleis* always remained unprotected, and space in their interior was too limited to support a function as places of refuge in case of war.[175] Instead, they were designed to divide; divide the urban space as well as the community. Moreover, this novel spatial and symbolic division was extremely loudly expressed with the monumental dimensions of the fortifications. As such, one would expect this building programme to cause reaction and distrust from the rest of the community.

This did not happen, however, as is evident by the fact that soon after the first fortification construction, another program was initiated at Mycenae and at Tiryns, in the middle of the 13th century B.C.E., to expand and make the fortifications even larger and more impressive. One could conjecture that these building programmes would have involved personally all members of the respective communities either through actual participation in the construction or through witnessing their raising.[176] Thus, it is alternatively possible that they stood as memorials not only of the power of the elite, but also of the consensus and participation of the community to the newly formed so-

172 Fitzsimons 2006, 297-302; Fitzsimons 2007, 111-114.

173 Colloredo-Mansfeld 1994, 861-862.

174 Maran 2006b, 79.

175 Even though there are advocates of the function of the Acropoleis' fortifications as defensive works or places of refuge in case of war (see Iakovidis 1983; Dickinson 2006, 36; Maran 2010, 248; Hitchcock 2010), most scholars tend to stress the strength of Mycenaean cyclopean fortifications as monuments of power and prestige (see Loader 1998, 30; Dickinson 2006, 40; Schofield 2007, 78-79; Maran 2006b, 79; Hitchcock 2010, 206-208; Wright 2006b, 59; Mee 2011, 204).

176 See Santillo Frizell 1998, 174-183; Santillo Frizell 1997-1998, 103-116; Santillo Frizell 2003, 15-30; see also Brysbaert 2013, 86, where she estimates that the actual number of persons involved in the Mycenaean monumental building *chaîne opératoire* would not have been as large as hypothetized until recently by scholars, while the performative aspects of the building activities would have led to the materialization of the mythological stories that are to-date evoked in the wider public's imagination of Cyclopean giants as their builders.

cial order,[177] which was more divided and more individualistic as opposed to the earlier kin-based and group-oriented social organization of the MBA. It is possible, thus, that these monuments were as much memorials of communal cohesion as physical manifestations of the elite's power, and that they were aimed to strategically project outwards the power of a novel idea, that is, the idea of a unified and powerful homeland.[178]

The architectural design of the similar building programmes at Tiryns and Mycenae might have aimed to the regular reproduction and verification of the sociopolitical order through accentuating the importance of specific events and of the differential rights of the members of various sociopolitical ranks to participate in them.

3.5 Architectural design in the Mycenaean world

In 2006, Maran[179] insightfully described the architectural design of the acropolis at Tiryns and, in particular, of the route towards the megaron as *performative space*. With this notion he referred to those features of the architectural design of the Upper Acropolis of Tiryns that aimed at creating a performer-spectator interaction during special events, such as processions – a 'central category of ritual practice' in Mycenaean times.[180] According to him,[181] the design of the fortifications and the interior space of the acropolis were designed, firstly, to keep the interior organization and form of the structures inside unrecognizable from the exterior. Secondly, it created an arc of tension with the circuitous design of the road leading to the central megaron, which kept the end of it and the seat of wanax hidden from view until one would reach the very last part of the route. This design would also use the placement of gates and monumental *propylaia* to control visual and physical accessibility between various spaces along the route, and alternate emotional tension and relaxation leading towards a climax upon reaching the end-goal. Finally it placed symbolically-charged raw materials[182] and decorative elements at liminal places (i.e., use of conglomerate stone at thresholds)[183] to mark the physical and symbolic passage from one space to the next and make references to the power of the wanax of Tiryns and his association to the kingdom of Mycenae.[184] These are all features of architecture that create a dramaturgical effect and aim to emotionally heighten the experience of approaching the megaron and symbolically raise the centre of power, the wanax. Viewed from a parallel vantage, the gates and *propylaia* of Tiryns stood as points of access control. This would mean that the system of open courts along the route towards the megaron would accommodate those who did not have the right to proceed past each control point further in towards the actual megaron. The size of these courts indicates that they could hold large numbers of spectators for the ritual processions that would have taken place: the first court could

177 Fitzsimons 2011, 109; Wolpert 2004; Brysbaert 2013; Brysbaert 2015; Brysbaert 2016.
178 Santillo Frizell 1997-1998, 103-116; Brysbaert 2013, 79; Brysbaert 2016.
179 Maran 2006b.
180 Maran 2006b, 78.
181 Maran 2006b, 78-85.
182 On the symbolic value of conglomerate see Wright 1987, 174-183; see also Brysbaert 2013, 51; Brysbaert 2015, 78 for a systematic evaluation of the geological properties and symbolic value of conglomerates and other stones used in the palatial architecture of Mycenaean Tiryns.
183 Müller 1930, 167-168, 193-195, figure 175; Maran 2006b, 82.
184 Brysbaert 2015, 83-87.

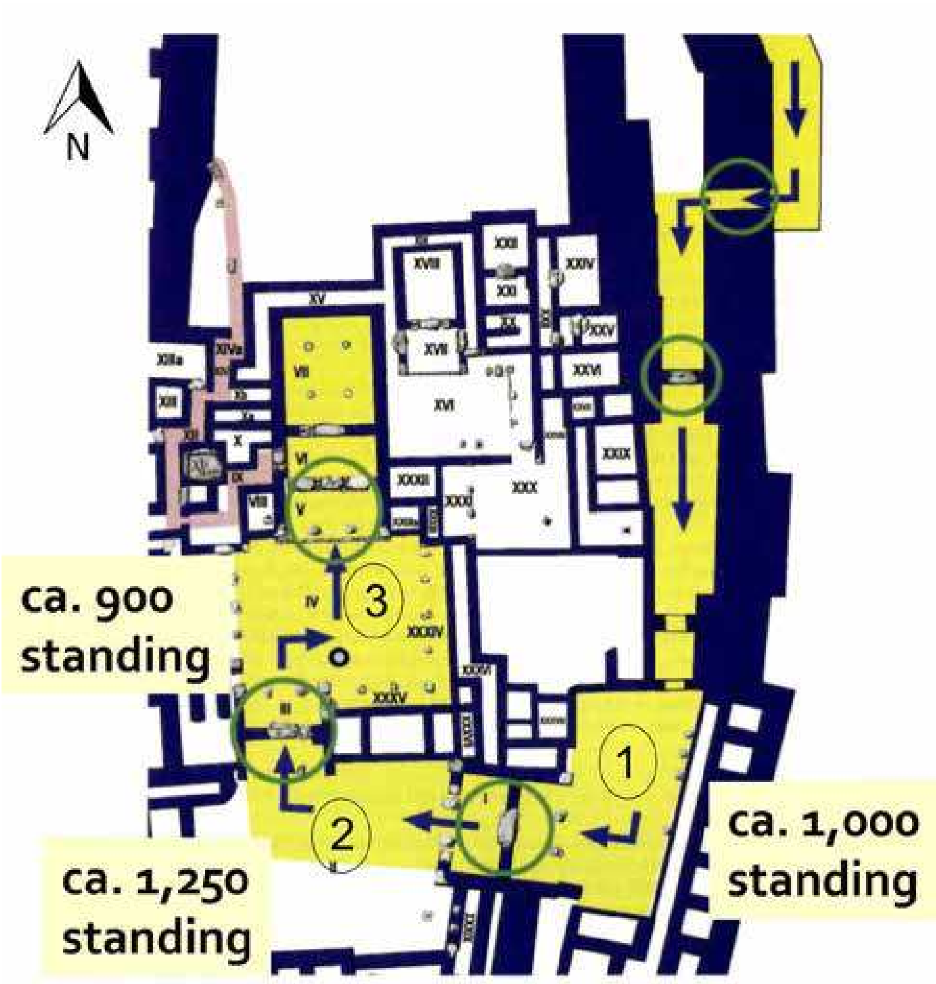

Figure 3.1: Architectural design and courts' capacity in Tiryns (c. 1250-1200 B.C.E.) (Plan adapted by the author from Maran 2006, pl. 13).

accommodate c. 1,000 persons, the second 1,250 and the third 900.[185] At the same time, they physically and symbolically reproduced basic social hierarchical divisions as each court progressively accommodated those members of the community who had higher ranks and rights of access to the wanax[186] (Figure 3.1). It always impressed me how divisional this succession of spaces must have been for the stability of the community, especially when its impact is examined not only in the context of periodical ritual performances, but also within the everyday function of the palaces. My assumption is that the large size of these courts as well as their open-air design counteracted, at least during ritual events, this divisional character, by uniting the population through the shared perceptual experience of the ritual events that was based on vision, audition,

185 Efkleidou 2017, 222-223. See also Maran 2006b, 80.

186 It is also interesting that the size of the three courts, following this interpretation of their succession, does not fit or support a pyramidal reconstruction of the social hierarchy of the community at Tiryns.

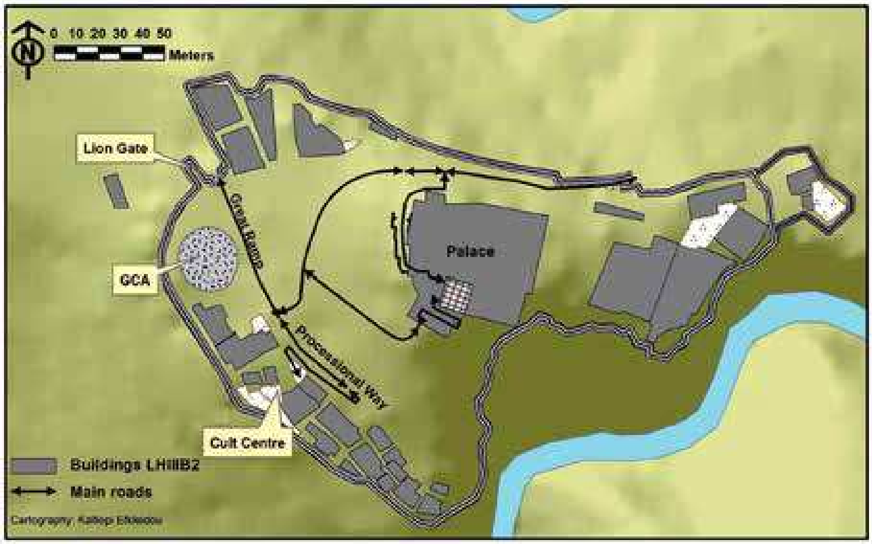

Figure 3.2: Map of the Acropolis at Mycenae with its internal road network (c. 1250-1200 B.C.E.). Map by K. Efkleidou.

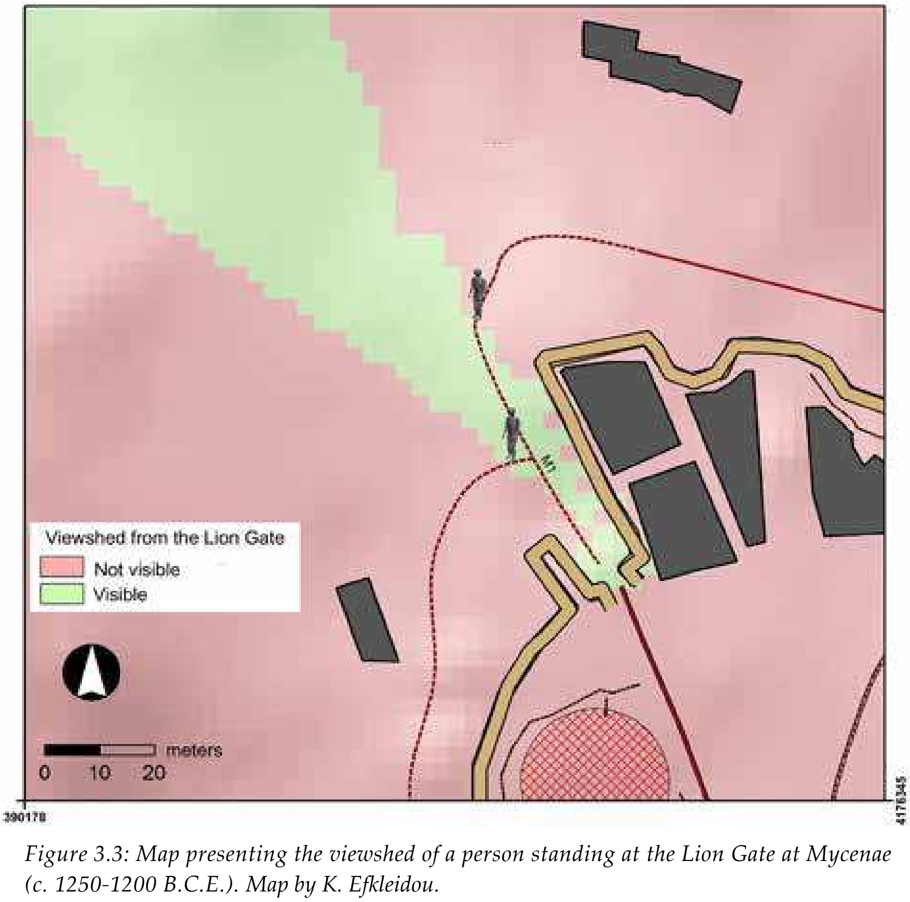

Figure 3.3: Map presenting the viewshed of a person standing at the Lion Gate at Mycenae (c. 1250-1200 B.C.E.). Map by K. Efkleidou.

and olfaction. That is, they would all be united in watching the same procession, hear the chanting and probably smell the sacrifices that would have taken place at the last court in front of the megaron.[187]

The same elements of architectural design are also found at Mycenae, especially in the design of the Lion Gate, in the zigzags that lengthened the route towards the megaron, as well as by the uphill inclination, which added physical strain likely causing a conceptual misjudgement of the real length[188] (Figure 3.2). The design of the Lion Gate,[189] in particular, is especially instructive on its power to manipulate one's perception of it. Even though all the roads at Mycenae seem to lead to the Lion Gate, the anticipation of entering the acropolis of Mycenae was raised by keeping the gate hidden from view, until one made the final turn some 20-50 m before reaching the gate, depending on the direction of one's approach (Figure 3.3). From the point on the road when the Lion Gate became visible, a mild inclination followed and led to the gate which stood slightly elevated. The passage was flanked by the fortification walls, which kept it shaded during almost the entire day, and charged those approaching with a sense of entering a trap. The mild inclination of the road, the elevated position of the gate and, most of all, of the Lion Gate relief magnetized people to move with their heads facing upwards, enforcing thus on them both a sense of awe as well as of physical and symbolic self-elevation and validation. Crossing through the gate, with its narrower width relative to the passage leading towards it and into the acropolis would then culminate the tension and function as a liminal point for the reproduction of differential social ranks and for rights invocation, status verification and negotiation.

While, at Tiryns, the spatial configuration of the Acropolis is centred on the megaron of the wanax, at Mycenae the road beyond the main entrance, the Lion Gate, forks with one branch leading uphill to the megaron and a second, equally important as evidenced in its design, leading gradually downhill to the Cult Centre. The group of buildings comprising the Cult Centre were initially built on the west slope of the acropolis hill, on top of the Middle Helladic cemetery and outside the first fortifications dating to the end of the 14th century B.C.E. Their incorporation into the acropolis took place with the expansion of the fortification around the middle of the 13th century B.C.E.[190] As a result, access to the rituals that took place at the Cult Centre fell under the control of the palace and became increasingly restricted during the last 50 years (c. 1250-1200 B.C.E.) before the destruction of the citadel. The design of the access system leading to the Cult Centre suggests also that admission to it became vested with specific meanings which connected the power of the wanax with the divine and with its priesthood (Figure 3.4).

A downhill passage from the Lion Gate towards the buildings of the west slope ended in a staircase of 14 steps leading to a corridor on a lower terrace whose direction changed by 180°.[191] The width of the staircase (1.75 m) and the corridor after (1.90 m) suggests that people could move through them best in processional formation. The initial part of the corridor (i.e., the first 10 m)

187 Kilian 1981, 49-50; Kilian 1988, 148; Kilian 1990a, 193; Hägg 1990, 181; Wright 1994, 54-60.
188 Tenhundfeld and Witt 2017.
189 Iakovidis 1983, 30-31.
190 Wardle 2003; Wardle 2015.
191 Detailed description of the physical remains in Mylonas 1972, 18-24.

formed a vestibule, of which the final part would have been roofed. This vestibule ended in a gate closed off with a wooden double door which stood on a threshold of conglomerate stone, the distinctive material symbolizing the power of the wanax at Mycenae.[192]

Following van Gennep[193] and Turner,[194] I see this gate as a limen, a spatial threshold or transitional space, the design of which played a crucial role in preparing and transforming those who were about, or rather held the right, to attend the ritual events taking place at the Cult Centre. While people waited to cross it, they would have to stand inside the shaded roofed area of the *vestibule*. Its walls were decorated with frescoes depicting a figural scene in small scale of a chariot and two male figures, one in front and one at the back.[195] Once the doors opened, a symbolically charged interplay between darkness and light would then take place heightening the feeling of crossing over from the profane into the sacred domain. Crossing this gate became then a re-affirmation of one's social and political standing and of one's right to participate in the rituals and to commune with the divine.

The small size of the buildings of the Cult Centre has already been considered as evidence of only a small number of persons able or allowed to stand inside them.[196] For this reason, it has been suggested that public ritual ceremonies would have taken place in the open courts instead.[197] The size of the courts, nevertheless, is not impressively larger. The capacity of the court in front of the Tsountas House Shrine would not exceed 100[198] standing persons, while communication with the larger court (capacity of maximum 358 persons) in front of the Temple and the Room with the Fresco at the lower terrace would probably have been impractical, at least during ritual performances, due to the small width of the steps leading to it.[199] One realizes, therefore, that accessibility to the Cult Centre became significantly restricted after its incorporation into the acropolis. Furthermore, the connection of the processional road leading to the Cult Centre with the road leading to the megaron emphasized its direct association with the wanax and participation to rituals with those holding the highest ranks of the sociopolitical hierarchy of Mycenae.[200]

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192 Wright 1987, 174-183; Maran 2006b, 82.
193 van Gennep 1960.
194 Turner 1967.
195 Mylonas 1972, 22-24; Kritseli-Providi 1982, 90-92.
196 Whittaker 1997, 144; Aamont 2008, 34.
197 Aamont 2008, 34.
198 According to Hatzaki 2009, 27, fn 52, an estimate of 1 m^2/person is 'generous'. Instead, I have used a comfortable measurement of 0.55 m^2.
199 French and Taylour 2007.
200 Efkleidou forthcoming vs. Albers 2004, 126, where she argues that the Cult Centre of Mycenae functioned as 'not only the central area of public communal cult in the context of that settlement itself, but the cultic centre of the entire region of the Argolid'.

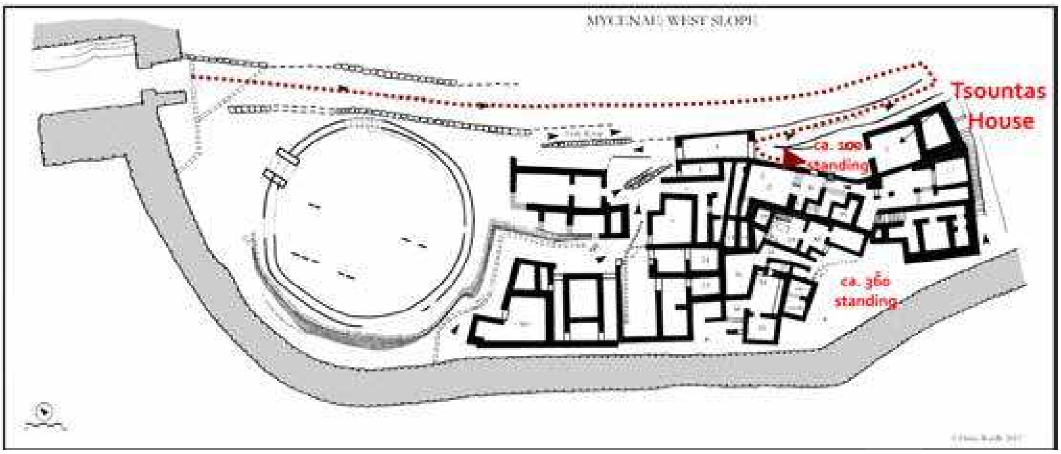

Figure 3.4: Plan of the area of the west slope and the cult centre at the Acropolis at Mycenae (c. 1250-1200 B.C.E.) (Plan adapted by the author from Wardle 2015, 587, fig. 7).

3.6 Conclusion

From the case studies presented, it appears that Mycenaean communities had realized early on the effectiveness of using architecture and its perception to their socio-political or economic benefit. This is particularly clear in the early, MBA and early LBA, cases of small groups aiming to differentiate themselves and claim higher and more powerful status. These groups used architecture strategically in such ways as to challenge the existing social order and introduce novel social values, while in later periods (LBA III) they used architecture to reproduce and constantly re-affirm the social order that they had over time definitively worked to construct.

Even though architectural conspicuous consumption was connected to great investment, measured not only in economic expenditure, but also in socio-political investment, it cannot be universally interpreted solely as a means of demonstrating high social ranking or of establishing power. Practices of wasteful spending should be examined within their historical and social context and against concurrent notions of wealth and means for establishing status.

Practices of conspicuous consumption in the early LBA in the Argolid, especially at Mycenae, have been generally treated as a sudden explosion of wealth wasting. Sudden explosion, however, suggests that these practices would have lacked interpretative basis and legitimization and, hence, their message would have been challenged. If conspicuous consumption is examined, however, against its historical sociopolitical background, it should rather be considered as only a stage within a very long sequence of competitive social practices aimed to differentiate small parts of the population from their respective communities by establishing a novel basis for social ordering and ranking. This differentiation that started already from the MBA II period (c. 1900 B.C.E.) continued though the LBA IIIA period (lasting c. 600 years). Only with the gradual transformation of the fundamental social values of the communities, did architectural conspicuous consumption (expressed by then in the construction and use of a handful of tholos tombs) become a legitimate mode of establishing and displaying high social status. A similar challenge to the doctrine 'architectural conspicuous consumption equals power' could guide our interpretations of the monumental cyclopean wall-construction.

Other methods of using architecture, such as architectural design, likely had a more direct impact on both the message that was being conveyed, by making it more concrete and clear, and on the targeted audience, by rigorously controlling and guiding the perceptual experience of architecture. The ranking of spatial domains, the control of physical and perceptual access, the staging of movement, the controlling of types and levels of participation and, ultimately, of feelings that users developed during important events, constitute features of Mycenaean palatial architectural design that were used to invoke and establish the different sociopolitical tiers and people's place in the world order. Thus, the impact of architecture on societies appears to have been important in shaping social values, identities and in establishing or challenging social structures.

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4

Outer worlds inside

Lesley McFadyen

4.1 Introduction

Archaeological accounts of monuments often note that architecture physically endures in the landscape after it has been constructed, and of how perceptions of monumentality do not remain constant alongside the materially durable form (both in substance and shape) of the monument (*e.g.* Stonehenge[201] and Tiryns[202]). This chapter asks archaeologists to consider monuments in which the building materials involved in construction are durable (substance), but the form of the monument is unstable and changes (shape).[203] Rather than accounting for a stable monument in a changing world, we could enquire after an unstable monument and the associated people and underlying processes that generate something mutable? The focus of this chapter is the earthen long barrows (sometimes called long mounds) of the Early Neolithic in southern Britain, in this case north Wiltshire and Dorset. It argues that building materials (substance) shift through time; that architectural form (shape) is immanent in unfolding practices, not given or transcendent (*i.e.* there is no formal design approach or a priori knowledge of an end result); that the materials themselves allow for specific kinds of shape shifting; and that often form follows from materials rather than vice versa. This is a study of an architecture, a monument, that you cannot get back into, how it emerges through the process of construction, and the effects of that practice on those that participate in building work.

Barrows are most often considered as examples of stable, almost inert, monuments in substance and shape. Today, as I start to write this chapter, the landscape writer Robert Macfarlane has used 'barrow' as his 'word of the day' on his Twitter feed.[204] He tweeted, 'Barrow – burial site/chamber covered with a mound of earth'. The

201 Barrett 1994.

202 Brysbaert 2015.

203 Brysbaert also mentions movement in buildings and monuments that are not motionless objects: Brysbaert 2016, 18.

204 Macfarlane is conducting a project on the language of landscape, so the term 'barrow' appears alongside phrases for 'the shadow from clouds on moorland', things that are of the landscape and to do with nature writing.

In: Brysbaert, A., V. Klinkenberg, A. Gutiérrez Garcia-M. & I. Vikatou (eds) 2018. *Constructing monuments, perceiving monumentality and the economics of building: Theoretical and methodological approaches to the built environment*. Leiden: Sidestone Press, pp. 87-102.

intersection between burial and architecture and earth and landscape could be dynamic in landscape and archaeological writing, but for some reason it is not. For example, the earth material is described as a mound of earth and so material and form are equivalent: the function of the barrow is to cover something else and so its form is not autonomous. It is as if the barrow is more a part of the landscape than of architecture. This is even more interesting when you consider that there are just as many earthen long barrows that are unchambered and without burials, as there are with a burial site/chamber.[205] So why is barrow monumentality defined by commemoration?

4.2 A short comparative history of barrows and monuments

I want to go back a little in time and consider the history of ideas on long barrows and monuments. I will start my account in the 17th century with the antiquarian John Aubrey. The archaeologist Stuart Piggott argued that a transformation occurred in the history of the representation of monuments when it became necessary to visit architecture in order to be able to visualise its character. He wrote, a 'direct pictorial representation (produced in)…a world in which topographical and landscape draughtsmanship was becoming increasingly commonplace, and into a mood of scientific sophistication in which a structure could be viewed not from the obvious eye-height level, but in the form of an artificial projection from an assumed vantage-point, the better to show detail'.[206]

There were no disciplinary distinctions between archaeology and architecture at this time,[207] and images of monuments were drawn from a topographical and landscape point of view. John Aubrey compiled a work called 'Monumenta Britannica', and a main focus of this work was the prehistoric monument. He writes of barrows as 'loads of earth',[208] very similar to the landscape writer Robert Macfarlane's 'mound of earth', and one might think that a topographical hand in the landscape might draw a monument that is even more a part of the landscape than of architecture. However, his images of barrows are dynamic and architectural. The extant barrow architecture seems to defy the laws of gravity. His drawing of Millbarrow, Wiltshire[209] (Figure 4.1) is like a water balloon full to bursting, it is a bulging form held in the air without flopping over. It is these areas of full form, that stand up and away from the ground, that are shaded and striped: striped with lines that curve around, in and under 'loads of earth'.[210] The emphasis is on the artificiality, the physical 'making', the human-made, of the monument – this barrow architecture is lively. The form (shape) of the barrow is dynamic.

It is easy to establish that techniques of topographical perspective were employed by Aubrey in producing his pen and ink drawings,[211] either from view points that are full-on from the side, or slightly raised from above and on the side. These images are also about mapping the sheer quantity of an external surface in order to take in the length

205 Ashbee *et al.* 1979.
206 Piggott 1978, 8-9.
207 Hill 2012.
208 Aubrey 1980, 83.
209 Aubrey 1980, 803.
210 Aubrey 1980, 83.
211 Piggott 1978.

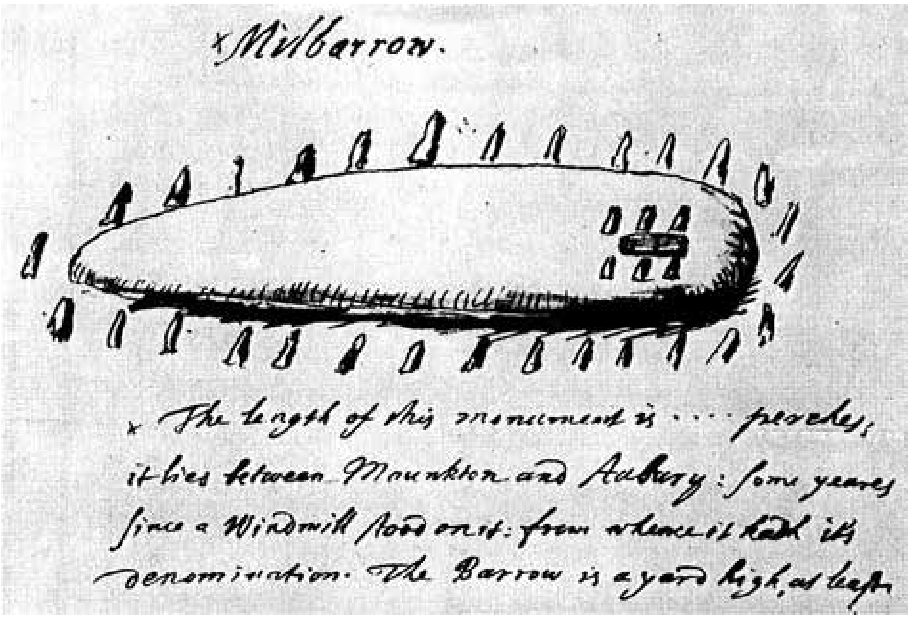

Figure 4.1: Milbarrow, Wiltshire drawn by John Aubrey (detail from Aubrey 1980, 803).

and scale of the barrow as an external surface, allowing him to show that monuments are about size as well as burial. In the 19th century, Richard Colt Hoare and William Cunnington excavated many of the most important long barrows in south-central England. The findings were published in 'The Ancient History of Wiltshire' (1812 and 1819). I find this work to be frustrating reading, for although Colt Hoare excavated so much; there is no detail on the complexity of the barrow architecture. He wrote: 'These indicia attest the high antiquity of the long barrows; and though we clearly perceive a singularity of outline in the construction of them, as well as a singularity in the mode of burial, we must confess ourselves at a loss to determine, or even to conjecture, for what particular purpose these immense mounds were originally raised'.[212]

This 'singularity of outline', a clear physical form (shape), is embedded in many areas of the image that Colt Hoare produced in his published work to portray a long barrow (Figure 4.2). The length of the barrow is conveyed in this image in a full-on side perspective. The length of the barrow is located in the centre of the image and stretches across both edges of the frame. It is held between, or holds, the grass and the sky. The cloud cover gently mimics the undulations of the barrow outline, as does the light that reflects off the outer edge of the flanking ditch. The differentiation between areas of earth and earthwork are subtle. For example, there are no coarse specimens of grass growing on the barrow as there are on the earth nearest to the viewer. Techniques of darker or concentrated shading are employed along the base of the extant mound in the areas where it is in contact with the earth (some of this was artistic convention of the time in order to convey relative spatial distance). However, this leads to a tightness of effect in the mounds form (shape) that only hints at the barrows artificiality as a

212 Colt Hoare 1812, 21.

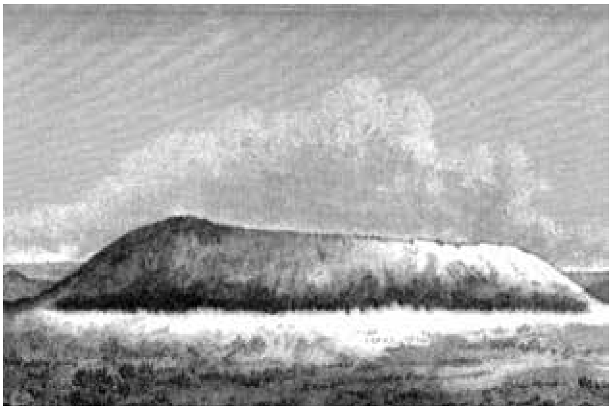

Figure 4.2: Long barrow drawn by Richard Colt Hoare (detail from Colt Hoare 1819, plate 1).

work of earth. This artificiality is not emphasised to dramatic effect as in the work of Aubrey. The long barrow is grassed over, downward sloping, slumping earthwards, more inert. The barrow is monumental through its external size, but it is now depicted more as landscape than as architecture. The architectural focus has shifted internally to the site of burial. Monuments are about size as well as about burial, but barrows have become (for Colt Hoare) no longer about both of these elements. The distinction, or dislocation from architecture, is important.

John Thurnam carried out an extensive excavation programme of barrows in Wiltshire during the late 19th century. In his publication,[213] he separated his research out into unchambered and chambered long barrows. He produced only one image of an 'unchambered long barrow' as a type of barrow, and it is the same image by Colt Hoare (Figure 4.2), but reduced, and sandwiched in a section of the text on 'External form'. Part of the text reads: 'The long barrows are for the most part immense mounds…'.[214] As Thurnam saw things, due to the inert materials of the mound, it is understood to simply cover the event of burial. The only event of import in architectural history is then that of burial and not that of barrow construction. The materials and building techniques that were a part of the barrow were, to Thurnam, disappointing. The only question that Thurnam asks of external form (shape) is whether or not barrows were actually created through geological processes. This line of argument is perhaps further evidence for a conceptualisation of these areas of construction on passive terms. The barrow is not understood as 'architecture' per se, and certainly not an architecture that past people engaged with in any complex way. The barrow is only one step away from a drumlin or drift of glacial deposits.

This legacy has continued to an extent, with barrows in scholarship being about external form (shape) and so monumental in their size, but treated more as a landscape formation that is then distinct from an internal architecture to do with burial. More than a century after Thurnam, Alasdair Whittle has written in plain terms of the barrow element of his excavations of Eastern Down long barrow, Wiltshire: 'The rest of the mound consisted of chalk above the inner, axial core, rising up to 1.6 m above the old ground surface. The chalk was generally finer and smaller in the lower parts, larger

213 Thurnam 1869.
214 Thurnam 1869, 172.

and blockier in the upper parts, with lenses and patches of fine grey chalk throughout. Tip lines are clearly visible in the sections and show *straightforward dumping* from the centre of the barrow outwards'.[215]

This is striking given that this text is informed by architectural rather than topographical draughtsmanship, the archaeological text accompanies an architectural section (Figure 4.5). The section is an architectural drawing convention that was created in order to show how the interior of a building is constructed, and yet for the barrow the section communicates details more akin to formation processes rather than those of building techniques.

4.3 Long barrows revisited

How can we get back to Aubrey and a barrow with a lively form (dynamic shape), and an understanding of the barrow as architecture? In my work, I argue that long barrows are better understood through the details of their making rather than as an explanation of form – architecture as practice, rather than architecture as object.[216] The main reason being that in the Neolithic long barrows were never seen as 'all at once' totalities (*i.e.* there was no formal design approach or a priori knowledge of an end result). There are three ways in which I do this. Firstly, I attempt to persuade fellow archaeologists that a more effective account of long barrows comes from an exploration of the range of materials that were involved in the process of construction. Secondly, that an understanding of building practice requires an examination of the ways in which materials were positioned in relation to each other. Finally, the kinds of participation between people, and between people and things, that are required by materials during the process of making.

I will start with the different kinds of material that are a part of a barrow, for they are not homogeneous accumulations of earth or chalk. Figure 4.3 is a plan of South Street, Wiltshire.[217] The site is located on a plateau, west of the northward bend of the River Kennet. It is on a geology of Middle Chalk, with overlying drift deposits of periglacial origin. The materials used in construction range from wooden posts, turfs, chalky soil, sarsen boulders, coombe rock (drift deposits), and chalk rubble. The building materials are local, from that spot, though most have to be quarried for. The quarried materials are natural materials (*i.e.* they are not a human-made mixture). Ashbee *et al.*[218] write that the materials that were used in construction were employed in the order in which they were encountered on quarrying, but I argue that the ways in which the materials were positioned in relation to each other were not that simple. For example, it is interesting that between the co-axial lines of wooden posts that are depicted by red circles, and after the stacks of turf depicted by dark concentrated shading and a black line, there is the blank white paper of the coombe rock that is given a black dashed-line edge, and the blank white paper of the chalk rubble that is picked out by black hachured lines (labelled as battered edge). Despite the straightness of the

215 Whittle *et al.* 1993, 200.
216 McFadyen 2007; McFadyen 2016.
217 See Ashbee *et al.* 1979.
218 Ashbee *et al.* 1979, 259.

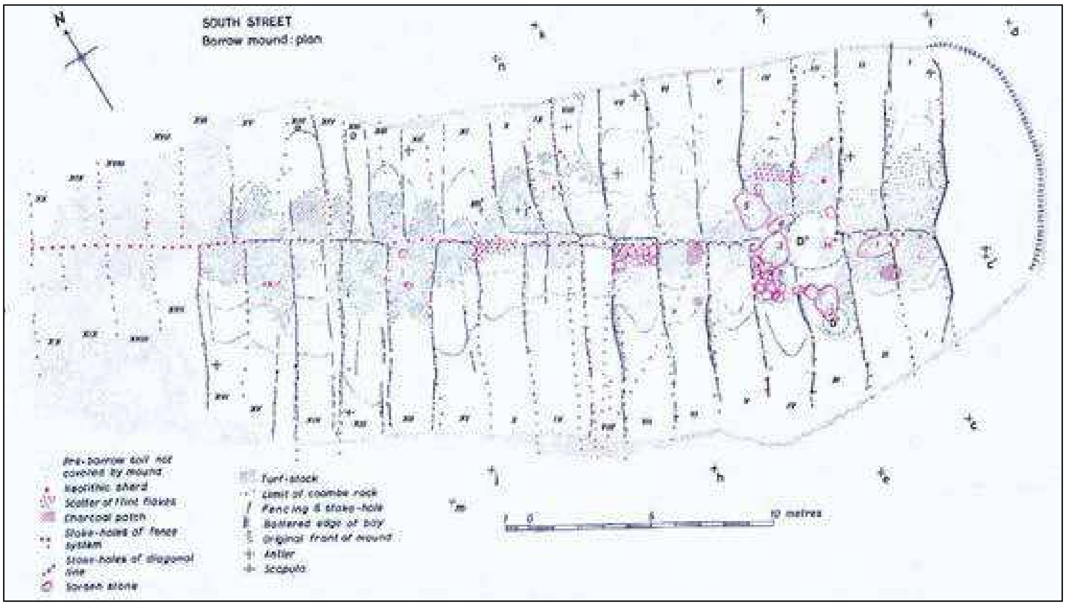

Figure 4.3: Plan of South Street, Wiltshire (detail from Ashbee et al. 1979, 256, figure 25).

vertical lines in red (wood), and the continuous horizontal lines in black (turf), there is an undulating and organic shape to the pale dashed-lines (coombe rock) and hachured lines (chalk rubble). Although under-represented in the archaeological drawing, the coombe rock and chalk rubble have a physical form (shape) that appears mutable.

4.3.1 Materials without stable form

Materials without stable form is a category of material that did not have a primary shape and that remained without a stable form, materials such as the chalk rubble and coombe rock. These materials hold a problematic position in archaeologists' architectural drawings, in that they are not drawn at all or other materials or drawing conventions are used to give them limits or form (shape) *i.e.* the hachured lines that are given to the chalk rubble in the plan of South Street. The chalk rubble is represented as a non-material in the architectural plan drawing, but what is the actual physical and material nature of this building material? Isn't chalk rubble dry and crumbly, how do you batter it down? Why is the most crumbly, shape-shifting, material the one that was used in the outer part of the build?[219]

Beckhampton Road long barrow is located on the valley floor in the same valley as South Street. It is situated in the Lower Chalk but on a drift deposit that had created a low ridge.[220] Once again, the materials are from this local environment: marl, chalk rubble, coombe rock (drift deposit), wooden posts, turfs, and occasional small sarsen boulders. The archaeologist Josh Pollard[221] has written that two cattle skulls, or hides

219 The so-called actual form of a complete barrow.
220 Ashbee *et al.* 1979, 228.
221 Pollard 1993.

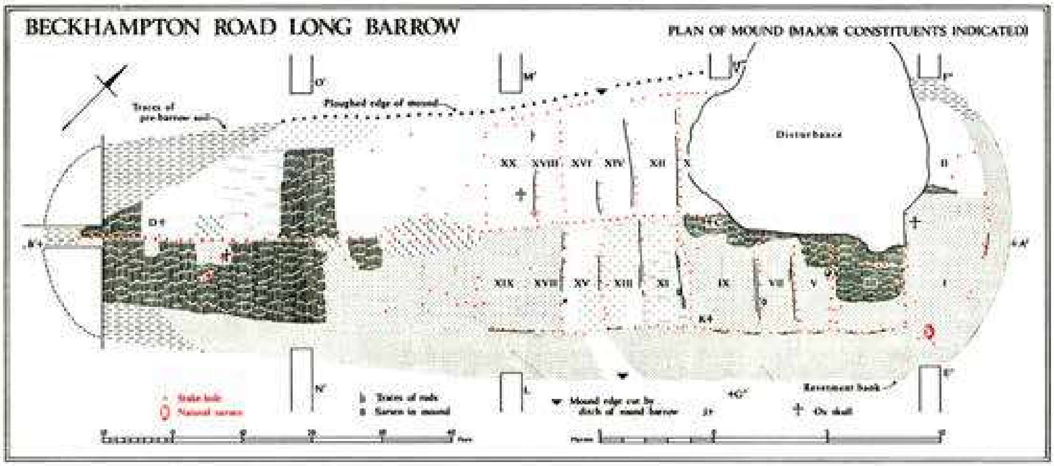

Figure 4.4: Plan of Beckhampton Road, Wiltshire (detail from Ashbee et al. 1979, 235, figure 14).

on posts, were used to mark out the axial divide of the barrow at Beckhampton Road, Wiltshire (marked X in Figure 4.4).[222]

He then went on to describe an axial divide defined by posts that was surrounded on either side by stacks of turf. However, if you look closely at the materials in the plan, and the way in which the materials are positioned, both cattle skulls (marked as an X on the plan) had been incorporated into areas of coombe rock and it was the coombe rock that was then enclosed by stacks of turf. Turf is a stable element within a build – turves were cut into small blocks and then laid flat in courses. Coombe rock has a more ambiguous form (shape). As a material, derived from a drift deposit on the chalk, it is composed of weathered chalky silt in a clay matrix, it was sticky and would initially have held together in the process of building. At Beckhampton Road it was not worked any further into shape but instead always used as it was. It was quarried and then dumped on top of and surrounding the hides on poles, and then stacks of turf were added.[223] The turf stacks did not so much hold the assemblage in place, as the coombe rock was a fairly adherent material, but instead the cut and stacked turves had a stable form (shape). The qualities of these different materials, and the dynamics that they were caught up in, only become problematic when we turn to the plan drawing as blocks of turf are used to give definition to an area of architecture in a way that the formless coombe rock cannot. The drawing transforms and misrepresents the qualities of materials. It is perhaps for this reason that turf is remarked on in the plan drawing of the long barrow whilst the coombe rock remains in the background as an inactive fill. However, one of the most important qualities of the coombe rock is its lack of stable form (shape) – it lends itself to other materials and it could be dumped quickly against the posts with the hides. On these terms, where practice rather than form is being considered, coombe rock is an active and responsive material whilst turf is inert and

222 See also Ashbee *et al.* 1979.

223 The order of the building materials does not quite reflect the order in which they were encountered on quarrying.

autonomous. Coombe rock is sticky but it is not structural, these dumps would have slumped and shifted through time. The shape or form of the material being used was unstable[224] – it had a short duration, but it would and did fix itself to the cattle skulls and posts indefinitely. Using coombe rock also made things more impenetrable to the builders, they could not re-enter this matrix without digging back in to it.

It is interesting that more than one material without stable form was used at the site of Beckhampton Road. There were many wooden partitions within the build, but not at the margins of the barrow (*i.e.* not in the area that archaeologists traditionally recognise as that of the façade boundary element). For example, as with South Street, chalk rubble, a crumbly material, was used at least on the eastern and southern limits (with the other areas of the site subject to plough damage). It is argued that the chalk was battered against the rest of the assemblage in order to hold it in place. In the plan drawing of the long barrow, the outer limits of the chalk rubble have been given a dashed line detail in order to suggest that it had been used to create a façade. But did the chalk rubble have or hold a distinct or stable form (physical shape)? Why else might chalk rubble have been used in construction? Chalk in rubble makeup is a messy material, it is active in that it will respond to the shape and weight of other things if people are there to move it into place and put themselves into the fray. Rather than the seamless finished form of a long barrow, and a contour created through battered down material (a singularity of outline), chalk rubble would have made a mess of those that were moving it into place. The chalk rubble would have kept shifting in time, and it would have made things impenetrable.[225]

Long barrows need to be understood through these emergent qualities of materials, and that autonomous elements or dependent assemblages create moments for consideration or the impetus for future work.[226] Crucially, added to this mix, are materials without stable form (shape) that conceivably lent themselves most of all to situations where participation in architecture was unequal. Unequal does not necessarily denote a negative experience but instead the possibility for a more intense work experience. However, it was perhaps these materials most of all that created an architecture that you cannot get back inside of.

4.3.2 Long barrows as architecture

> 'Deleuze thinks difference primarily as force, as affirmation, as action, as precisely effectivity. Thought is active force, positive desire, thought which makes a difference, whether in the image-form in the visual and cinematic arts, in the built-form in architecture, or in concept-form in philosophy. Deleuze's project thus involves the re-energization of thought, the affirmation of life and change, and an attempt to work around those forces of anti-production that

224 The form (shape) of the barrow under construction was also unstable.
225 It would have been impossible to re-enter this architecture unless you dug your way back into it.
226 McFadyen 2007.

> aim to restrict innovation and prevent change: to free lines, points, concepts, events from the structures and constraints which bind them to the same, to the one, to the self-identical'.[227]

I include this quote because I want to think of long barrows as effects of force, of differentiation, of emergence through difference.

4.4 Easton Down

Easton Down long barrow lies on the lower slopes of the Upper Chalk, above the valley where the Beckhampton Road and South Street long barrows had been built. Figure 4.5 is a redrawing of the latitudinal section from the Easton Down barrow excavations.[228] In this section, I have paid particular attention to the ways in which materials are positioned in relation to each other. Although there are no drift deposit materials this time (*i.e.* coombe rock), there are different elements from turfs to wooden posts to chalk rubble to chalk blocks. Interestingly, smaller chalk rubble is used in many of the initial inner areas of the build (*contra* to South Street and Beckhampton Road). I discovered, whilst redrawing the pitch of the materials that there is a verticality to the physical outer limits of many of them. In several of the cases there is the ghost or void of where a post has been, but in many other areas I can only imagine that such a clear vertical edge and distinct contrast in the materials comes from there having been a wooden post as a part of the assemblage. By marking in these areas as dashed lines, by drawing attention to the gaps, I create a vertical dimension to the ways in which things have been put together that works against the gravity from slope action processes. There are no longer continuous layers of material, but instead parts and fragments that break off and that are interrupted by posts that shoot upwards. There is less a general flow from an inner

Figure 4.5: Latitudinal section, facing north to south, from the back end of Easton Down, Wiltshire (drawn by author, see also Whittle et al. 1993, 208, figure 3).

227 Grosz 1995, 129.
228 See also Whittle *et al.* 1993.

to an outer area, there is less of a contour or mound, and more a dynamic rearticulating of boundaries on architectural terms (there is less of a stable shape).[229]

The form (shape) of the chalk in construction and completion was unstable – it had a short duration. Furthermore, the chalk material made it an architecture that you cannot get back inside of. Is this not perhaps why so many materials with mutable and fluid form were used in their making? For when the assembled materials had started to stabilise, the builder's body could be withdrawn from the assemblage and the material matrix could seal shut behind them. Maybe that is why the posts were added to the mix, as a material reminder of the effects of such imbricated building practices, such a dependent architecture. There is no evidence for the recutting of these materials. This is in direct contrast to many Early Bronze Age round barrows that were routinely recut. And it is interesting that Koji Mizoguichi[230] argued for the presence of marker posts in round barrow construction in order for past people to make the precise recuttings that they did. In long barrows there is evidence for Neolithic markers, but the long barrows were never reworked.

Figure 4.6: Longitudinal section, facing east to west, from the back end of Easton Down, Wiltshire (drawn by author, see also Whittle et al. 1993, 208, figure 3).

If we look at the redrawn longitudinal section (Figure 4.6), there are many more directions through which we have to follow the efforts of labour. There are tip lines from west to east, and from east to west, and on several levels. These lines of activity, in addition to the tip lines from north to south, and south to north, in Figure 4.5, are evidence that chalk materials were constructed together in many different ways, in all directions and on several levels, that were certainly not constricted to an inside to out, front to back, evolution of a barrow. There is no one direction, or any one section, that records a sequence by which a monument or phases of monument evolve. Instead, there is an intensely complex and densely interconnected assemblage of things that cannot be caught or comprehended in any one way.

4.5 Gussage Cow Down 78

Figure 4.7 is the excavation drawing of the latitudinal section of the Gussage Cow Down 78 long barrow, Dorset.[231] This section represents an excavation cut of just over 4 m in width into an upstanding mound that measures over 50 m in length, 22 m in width, and 4 m in depth. The drawing depicts a range of building materials from turfs to compacted chalk, from cubes of fresh chalk rubble to earth and chalk rubble, to

229 To the form of the barrow under construction.
230 Mizoguchi 1993.
231 See also French *et al.* 2008.

Figure 4.7: Latitudinal section, facing north to south, from the front end of Gussage Cow Down 78, Dorset (drawn by author).

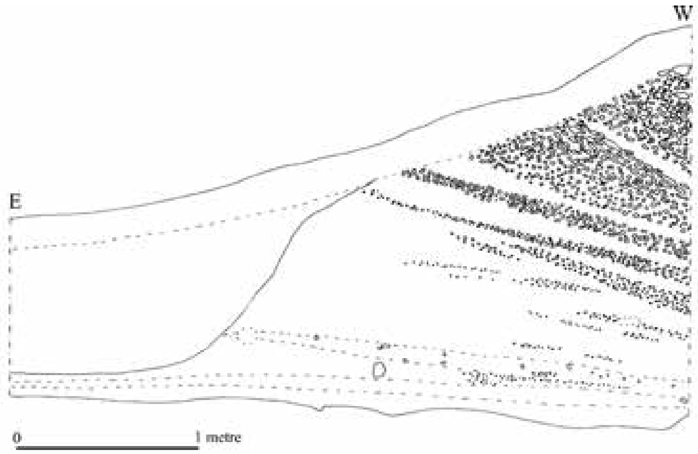

Figure 4.8: Longitudinal section, facing east to west, from the front end of Gussage Cow Down 78, Dorset (drawn by author).

chalk blocks. If we look at the way the materials are positioned in relation to each other, there is no one movement from inside to outside, or contour from top to bottom.

There are other directions through which we have to follow the efforts of labour; and these lines of counter-force are marked by posts. Between the rubble of fresh chalk and dirtied earth and chalk, there is a densely interconnected assemblage of things that builders could not get back into once they had moved themselves out of the way.

There is a proximity of materials, one propped against another, another pushing in the direction of the other, that created an intense territory of occupation[232] for the builders whilst in the process of building, and this is marked by posts. Figure 4.8, the longitudinal section, is evidence of building materials being employed in an inwards rather than outwards direction, and again shows that the idea of common earth dumping sequences is wrong.

232 After Rendell 2002.

4.5.1 Unstable monuments

Renfrew[233] has argued that long barrows were constructed from the coordinated efforts of many people coming together at once. However, this interpretation is determined by a calculation of worker-hours from the overall length, width, and height of an external form of a singular monument and it side steps the fact that many long barrows have several phases of construction. Another line, developed from Edmonds[234] work on causewayed enclosures, is that a small group of builders over time, or a series of small groups contemporaneously, were involved due to the interconnected pit like nature of the long barrow flanking ditches (*i.e.* only three to four people could fit in the area of each pit as it is cut). In both of these cases, the qualities of the building materials and the building techniques that they were a part of, and how this had a direct effect on the builders, has been ignored.

How should we understand bodies building in these areas of construction? For example, at South Street and Beckhampton Road, turf was used in such a way that it could allow people to develop relations of group cooperation in the process of construction.[235] Blocks of turf were laid down next to each other, one after the other; and then on top of each other, course by course. Turf blocks are solid materials and laid in a consecutive manner (butting against each other, rather than overlapping) they make a stable element. One person could have carried out this work, because they could take time; or a group could have undertaken the task as part of a sequential routine. However, a key condition to these long barrows is that stable materials and building techniques did not constitute the majority of the build, and so a routine of this kind could not become established. As archaeologists, we therefore have to consider the kinds of body dynamics and politics involved in a more dependent building practice.[236] For the very reason that, for a short period of time, some of the participants became a part of the build whilst others carried on barrow-building on top of them. What kinds of negotiations between people would have been worked through in order to create such dependent assemblages? What would change in our understanding of the Neolithic if disruptive issues were more frequently highlighted, and if participation was more unequal than equal?[237]

So, what is it about the architecture of a long barrow that exists or operates within? Especially if architecture is not to be viewed as something external or foundational in terms of a final or stable form (shape). What is it, if it is not integral either in terms of human remains or material culture as content? I have come to realise that form (shape) is significant but it involves making building materials with mutable and fluid form matter. I argue that the value of materials such as coombe rock or chalk rubble is that they allow us to think about building in a different way. This is an architectural practice that involves unequal participation.[238] The use of these materials creates conditions where certain bodies are a part of the assembled build for a period of time. Certain bodies become a dominant focus in interaction for a period of time. However, that

233 Renfrew 1973.
234 Edmonds 1999.
235 See Holst and Rasmussen 2012, 269.
236 Till 2009.
237 After Till 2005.
238 Till 2005.

period of time is short in duration for when the assembled materials start to stabilise, the builder's body is withdrawn from the assemblage and the material matrix seals shut behind them. There is a temporality involved in the mediation between form (shape) and matter (substance) – matter is forced into forms that do not endure.

Coombe rock and chalk rubble required several of the builders to put themselves into the assemblage – they created a particular kind of interaction. Materials with mutable and fluid form have to be considered through practice and its speed. The intensity of that practice would have lingered through its effect, and knowledge gained therein, rather than any drawn out duration. And perhaps most crucially of all, it was a kind of interaction that could not be repeated. The material traces of these encounters could be seen on the bodies of the builders and remembered as something that operated within the long barrow. And maybe that is why the markers are there at so many points in the build. On these terms, the one thing that these building materials were not was disappointing.[239] The main quality of coombe rock and chalk rubble is their lack of stable, final, or transcendent form (shape) – the reified version in archaeology – for this makes them responsive to other materials and to a sealable matrix.

Long barrows involved different kinds of participation, the material traces of some of those encounters could be seen on the body of the builder, remembered and marked as something that operated within the long barrow. But the practices that were involved were of short duration, and the physical inaccessibility of the architecture and its lack of stable form meant that inequality could not be repeatedly played out through an engagement with an architectural object. Perhaps, the characteristics of building practice are to be understood in the way they created a notion of trust that was temporally and materially contingent. Trust that was not necessarily between builders, but a trust in what the materials that builders were caught up in using would do. Chalk rubble could be relied on for a speedy (if messy) practice, but also as a practice that could not be repeated. So, I too argue for architectural form, but it is mutable because of vibrant materials,[240] and just like Aubrey, it is lively.

4.5.2 Outer worlds inside

Of course, a landscape perspective is important in a consideration of barrows. There is an element of landscape inversion to barrow construction[241] – cutting down into grassland and stacking upwards in turf stacks, the underlying coombe rock and chalk rubble prised out of the ground and onto the turf (though chalk rubble is used in the inner areas of construction at Easton Down and Gussage Cow Down 78). However, the focus of landscape inversion is on what the categories of material *are* and not on what the materials *do*. Chalk materials produce active forces within the construction process that builders have to work with. I hope I have shown that there are many lines and directions of force in a barrow, and the materials continued to shift with momentum and continued to change shape after the builders had removed their bodies from the matrix. These energies between material and builder did not materialise on stable terms, and so I argue that barrows have to be understood on architectural terms. What

239 *Contra* Thurnam 1869.
240 Bennett 2010.
241 Bradley 1993.

knowledge and experience did the builders draw on from their worlds to help them deal with the inner workings of construction? How did this inner world of building change the way builders then operated back out in the world?

The nearest precedent that I can think of is not from landscape architecture,[242] but from the land artist Robert Smithson's work. I am thinking of the rock salt and mirror installations from the 'Earth Art' exhibition in 1968 in the Andrew Dickson White Museum, Cornell University. Smithson made his work with rock salt from Lake Cayuga rather than chalk rubble from the Wiltshire valleys, and there are mirrors instead of wooden posts, but both are about shoring and supporting. From the material pressures, that is the ways in which materials act together whilst he props them up, and the ways the materials continue to move after his hands have been removed from the assemblage; he writes 'the material becomes the container'.[243] With barrow building, I have been thinking of outer worlds inside, and Smithson uses the dialectic of 'site/non-site'. Smithson argues that the artist is 'confronted not only with an abstraction but also with the physicality of here and now, and these two things interact.[244] Architecture and landscape and site/non-site do come together, but through the qualities of the materials and the practice of making, and the way these factors made the present world a point of focus (the here and now of the Neolithic), rather than any perception of commemoration.

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242 LAE 2006.
243 Smithson in Flam 1996, 190.
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Part Two

Methodological approaches to studying architecture

5

Interpreting architecture from a survey context: recognising monumental structures

Yannick Boswinkel

5.1 Introduction

The site of ancient Koroneia was studied as part of the *Ancient Cities of Boeotia Project.* Alongside the pottery survey a separate architectural survey was conducted. This architectural survey went beyond documenting the few standing structures at the site, also a detailed recording of all individual architectural elements (not *in situ*) was part of the survey. In the end, over 2,000 objects were registered comprising a, potentially, useful dataset for more in-depth analyses, which could provide more insights about the build-up and infrastructure of the ancient city. Part of this detailed recording was the documentation of the dimensions of all these individual blocks. These data form the core of the current paper in which it will be assessed what insights the size of architectural elements can provide. One of the main aims is to see if larger blocks could be used as an indication of more imposing structures. In line with the workshop's subject of monumentality where this paper was first presented, it could be argued that larger, more imposing structures might be considered monumental. In other words, an attempt is made to see if through the study of the size of structural elements, monumentality can be recognized, even if these elements are no longer in their original context. This is done by looking at the distribution of size categories and how often each category is present at the site. Such a distribution could take various forms, such as a uniform, normal distribution or a multi-modal distribution (multiple peaks). From what is known of the site, a multi-modal distribution would be expected as each 'peak' would indicate a set of structures that have comparable building materials (in terms of size). It could be argued that the majority of the structures built at Koroneia were houses, of which at least the foundations were built in stone. Most likely these were fieldstones of limited size, which would thus amount a large part, if not the majority, of the material, creating the first peak. Secondly, it is known that various sanctuaries and more 'imposing' structures existed at Koroneia. These were, arguably, built with

In: Brysbaert, A., V. Klinkenberg, A. Gutiérrez Garcia-M. & I. Vikatou (eds) 2018. *Constructing monuments, perceiving monumentality and the economics of building: Theoretical and methodological approaches to the built environment*. Leiden: Sidestone Press, pp. 105-116.

larger blocks and as such forming a second peak, showing the 'monumental' structures at the site. Using this idea of size-based differentiation, the material will be analysed, and an attempt is made to ascertain if the monumental constructions can be identified in this manner.

5.2 The site and the survey

The ancient settlement Koroneia lies in the province of Boeotia, Central Greece. It is located on a hill rising some 100 metres above the Lake Copaïs basin.[245] The hill is part of the outliers of the Helicon range. The site has human-made terraces on its east side which provides level building ground. The west side is much steeper and more prone to erosion.[246] On this side few architectural elements were found, except for some possible stretches of the Classical-Hellenistic city wall. Preliminary pottery studies show that the site has been used from prehistory up to the medieval period.[247] This long occupation history is also (partly) visible in the architectural remains, which date from the late Archaic period (early sixth century B.C.E.) to the Frankish period (14th century C.E.). Although small, Koroneia has been mentioned by ancient authors throughout early history, from Homer's catalogue of ships (eighth century B.C.E.) to the earliest Boeotian confederacy (sixth century B.C.E.) up to resisting Roman dominance (second century B.C.E.)[248] (see also Table 5.1). However, Koroneia's *in situ* architectural remains are few, and only traces remain of each of these periods.[249] Those architectural features that can be (roughly) dated, show that the city was small in the Archaic period, with finds mostly on and immediately around the acropolis. The settlement expanded, reaching its maximum extent during the Classical-Hellenistic age. Although larger than in the preceding periods, Koroneia remained small in comparison to Boeotian's main cities, Thebes and Orchomenos. By Late Antiquity the settlement is mostly confined to the acropolis once more. The only remnant from the even later Frankish period is the ruin of the 'Frankish Tower' on the northwest slope of the hill.[250]

Period	**Dates**[a]
Archaic	8th c. – 480 B.C.E.
Classical	480 – 323 B.C.E.
Hellenistic	323 – 160 B.C.E.
Roman	160 B.C.E. – 3rd c. C.E.
Late Antiquity	3rd c. – 6th c. C.E.
Byzantine	6th c. – 12th c. C.E.
Frankish	12th – 14th c. C.E.

Table 5.1: Chronological overview of the periods mentioned in the text.
a: Most of these dates are very rough and only meant to give a general indication of the placement in time of the various periods discussed in the text.

245 Bintliff *et al.* 2009a, 18.
246 Wilkinson in Bintliff *et al.* 2009b, 50.
247 Bintliff *et al.* 2013, 7-8.
248 E.g. Hom. *Il.* 2.2.500; Hdt. 5.79.2; Thuc. 4. 93-96.
249 Boswinkel 2015, 68-85; Boswinkel 2015, 144-151.
250 Boswinkel 2015, 144-151.

Thus, within the context of such a multi-period site, a complete[251] surface survey was executed. Architecture, especially in Greece, is usually only studied in surveys when it comprises *in situ* architecture.[252] It may seem odd to disregard the non *in situ* architecture since the collected pottery is, obviously, also not in its original context. However, pottery fragments are stronger temporal and cultural markers than architectural elements. While there are elements in architecture that are traceable to their original position, such as columns, capitals and thresholds, generic blocks are nearly impossible to trace back to their original location within the building. This is most likely the reason why in many survey projects, architecture is only studied when structures can be identified. Individual elements are either disregarded, only mentioned briefly, or documented but not presented in fieldwork publications. At Koroneia, however, the *Ancient Cities of Boeotia Project* team decided to take a more elaborate approach. The survey started in 2007[253] focusing on collecting pottery in a systematic manner throughout the urban area that made up the ancient city.[254] Already during the pottery survey, the encountered architecture was documented with a GPS location, a photograph and a short description.[255] From 2009 the architectural documentation was executed parallel to the pottery survey by a separate team led by Dr. Inge Uytterhoeven. The team first revisited the original finds and later expanded the architectural survey, adding many more architectural finds.[256] The documentation of this new survey added extra information regarding dimensions, material, quality of the cuttings and tool marks. All these data were recorded in a database connected to a GIS, which allowed the creation of detailed thematic maps as well as performing various (spatial) analyses.[257] The architectural survey was finished in 2013 and almost 2,300 architectural features were recorded.

5.3 Size matters?

Over 90% of the architectural finds at Koroneia are not *in situ,* therefore, any study on size can only be conducted in relation to the individual building blocks, rather than the buildings themselves. While, in theory, larger buildings are not automatically built with larger blocks, a small overview of the size of some elements of various sites from Classical-Hellenistic Greece shows that public structures are generally built with larger materials than houses, often using blocks larger than 1 m in length.[258] The choice for using parallels from the Classical-Hellenistic era comes from the fact that Koroneia was at its largest then, therefore, this period covers the entire site and all documented material can be incorporated in the analysis. From the example of the public structures it could be argued that the hypothesis that 'monumental' structures might be recognisable based on the size of the building material seems valid. It is known that some

251 As far as the surface was accessible for survey.
252 Boswinkel 2015, 56-66.
253 Bintliff *et al.* 2014, 2.
254 Bintliff *et al.* 2009a, 19.
255 Bintliff *et al.* 2009b, 33.
256 Bintliff *et al.* 2012.
257 This was done as part of my master thesis, written at Leiden University.
258 Boswinkel 2015, table 7.2.

structures at Koroneia were built with larger blocks, some of which are up to 2 m. Also, through ancient descriptions of the site it is known that various sanctuaries and altars were present, indicating the occurrence of monumental structures. Thus, there is a presence of buildings with various functions and there is different sized building material, some of which might be deemed monumental.

In order to be able to differentiate between monumental and non-monumental blocks, based on size, there needs to be a threshold value. To determine this value one could turn to the frequency of the various size categories. Since Koroneia was, as far as we know, an urban site and not home to an important oracle (such as nearby Delphi), it can be assumed that the majority of the structures were domestic. Domestic structures usually only have a stone foundation on which walls were built of perishable materials.[259] The majority of the stone material would thus be small fieldstones/blocks (up to 30 cm), in comparison to the larger blocks for the more monumental structures. The latter might be built entirely of stone to highlight their monumentality in comparison to the other structures. Of course, this is era-specific and dependent on the available resources of a city, but it would be safe to state that more was invested in such buildings than in domestic structures. Finally, it should be noted that when it comes to the size of individual elements, a distinction should be made between 'generic' building material and 'specific' features. The 'generic' building material makes up all the normal blocks that form the walls of a structure whereas the 'specific' features refers to special blocks like thresholds, lintels, columns. Finds from the latter category are considered separately here since these objects are generally larger due to their specific function within the structure and should, therefore, be compared to similar features (*e.g.* the size of a threshold should be compared to the size of other thresholds). Hypothesising the distribution of monumental blocks based on size is thus established on three basic assumptions:

1. Monumental structures are built with larger blocks
2. There are less monumental structures than domestic structures
3. There is a distinction between 'generic' and 'specific' building blocks

Considering these three assumptions as well as the fact that there is a large range in the dimension of the material recorded at Koroneia, it would seem that, ideally, a distribution of the finds according to size would yield a bimodal distribution. In other words, this would form a graph in which two peaks are present; one showing the large quantity of small stones, representing 'non-monumental' structures, and a second peak consisting of fewer, but larger blocks, signifying the 'monumental' structures (Figure 5.1). The width of both peaks indicates that there is a spread of values denoting each type of building material, while the 'dip' in the middle shows the threshold values separating the two types. Subsequently, these ranges would allow detecting clusters of monumental and non-monumental blocks. This could then serve as a means to locate possible monumental structures at the site.

A local test case to which the architectural elements might be compared, is an excavated structure near Koroneia. It comprises parts of a rectangular, temple-like

259 Adam 1994, 60-61; Malacrino 2010, 45-47.

Figure 5.1: Hypothetical bi-modal distribution.

structure which was excavated in the 1970's by T. Spyropoulos.[260] It is a multiphase structure (sixth century B.C.E. – fifth century C.E.),[261] but for this comparison only material from one phase (second half of the fourth century B.C.E.) is used. The fact that Spyropoulos was convinced that this was a temple-like structure means that it should thus not be considered an 'average' structure. Yet, despite its 'public' nature (considering his designation of 'temple'), its building components are not remarkably large such as those used in other public structures in Greece, mentioned above. One of the interesting features of the walls of this building is the distinct size difference between the blocks of the outer and inner faces of the walls. The blocks on the inner face are smaller, not exceeding 0.5 m, while the blocks on the outer face are larger, up to 0.98 m. While there is an obvious differentiation in size, there is a grey area as well in which the block size of the two faces overlaps (between 0.2-0.5 m). The difference in size between the outer and inner faces is, furthermore, a conscious decision to show off these larger blocks, since there is no structural need for larger stones on the outside. Perhaps these larger blocks added prestige to the structure and thus represent indeed an expression of monumentality. This feature is important as it might mean that the peak representing 'monumental' material at Koroneia might be even smaller, due to the limited use of larger blocks, even within a 'public' building.

A secondary hypothetical distribution that could be the result of this dataset is a normal distribution. The Central Limit Theorem explains that there may be so many variables that influence the size of the block that it will result in a normal distribution[262] and thus not showing any sign of the factor that is actually being sought (monumentality). Technically, in the case of a distribution of only positive values (such as length) such a distribution would be log-normal, rather than normal.[263] Such a distribution is positively skewed, which means it has a high peak with low values, followed by a long tail towards the larger dimensions. Thus, the Central Limit Theorem would predict that throwing all the architectural finds on one pile 'always' results in a (log)normal distribution and thus never show the differentiation between *types* of architecture. There would, then, be a need to differentiate between these types in the data instead of putting all the architectural blocks together.

260 Spyropoulos 1975. Spyropolous was convinced it was a temple dedicated to Athena Itonia, later scholars have contradicted this (see e.g. Buckler 1996).

261 Spyropoulos 1975, 398.

262 Lyon 2014.

263 Lyon 2014, 628-630.

5.4 Data

Out of the almost 2,100 documented architectural fragments, 1,794 (85%) can be considered 'generic' building material and of these, 1,778 (99%) have recorded dimensions. The dimensions of the blocks, ranging from 0.1 to 2.0 m, are grouped in categories of 5 cm intervals. In this research the largest dimension of the block is used. Seeing that it is often unknown how the block was placed in a building, it is thus unknown which side would be the length, width, or height. The resulting distribution is shown in Figure 5.2. It is immediately clear that this distribution is very different from the hypothetical distribution from Figure 5.1. Rather than two distinct peaks, showing the difference between non-monumental and monumental building blocks, there is only one peak with a long 'tail' towards the larger dimensions. While this did not produce the anticipated result, it does show that the majority of the material is relatively small, and it fits well with the log-normal distribution, described in the second hypothesis.

Figure 5.3 shows a cumulative graph of the amount per size category (as percentages) which shows that almost 80% of the blocks are smaller than 0.6 m. Compared to some known measurements from public structures from Classical-Hellenistic Greece, in which blocks are often longer than 1 m, this is certainly small material. Although material of the larger size category is present in the dataset, it seemingly represents such a small portion (less than 3%) that it does not show significantly in the distribution.

Setting these results side by side with the measurements from the blocks of the 'temple' at Koroneia, there are both dissimilarities and parallels. In Figure 5.4 the size distribution of the blocks is shown as the percentage of blocks at 10 cm intervals.[264] Clearly, the perceived difference in size between the blocks of the inner and outer faces is substantial. Yet, despite the clear difference in size, there is also an overlap in block size between the two faces. This overlap coincides with the overall distribution

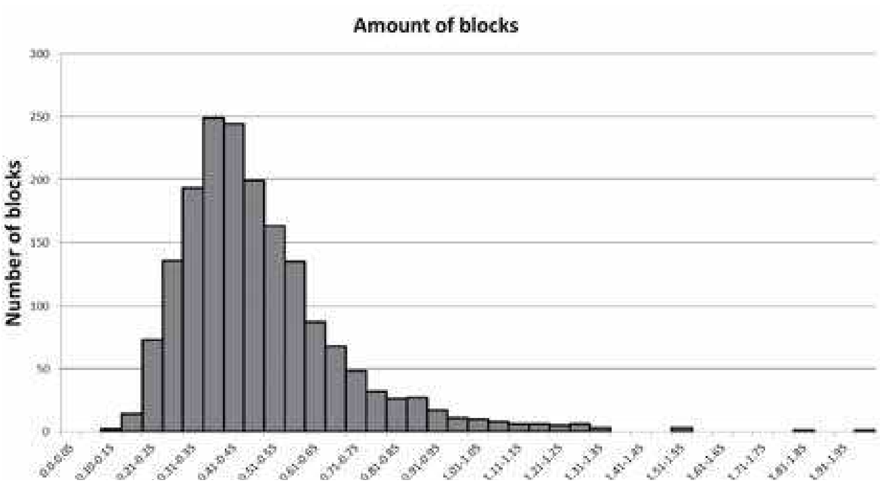

Figure 5.2: Distribution of the size of building blocks at Koroneia.

264 Due to the low number of blocks (n=48) percentages are used and the interval is 0.10 m instead of 0.05 m because it otherwise creates an unreadable graph.

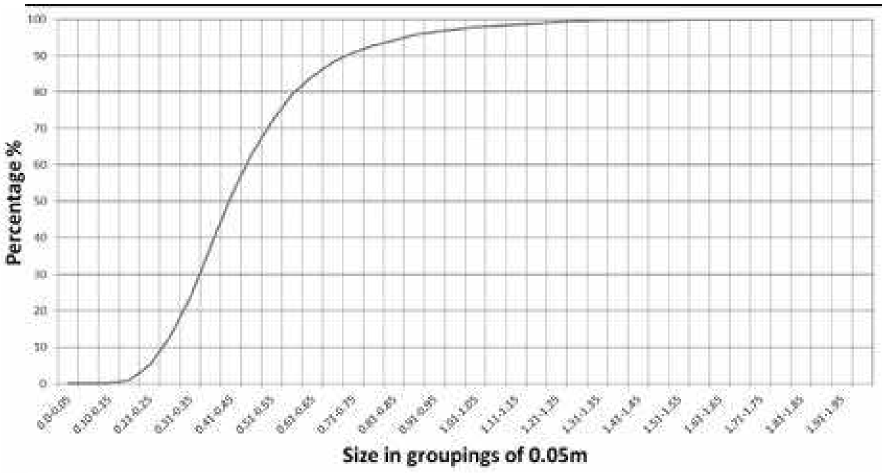

Figure 5.3: Cumulative distribution of the size of the building blocks at Koroneia.

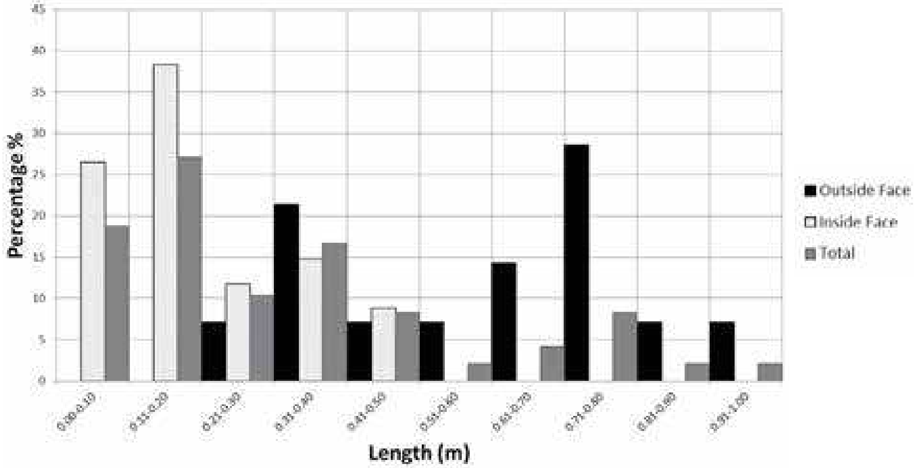

Figure 5.4: Distribution of the size of blocks of in- and outside faces of the temple structure.

at Koroneia which peaks between those same measurements (although somewhat narrower: 0.3-0.5m). On average the blocks at Koroneia are larger than those used in the inner face of the temple-like structure, but smaller than most of the blocks on the outer face of the structure. Furthermore, if this was a typical building and/or building style it would explain why the majority of the blocks at Koroneia are relatively small, since more smaller blocks are needed to cover the same distance with larger blocks (inside vs outside face). More than 50% of the blocks from the outer face of the 'temple' are larger than 0.6 m and thus larger than 80% of the loose blocks from the survey at Koroneia (Figure 5.3). Considering that over half of the blocks belong to the 20% largest blocks it might indicate some form of monumentality on a *local* scale. The large quantity of finds at Koroneia would eliminate peaks in extreme dimensions and thus it might not be strange that the largest quantity of finds is concentrated around the values in which both ranges overlap. Finally, Figure 5.4 also shows that there are less large blocks than smaller ones and how this affects the overall distribution. Most of the blocks from the outer face fall in the range of 0.71-0.80 m (largest dimension). However, because the number of blocks in the outer face is less than half of those from the inner face,[265] this peak is only marginally present in the total distribution. This might underline the argument that there are simply not enough monumental structures to form a discernible peak in the distribution graph for the entire site. Furthermore, these 'larger' blocks in the temple-like structure are still smaller than those encountered in other public structures (1 m and up). So, interestingly, in terms of absolute measurements, it seems that overall the material used at Koroneia may have been smaller than at other sites.

5.5 Discussion

In a previous section it was stated that the hypothesised bi-modal distribution of the blocks was founded on three assumptions. Since the actual distribution is not in line with the bi-modal hypothesis, it follows that either the hypothesis is wrong, one of the assumptions may be wrong or the data is insufficient. Considering the dataset, firstly, there may simply not be enough 'monumental' material to cause a peak in the distribution graph. Although it is known that some public/monumental structures were present at the site, the amount may simply be so low in comparison to the rest of the material that it becomes 'invisible'. Secondly, all architectural elements are combined in the dataset, regardless of their characterization or age. Architectural elements are notoriously difficult to date; most often structures are dated based on style or better datable finds in and around the structure. This is no longer an option when one is studying loose individual blocks, out of their original context. Comparing material from multiple periods is problematic and might obscure any patterns possibly present in the material. The lack of dates is also a problem because it conceals possible reuse of material in later periods. For example, in some of the *in situ* structures from the Late Roman period at Koroneia, there are clear signs of reuse. This might also involve re-cutting the material into different shapes and making the blocks smaller. Recycling material is not limited to the site either, as some ancient material has been used in modern constructions in nearby villages,[266] possibly altering the size distribution of finds. Finally, the range of block size for both non-monumental and monumental constructions might be more wide-spread than assumed, which means that there is no real threshold value and both distributions overlap. While monumental structures might be built with larger blocks, this does not mean that there was a strict separation of what size blocks were used for monumental structures and what size was not. The 'temple' example shows this very well. Thus, it would seem that by not differentiating the material in a sufficient manner, the numerous variables that influence the size inevitably leads to a (log-)normal distribution.

265 Fourteen for the outer face vs 34 for the inner face (total is 48).
266 Fossey 1991.

5.6 Conclusion

A question that may arise is, why, despite the known issues with the material (discussed above), this study was conducted. First of all, it was unknown what the effect would be of the various issues on the outcome of the analyses. Secondly, while larger building materials are often found in larger, more public oriented structures, it does not necessarily define them. Therefore, recognizing these public structures within the current dataset through the size of the material may have oversimplified the issue of monumentality. Yet, some interesting aspects have come out of this study. As shown through the size of the elements from the example structures, the larger material is indicative of a structure of a more public nature. However, as the 'temple' at Koroneia shows so well, the outer face of a structure does not define all the material used. This might be an indication of why the larger material is so unnoticeable within the distribution of the material based on size: it was only used sparingly for highlights, rather than as a building material for an entire structure. Furthermore, the lack of differentiation of the material in this study results in the mentioned '(log-)normal' distribution. As such, it shows that monumentality is relative and should, therefore, be compared to contemporary finds. Just as the 'temple' shows that the size of the material can be an indication of a *local* monumentality, so too could contemporary material perhaps show monumentality in a specific era. This analysis focuses on the entire site, while on a smaller scale, a concentration of large material might still be a good indication of a possible location of a larger, public, or monumental structure.[267]

There are thus two interesting issues to take into account: 1) the local nature of monumentality and 2) available data on the size of the building materials that are still *in situ*. These two form a somewhat problematic contradiction for sites such as Koroneia, where so few structures are preserved. More data on *in situ* material would thus have to come from outside, yet this clashes with the possible local nature of the monumentality. While the use of reference collections are part of studying other find-types (*e.g.* pottery, flint and bone), these do not exist in the same fashion for architecture. This has mostly to do with the fact that architecture is often studied in respect to style and layout. Subsequently, little attention is given to the characteristics of individual parts of a building. Even when these data are recorded they are often not published and, therefore, less available for comparative studies. These data would give more insights, though, into the relation between material and structures as well as insights on temporal trends regarding the used building material. More detailed data on the variety of size in building material in different buildings and from different periods is thus needed to distinguish between various types of architecture and to come to a more conclusive hypothesis on the distinction between monumental and non-monumental architectural elements.

267 Boswinkel 2015, 88-91; Uytterhoeven 2014, 2-4.

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6

Three-dimensional documentation of architecture and archaeology in the field

Combining intensive total station drawing and photogrammetry

Jari Pakkanen

6.1 Introduction

Imposing images, presentations and videos are widely used to present architectural and archaeological research projects to the public and their role should not be underestimated. They are often central to public understanding of the projects, securing future finances and communicating the research to colleagues. The promotional material can be directly created from the three-dimensional documentation and reconstructions of the architectural and archaeological remains, so the additional amount of work required is in most cases limited. However, the principal aim of three-dimensional recording must be efficiently producing accurate documentation which can be used in analyses of the documented features and publication of the project results. When the work is carried out professionally, the resulting models are precise representations of the geometry and textures of the targets, thus making it possible to extract the required two-dimensional publication illustration, to carry out further analyses and to produce digital reconstructions of the fragmentarily preserved monuments.

Traditionally, the principal illustrations in archaeological publications have been two-dimensional hand-drawn line-drawings of the documented features and photographs. Currently, one of the most cost-effective ways of producing precise two-dimensional line-drawings of monumental architecture is combining photogrammetry with intensive stone-by-stone documentation using reflectorless total stations: the two-dimensional projections can be produced to any required direction, including plans, elevations and sections. The benefits of the method

In: Brysbaert, A., V. Klinkenberg, A. Gutiérrez Garcia-M. & I. Vikatou (eds) 2018. *Constructing monuments, perceiving monumentality and the economics of building: Theoretical and methodological approaches to the built environment*. Leiden: Sidestone Press, pp. 117-140.

presented here include speed of production, higher measurement density and precision compared to hand-made drawings. It also allows for more time to be used in the actual study of the architectural features. For large complexes photography using an Unmanned Aerial Vehicle (UAV) can significantly shorten the time needed in the field. Here, several case studies of combining intensive total station drawing with land-based and aerial photogrammetry are discussed in detail. The projects are chosen so that they illustrate examples of combining different types of three-dimensional documentation in the field – total station line-drawings, point clouds and textured models – and deriving two-dimensional illustrations from these data. The presented case studies of superimposing reconstructions on three-dimensional data include sketching the main outline of maritime structures of the medieval harbour at Kyllene and a detailed partial reconstruction of the shipshed complex at Naxos in Sicily. A statistical study of the building block dimensions of a Hellenistic tower at Kyllene provides an example of the importance of accurate architectural documentation and how it can be used in an analysis of Greek measurement units.

Ancient architecture is in most cases fragmentarily preserved and, therefore, our perceptions of the scale, monumentality and relationship of the structures with other buildings are largely based on their reconstructions. Reconstructing Greek and Roman monumental architecture requires a good understanding of the regional and temporal variations of the buildings and of the combination of their conservative and innovative characteristics.[268] However, because of the conventional nature of the ancient architectural orders and the proportional rules guiding them, the completed structures can be quite reliably reconstructed based on a limited range of *in situ* archaeological features and preserved blocks.[269] Well-argued and documented three-dimensional visualisations of the built environment are an important aspect of communicating the significance of architecture both inside the scholarly community and to the wider public.[270] For example, the Classical shipshed complexes in the Piraeus were part of the great Athenian civic building programmes and their digital reconstruction serves several purposes. The three-dimensional model relates an interpretation of what the now lost ancient built environment looked like. It is also an important starting point for econometric calculations of the construction costs which, in turn, make feasible an analysis of the social significance and context of the shipsheds.[271]

Due to recent development in hard- and software, full three-dimensional documentation is fast replacing traditional means of architectural recording. Even though the cost of laser scanning can still be prohibitive, all fieldwork projects have access to good digital cameras and most to a reflectorless total station. Therefore, the methodology presented here can be applied at other archaeological sites enabling efficient, accurate and detailed documentation.

268 Coulton 1977; Wilson Jones 2000; Pakkanen 2013a.
269 See e.g. Salmon 2001, 195; Pakkanen 2013a, 75-109.
270 See e.g. Pereda 2014; Pfarr-Harfst 2015; Vitale 2017.
271 Pakkanen 2013b.

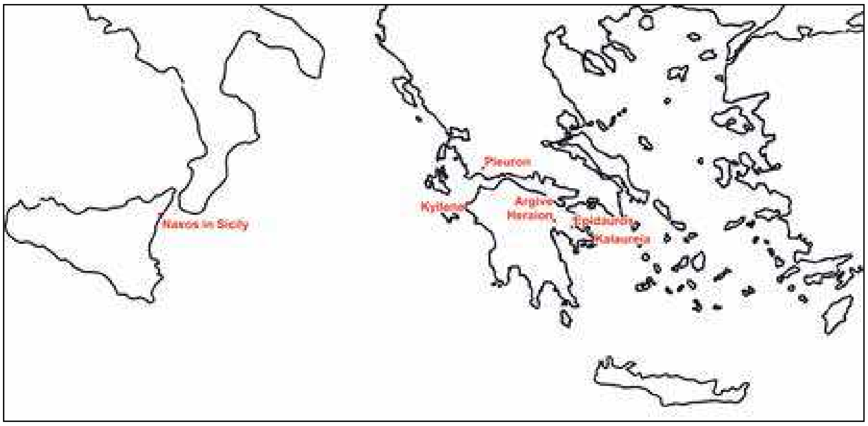

Figure 6.1: Map of the sites mentioned in the text (image by Jari Pakkanen).

6.2 Intensive documentation using total stations and line-drawing with laser

The strategy for intensive and extensive[272] total station documentation was an integral part of two large-scale projects which both started in southern Greece in 2007. The Kalaureia Research Program on the island of Poros was directed by Berit Wells and Arto Penttinen of the Swedish Institute at Athens, and the Kyllene Harbour Project is a collaboration between the Finnish Institute at Athens and the Ephorate of Underwater Antiquities.[273] A map of the sites mentioned in this paper is presented in Figure 6.1.

The methodology and the first version of the software for intensive total station documentation were developed in conjunction with these two projects by the author of this paper.[274] The software for converting the total station documentation into a three-dimensional CAD drawing was programmed using the script language of the statistical package Survo MM. The current version employs the same algorithms as the first, but as a console program it is very fast and works on any Windows platform.[275] The operator of the total station codes the beginning and end of a line (or an individual point) and the characteristics of the target before taking the point and recording the three-dimensional coordinates of the object into the instrument memory. Afterwards, the computer program translates these data into a layered CAD drawing.

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272 'Intensive' in this context refers to density of points and lines to draw the archaeological and architectural features using reflectorless total stations: for example, the three-dimensional documentation of a single typical foundation block of the Hellenistic Stoa C at Kalaureia comprises c. 20 lines based on c. 250 points, and the total recording of the building remains comprises over 4,300 lines. 'Extensive' refers mainly to the size of the area with buildings and other architectural features: c. 200 m × 100 m at Kalaureia and c. 300 m × 150 m at Kyllene.

273 Penttinen *et al.* 2009; Pakkanen *et al.* forthcoming.

274 Pakkanen 2009.

275 The software *ts2dxf.exe* has been developed in collaboration with Relator Ltd, a private company based in Finland, as part of the Three-Dimensional Development Programme of the Finnish Institute. A test version and instructions how to use the program are freely available from the author of this paper via email.

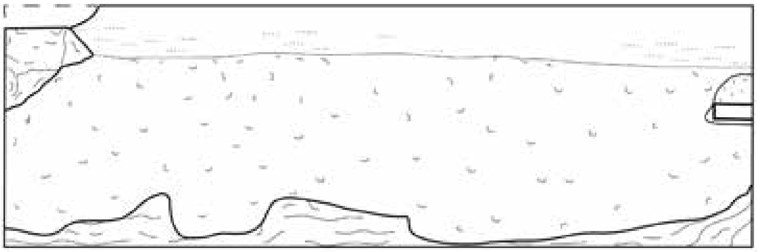

Figure 6.2a: Kalaureia Research Program, 2007-2008. Sanctuary of Poseidon. Documentation of the Hellenistic statue base blocks. Drawing of the top surface of Block A based on hand measurements (Anne Hooton).

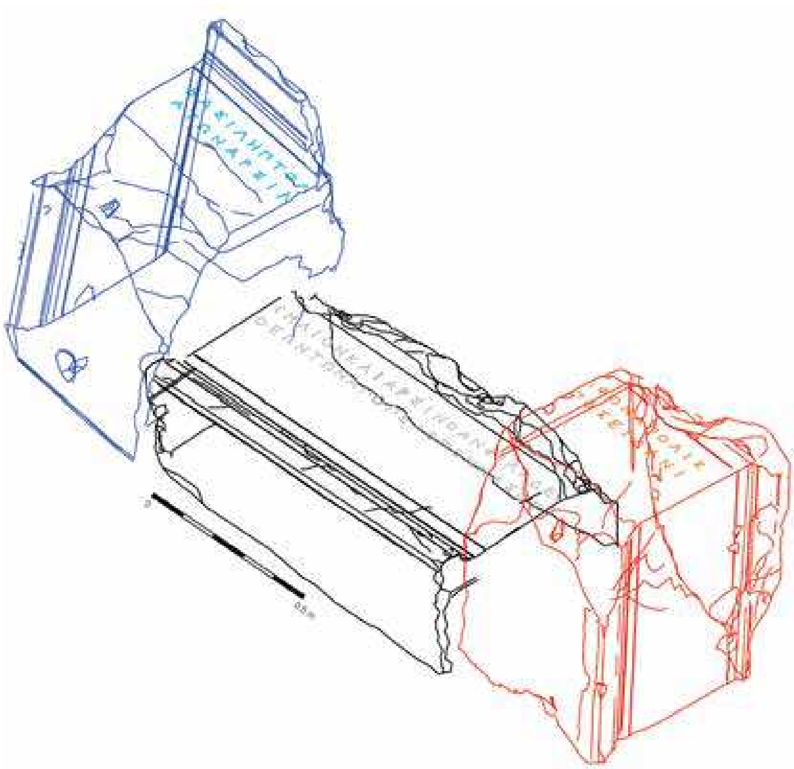

Figure 6.2b: Kalaureia Research Program, 2007-2008. Wireframe model of the raw measurement data recorded in the field: Blocks B, C and D (image by Jari Pakkanen).

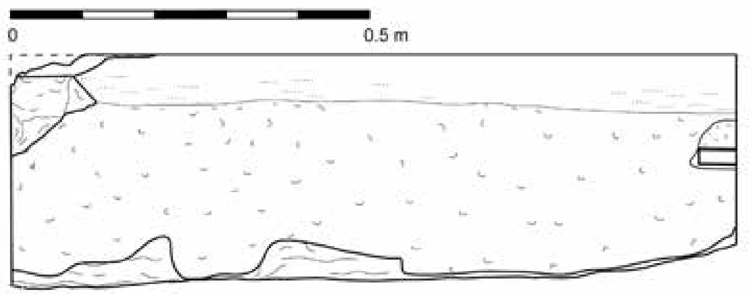

Figure 6.2c: Kalaureia Research Program, 2007-2008. Published illustration of the top surface of Block A directly derived from three-dimensional total station documentation (image by Jari Pakkanen).

During a normal working day several thousand points can be recorded to create a detailed line representation of the target.[276]

With a temple, four *stoai* framing a large central open space and a monumental entrance building, the sanctuary of Poseidon at Kalaureia on Poros is among the principal ancient sites of the Saronic Gulf. Its architectural importance is on par with other large nearby sanctuaries such as Epidauros and Argive Heraion, both in the Argolid. The temple of Poseidon is a small late Archaic *peripteral* building at the northern edge of the sanctuary, and one of the *stoai* and the entrance building are also Archaic. The two *stoai* on the northern flank of the open space are Classical and the fourth one is Hellenistic. This paper presents as a case study one of the early challenges of the research project: the documentation of a Hellenistic statue base comprising four separate limestone blocks discovered in 2007 to the southwest of the temple temenos.[277]

During the preparation of the publication illustrations in 2008, I could not make the hand-drawn blocks of the statue base fit with each other despite their excellent preservation. The problem encountered was that even professional illustrators are affected by the strong tendency of the human brain to perceive regularity where it does not exist (Figure 6.2a). The monumental statue base as a whole is highly symmetric, so it is not surprising that this regularity also has an impact on the documentation of the individual blocks. In this case the irregularity of the block sides facing the inside of the statue base was missed in the field documentation based on hand-taken measurements. In the lower right corner the discrepancy between the drawing in Figure 6.2a and the block is c. 6 cm. Increasing the number of accurate measurements adds to the detail of documentation but there is an understandable limit to how many dimensions can be taken when drawing by hand, as this is a slow and cumbersome process always involving a degree of approximation.

Therefore, in order to fit the four blocks of the monument together, it was necessary to return to the field to redo the drawings, but this time avoiding any hand measurements (Figure 6.2b). Using a reflectorless total station to draw the architectural and archaeological features requires abandoning the normal stationary way of working with surveying instruments and making them an active part of the documentation process. Using the laser requires a good reflection of the recorded surface and glancing shots of oblique surfaces should be avoided, so a dense network of laser backsights is required to be able to move the station to an optimal position whenever necessary.[278] When very high precision of the recorded target in the field is required, it is advisable to quickly reshoot the co-ordinates of the four to five backsights in use to minimise the positional and angle errors in subsequent short local moves of the instrument. An additional advantage of the method is that using the reflectorless laser instead of infrared with a prism target reduces the size of the survey team from two persons to one. Also, aban-

276 Metrology-grade tracking systems have also been used to produce three-dimensional line-drawings of archaeological excavations (Smeets *et al.* 2014), but the system is slower, more expensive and more cumbersome than reflectorless total station documentation.

277 Wallensten and Pakkanen 2009: The architectural importance of this particular statue base is that the inscription ties the used mouldings to the period after the death of Arsinoe the second and when Ptolemaios the first was still alive, c. 270-246 B.C.E.; Wallensten and Pakkanen 2009, 157-164.

278 Pakkanen 2009, 3-6.

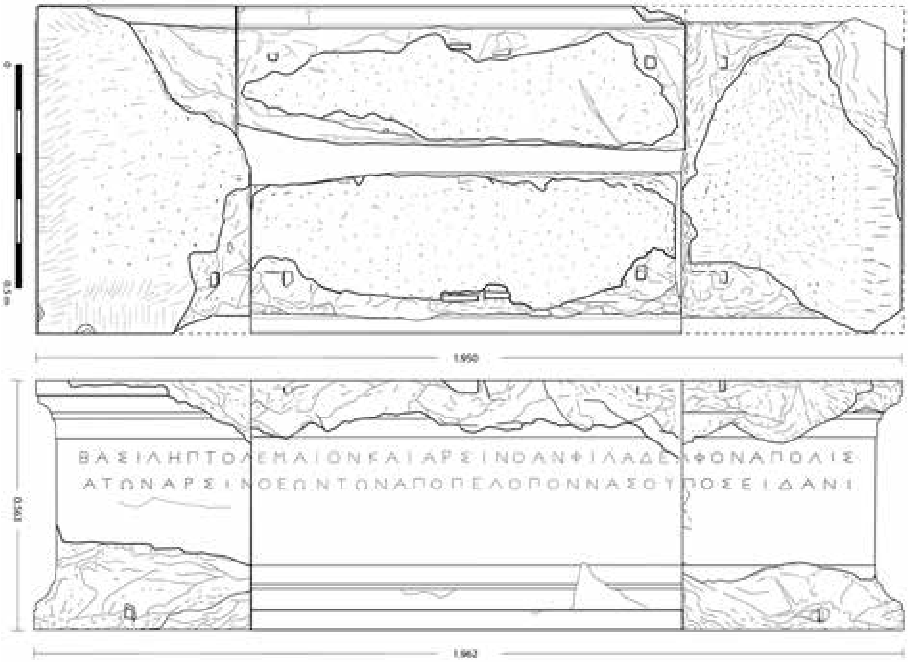

Figure 6.3: Kalaureia Research Program, 2007-2008. Sanctuary of Poseidon. Dedication to Arsinoe and Ptolemaios from the polis of Arsinoe in the Peloponnese (c. 270-246 B.C.E). Final illustrations generated from the reflectorless total station line-drawings (Wallensten and Pakkanen 2009, figure 6).

doning the use of the optical telescope of the total station and using the laser pointer, instead, makes it possible to directly observe what exactly is being recorded.[279]

Photogrammetry has quickly established itself as the preferred choice for three-dimensional architectural, archaeological, and topographical documentation.[280] However, when precise line-drawings are needed, photogrammetric models require retracing in a computer program,[281] while with reflectorless total station recording a line-drawing can be produced directly from the data. Automatic tracing of exported images tends to result in broken lines and the relationship between these lines and the traced target is not always straightforward. Subtle changes in texture and detail are often difficult to discern in orthomosaics and point clouds. This is apparent in all the case studies discussed in the next section: superimposing the total station data on the models makes it easier to read what the significant features of the target are.

The wireframe model presented in Figure 6.2b is based on unedited total station data. The varying colours of the drawing are produced by giving the blocks and the inscriptions different codes when shooting the points. All details are directly recorded as lines in order to simplify further processing of the data. The density of points depends

279 Pakkanen 2009, 3-5, figure 3.
280 E.g. Sapirstein 2014; Sapirstein 2016; De Reu *et al.* 2016; Sordini *et al.* 2016; Thomas 2016; Murray *et al.* 2017; Sapirstein and Murray 2017.
281 Cf. e.g. Thomas and Kennedy 2016, table 1 and figure 6.

on how much detail is required in the final drawings and on the scale in which they are published. Another critical factor is the available time for recording. The lines along the cracked surfaces in Figure 6.2b are documented at 5-10 mm intervals and the straight lines with approximately a 10 cm interval.

The final published drawings can be made in any vector-based drawing program by exporting from CAD the relevant two-dimensional elevation or plan view of the recorded target. The line weights and representations of the different surface textures can be modified to produce a 'traditional-looking' line-drawing of the target (Figure 6.2c and Figure 6.3).

I have experience of training colleagues and students in three-dimensional documentation in the field for 10 years and they have all learned the basics within a couple of days. The number of repetitions and field practice, however, need to be intense enough so that the procedures become automatic. Direct three-dimensional drawing can be monotonous work, but the excitement of seeing the results the same day on the computer screen often makes up for that.[282]

6.3 Total station line-drawing and photogrammetry

Since 2014 we have integrated the use of three-dimensional total station drawings with photogrammetry in the fieldwork projects of the Finnish Institute at Athens. The case studies of the application of these techniques illustrate their potential, especially how the integration can assist in documenting and analysing different types of features of the architectural and archaeological data. First, I discuss the documentation of an ancient harbour at Kyllene, Greece. Second, at Pleuron in Western Greece, in collaboration with Lazaros Kolonas, a large-scale Hellenistic reservoir was recorded 2015 and 2016.[283] Finally, examples from the on-going research at Naxos in Sicily, carried out by the Museum of Naxos and the Finnish Institutes at Athens and in Rome, are discussed.[284] For the locations of the sites, see Figure 6.1.

6.3.1 Kyllene Harbour Project

The Kyllene Harbour Project is an interdisciplinary study of the coastal and underwater remains of an ancient naval base and a medieval harbour. In 2007-2011 the main emphasis was on documenting all the archaeological and topographical features of the research area using total stations and underwater remote sensing methods. Since 2013 the project has concentrated on underwater excavations, monitoring coastal erosion of archaeological layers and in 2016-2017 also on aerial-based photogrammetry of the coastal and underwater remains (Figures 6.4a and 6.4b).

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282 The three-dimensional field documentation courses of the Finnish Institute at Athens were initiated in 2014 by the author of this paper and during the two-week courses it has been possible to train students without previous experience in archaeological documentation to use the method. In 2014-2015 the courses were run in collaboration with Ann Brysbaert (Leiden University) at Tiryns, and in 2016 the training course was arranged in co-operation with her ERC-funded SETinSTONE project on Salamis. The latest course in the summer of 2017 was also carried out at Ambelakia on Salamis.

283 Kolonas and Stamatis 2016, 117-118, 190.

284 Lentini *et al.* 2015.

The harbour is at the northwestern corner of the Peloponnese. In antiquity Kyllene was the second major port of Elis, the city-state controlling the sanctuary of Zeus at Olympia. By late fifth century B.C.E. it was a major Spartan naval base against the Athenian naval forces. In the Hellenistic period the harbour remained of key strategic importance and it is frequently mentioned in the written sources on the Macedonian and also Roman military campaigns in the region. Pausanias (6.26.4) comments on its suitable anchorage in the second century C.E. In 1205 C.E., after Constantinople was sacked at the end of the Fourth Crusade, western Peloponnese was seized by the Franks. The old Greek and Roman harbour was rebuilt and due to its ideal location between the eastern and western Mediterranean, it emerged quickly as one of the most important harbours of medieval Greece. The Frankish name of the coastal town was Clarence, and in Greek documents Klarentsa or Glarentza. It flourished for nearly two centuries but between 1407 and 1428 C.E. it changed hands five times. In 1431 C.E., Konstantinos Palaiologos, who later became known as the last Byzantine emperor, destroyed its walls to prevent another capture of the town. Because of the destruction of the towers at the harbour entrance and subsequent siltation, the inner basin became impossible to use, and in 1435 C.E. the town is reported as deserted.[285]

Considering the good preservation of the medieval harbour installations at Kyllene, very little archaeological interest has been shown to the maritime part of the site. The only previous plan of the port remains is a rough sketch published in the 1960.[286] The European Union Third Framework project in 2002-2005 has resulted in major research and improvements being carried out in the fortifications of Glarentza. Hellenistic and Roman pottery and coins have been documented in the medieval strata, thus verifying that the medieval fortress was built over the remains of the ancient town.[287]

The largest harbour installation is the great breakwater (S6 in Figure 6.5c) which has a maximum width of c. 17 m across the top platform and c. 35 m at the bottom of the sea, and its *in situ* remains on the surface project c. 120 m into the sea from the modern shore line. Other recorded structures can be interpreted as fortifications related to the medieval harbour entrance (walls W1 and W2, structures S1b, S1c, S2a, S3 and S4) and sea walls (S2b, S2c and S5b). The maximum distance between the installations measured in the east – west direction is 320 m between S1b and W7b and in the north – south direction 160 m between the north end of S6 at the bottom of the sea and W5 on the current shoreline. The typical medieval Frankish fortifications and harbour installations were built in mixed technique employing reused ancient ashlar blocks and rubble set in mortar. The discovery of the foundations of an ancient Greek tower (structure S1a) between the Frankish wall W1 and fortification S1b confirm that the medieval installations were built directly on top of the Greek and Roman harbour.

In 2016, the first attempt to build a three-dimensional model of the underwater harbour structures using UAV photography was made. The fieldwork has been annually conducted in late August and September to take advantage of the quiet period in the prevailing wind patterns. It was soon evident that the ideal conditions to take aerial photographs of the underwater structures are at 6:50-7:30 am, a little before and after

285 For discussions of the ancient and medieval sources, see Servais 1961 and Athanasoulis *et al.* 2005.

286 Bon 1969.

287 Athanasoulis *et al.* 2005.

Figure 6.4a: Kyllene Harbour Project, 2016-2017. Documentation of underwater targets using aerial photography. UAV DJI Phantom 4 ready for flying and waiting for the sunrise (image by Jari Pakkanen).

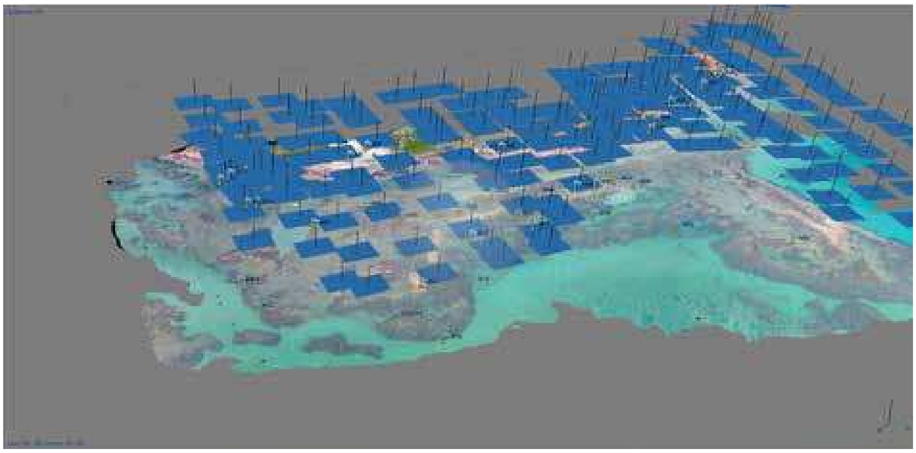


Figure 6.4b: Kyllene Harbour Project, 2016-2017. Modelling of underwater targets using aerial photography. Textured photogrammetry model with the locations of the drone photographs indicated by blue rectangles (image by Jari Pakkanen).

the sunrise. On several occasions there was great underwater visibility, with just enough light, no reflections of the sun on the water, and few surface ripples (Figure 6.4a). The textured model view in Figure 6.4b shows the locations of the 196 aerial photos taken on 4/9/2016 as blue rectangles: this was the first set which could successfully be used to build a model of the underwater structures from the UAV images.

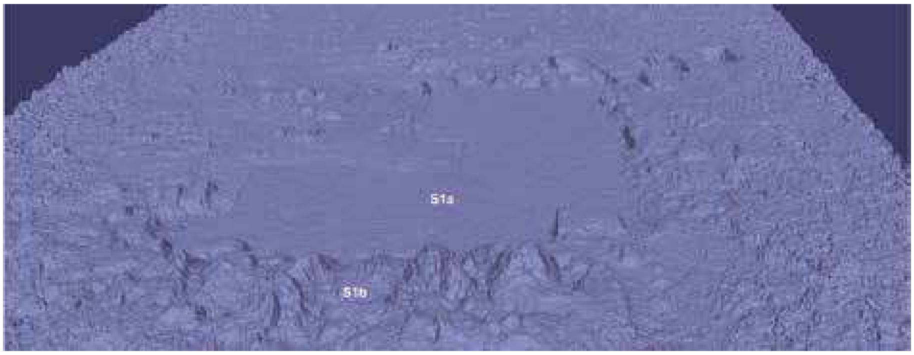


Figure 6.5a: Kyllene Harbour Project, 2016-2017. Three-dimensional surface model of underwater features derived from aerial photography: area of the Greek tower S1a (image by Jari Pakkanen).

Figure 6.5b: Kyllene Harbour Project, 2016-2017. Three-dimensional textured photogrammetry model of the area of the Greek tower S1a (image by Jari Pakkanen).

Figures 6.5a and 6.5b present two perspective views of the model of the area around the foundations of a Greek tower S1a: the first model shows the three-dimensional surface model of the area and the second the textured model. The eroded blocks in the foreground are part of the Frankish harbour installation S1b. The highest points of the stones are c. 0.3 m above the sea level. The top surfaces of the preserved blocks of S1a are c. 0.6 m below the sea level. Despite refraction between air and water, it is possible to build a precise representation of the sea floor. The standard method of dealing with refraction in photogrammetry has been to use a complex algorithm and run several iterations to correct the surface geometry of the three-dimensional model.[288] However, as is demonstrated here, a different method using underwater reference point markers can achieve similar results as the computational approach of the standard method. Due to shallow water and small height differences only nine reference markers on the seabed were needed to correct the distortions of the model in this area. The detailed model

288 Georgopoulos and Agrafiotis 2012; Skarlatos and Savvidou 2015.

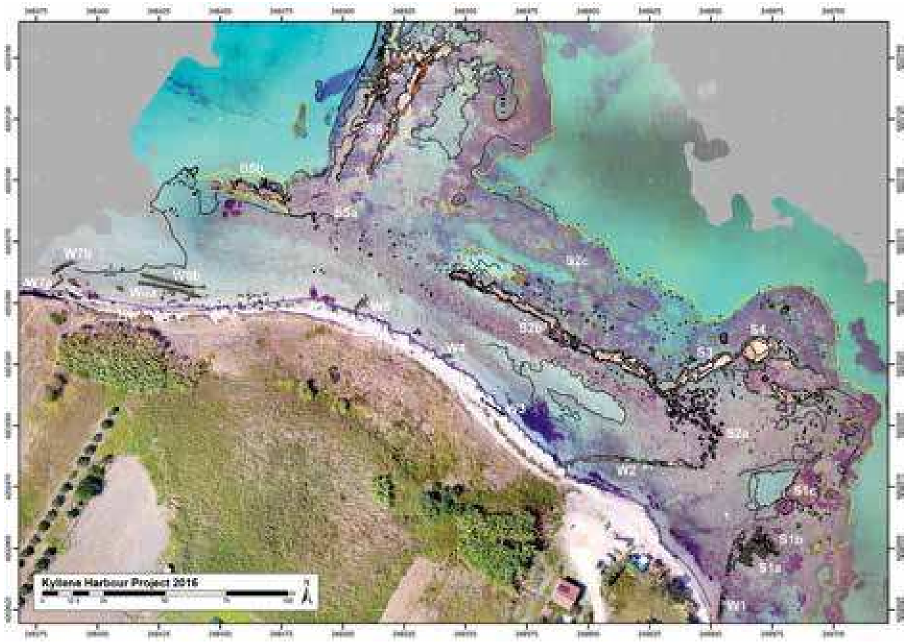


Figure 6.5c: Kyllene Harbour Project, 2016-2017. Total station survey data (line drawing) superimposed on top of the orthomosaic of the harbour (image by Jari Pakkanen).

shown in Figures 6.5a and 6.5b is based on 104 photographs taken at an altitude ranging from 7 to 15 m.

The model of the harbour structures in Figure 6.5c is created from 385 aerial photos. The deepest points of the model at the north end of the breakwater S6 are c. 6 m below the surface of the sea. In order to rectify the geometry of the model it was necessary to use 59 markers across the whole area. The resulting model matches very well with the stone-by-stone total station survey of the study area. The three-dimensional model can be used to create a two-dimensional rectified and scaled projection using the mosaic of individual photos. The readability of this orthomosaic is greatly enhanced by superimposing the total station line-drawing on top of it.

The high-precision total station documentation of the area of the Greek tower S1a was carried out in 2008-2011 using a three-person survey team and working only when there were no afternoon waves: the team working in the water consisted of a snorkeller pinpointing the mini prism tip and a relay person communicating with the surveyor behind the total station. The underwater model and the total station line-drawing of the ashlar blocks match well together (Figure 6.6a). However, due to slight surface ripples, it would not be possible to measure the dimensions of the individual blocks from the orthomosaic as accurately as from the total station data. The benefit of UAV-borne photogrammetry is the possibility of documenting the surface textures of both the manmade and natural features of the study area and, especially, the speed of recording: it is unlikely that a highly time-consuming project of underwater stone-by-stone line-drawing of the whole harbour would be initiated now that a faster alternative is available.

Figure 6.6a: Kyllene Harbour Project, 2014-2016. Total station survey data (line drawing) superimposed on top of the orthomosaic of the Greek tower S1a (image by Jari Pakkanen).

However, the first phase of documentation of the Greek tower S1a can be used as a case study to demonstrate why accurate three-dimensional total station data are necessary for architectural analyses. No scholarly consensus exists regarding the question of lengths and standardisation of possible Greek foot units. Where no inscriptional evidence exists, quantitative analysis of architectural measurements can provide an alternative approach.[289] In the Greek tower S1a, the width of nearly all the blocks is in the range 0.66-0.69 m and the length 1.34-1.38 m, so the block length is clearly twice their width. Cosine quantogram analysis provides a robust statistical method which can be used to estimate the length of a measurement standard based on a set of dimensions.[290] The larger the sample, the more probable it is that the quantitative method is able to detect an underlying basic dimension in the data set. Cutting building blocks to approximately fixed sizes was a relatively common practice in Greek monumental construction projects.[291] This made, for example, ordering the blocks from the quarries easier. Therefore, it is not a great surprise that the 162 block measurements from the Kyllene tower produce a statistically significant result. In Figure 6.6b the highest peaks q_1 and q_2 are the most probable candidates for the foot-standard. The length of the detected unit is unexpected: the two peaks in Figure 6.6b give very strong support to the hypothesis that a standard of 0.340-0.341 m was used for this particular building, and it is a foot-unit that has never previously been suggested for Greek architecture. The typical suggestions for the 'long' Greek measurement-standards are the 'Doric' foot of 0.325-0.329 m and the 'Samian'

289 Pakkanen 2013a, 11-22.
290 Kendall 1974; Pakkanen 2013a.
291 See e.g. Pakkanen 2006, 277-279.

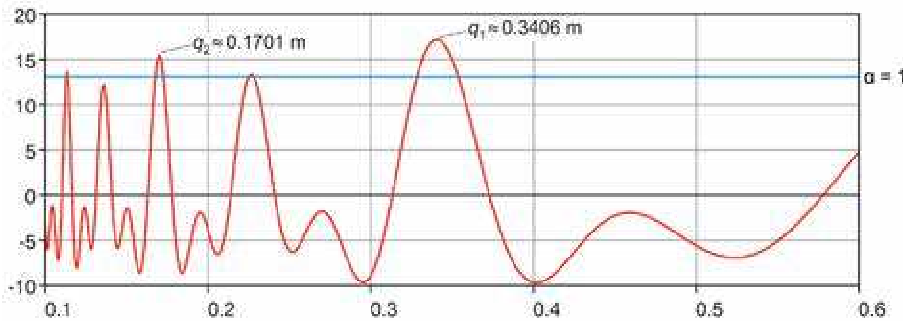


Figure 6.6b: Kyllene Harbour Project, 2014-2016. Cosine quantogram analysis of the block dimensions of S1a (n = 162) (image by Jari Pakkanen).

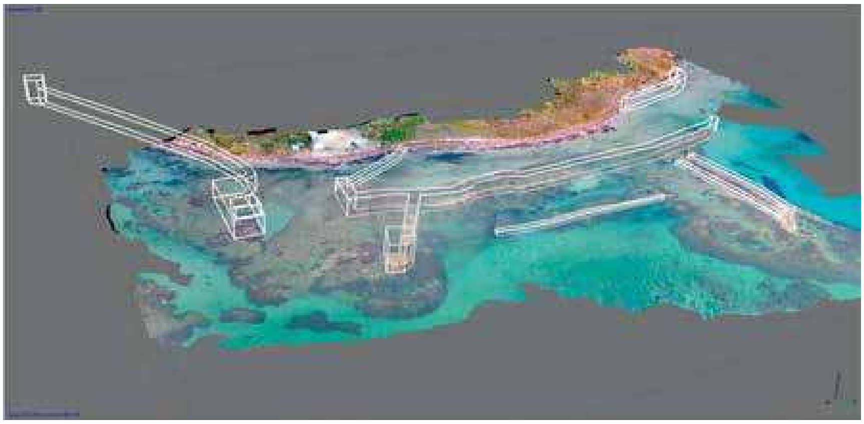


Figure 6.6c: Kyllene Harbour Project, 2014-2016. Hypothetical three-dimensional reconstruction of the harbour installations superimposed on top of the textured three-dimensional model. Projection from north (image by Jari Pakkanen).

foot of 0.348-0.350 m.[292] As this example demonstrates, metrological studies starting with preconceived notions of standardised Greek foot-units can result in invalid hypotheses of the design principles behind the analysed buildings. Methodologically sound analyses employing statistics are necessary if we wish to reach a scholarly agreement on this topic.[293]

The monumentality of the harbour installations can best be appreciated based on a reconstruction (Figure 6.6c). The quick three-dimensional sketch was produced in CAD and then superimposed on top of the textured photogrammetry model. There are, at present, too many unknown factors to produce a photorealistic model of the installations, but a wireframe image gives an idea of the possible heights and volumes of the constructions, and of the narrow entrance of the harbour.

292 See e.g. Wilson Jones 2001.
293 Cf. Pakkanen 2013a, 11-12.

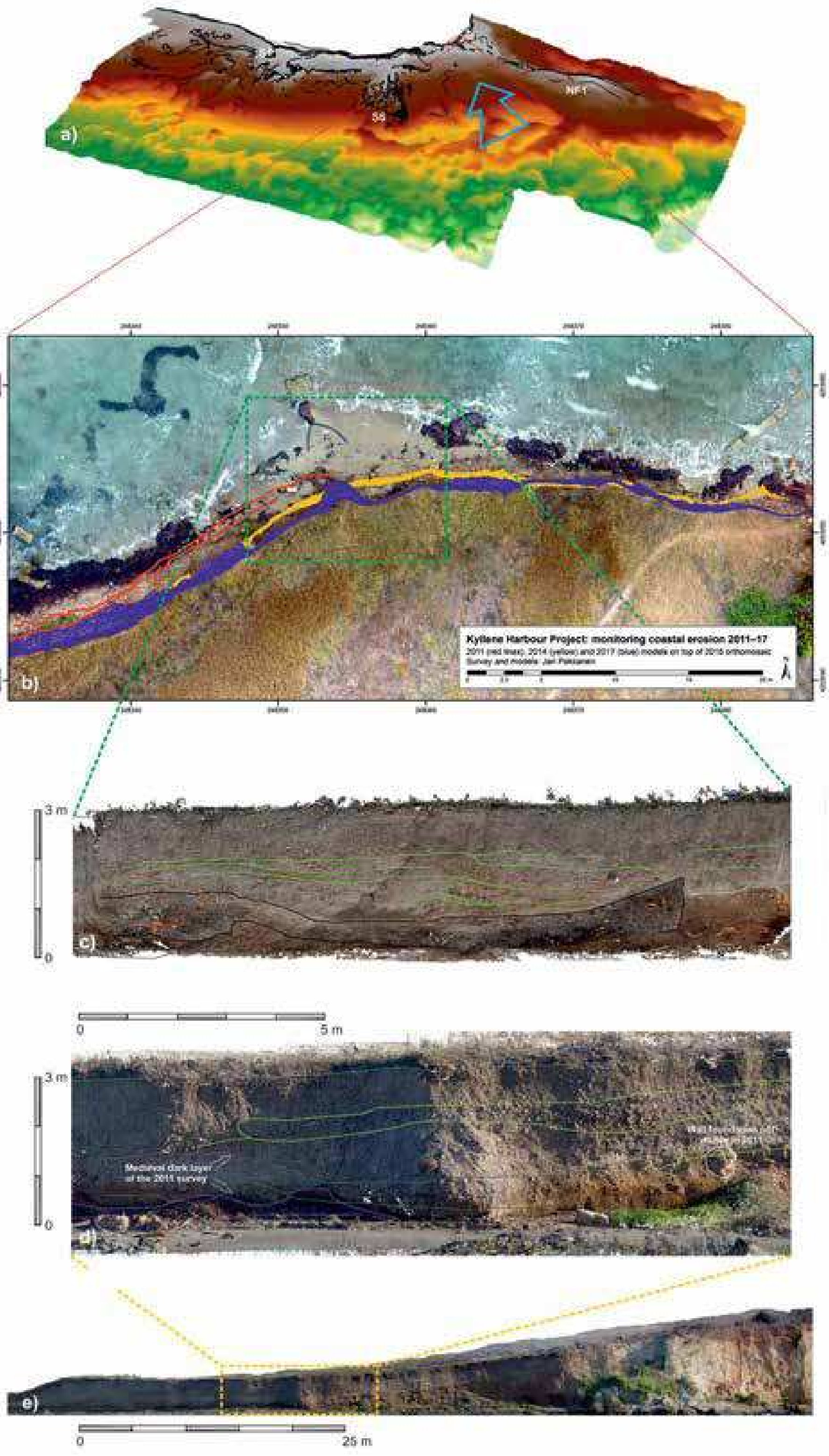
6.3.2 Monitoring coastal erosion to the west of the Kyllene harbour

The coastal scarp immediately west of the Kyllene harbour consists of archaeological occupational layers from antiquity to the end of the middle ages. Every winter, the waves directly hammer the archaeological layers of the site, critically endangering this part of the site (Figure 6.7). A programme of systematically monitoring the annual erosion of the cliff face was established in 2014 to collect data on the archaeological stratigraphy and its rate of destruction.

There are two features which jointly increase the destructive power of the waves: a finger of natural bedrock (NF1) and the great breakwater (S6) extend respectively c. 400 m and c. 150 m into the sea, and together they funnel the waves into the direction of the scarp (Figure 6.8a). One and a half metres of the cliff face disappeared into the sea as a result of the winter storms between 2011 and 2014. The sea floor data has been collected using an echo sounder, and in Figure 6.8a this information is combined with the total station survey data to produce a combined digital elevation model of the study area.

Figure 6.7: Kyllene Harbour Project, 2014-2016. Total station documentation of the cliff face with archaeological layers (image by Jari Pakkanen).

Figures 6.8a-e (right page): Kyllene Harbour Project, 2011-2017. Documentation of the fast erosion of the cliff face exposed to the sea. a) Digital elevation model of the coastal zone based on sonar and total station measurements (G. Papatheodorou, M. Geraga and J.Pakkanen). b) Orthomosaic and surveys 2011-2017 (image by Jari Pakkanen). c) Elevation of the cliff in 2014: total station survey and photogrammetry point cloud; black = medieval black layer; other colours indicate various stratigraphical layers and materials (image by Jari Pakkanen). d) Elevation of the cliff in 2017: total station survey and photogrammetry point cloud (image by Jari Pakkanen). e) Orthomosaic of the cliff face from the North in 2017 (image by Jari Pakkanen).


a)
SS
NF1
b)
Kyllene Harbour Project: monitoring coastal erosion 2011–17
2011 (red lines), 2014 (yellow) and 2017 (blue) models on top of 2016 orthomosaic
Survey and models: Jari Pakkanen
3 m
0
c)
0
5 m
3 m
0
Medieval dark layer of the 2011 survey
d)
e)
0
25 m

Since 2014, the area has been monitored annually by using photogrammetry and total station drawing. Figure 6.8b illustrates the annual changes of the cliff from 2011 until 2017. In certain places the archaeological layers forming the cliff face are quite resistant to weathering, but when these layers erode away, the changes are fast: up to 2.6 m of erosion has been recorded in the worst affected areas between September 2011 and September 2017.

Figures 6.8c and 6.8d show details of the cliff face elevations with the three-dimensional stratigraphical total station drawings superimposed on the dense point cloud generated using photogrammetry (the 2014 and 2017 views are of the same area). The textured surface models in photogrammetry are produced from dense point clouds. Importing the point clouds to CAD programs can be more straightforward than using the textured models. The model of Figure 6.8c was created from only 39 photographs taken with a handheld 12-megapixel digital camera. The model in Figure 6.8d was produced using 147 photographs taken with a 12-megapixel camera on the UAV. Several stratigraphical layers are visible both in the total station line-drawing and the point cloud, but the total station data is critical for the interpretation of the scarp especially in the case of the 2017 data where the lighting conditions for taking UAV photographs were not optimal. Finally, Figure 6.8e gives an orthomosaic of the cliff face as it was surveyed in 2017 viewed directly from the north.

6.3.3 Three-dimensional documentation at Pleuron

The ancient town of Pleuron was founded in 230s B.C.E. and it is located in Aitolia in western Greece (Figure 6.1). The early Hellenistic city walls, theatre and reservoir are particularly well-preserved. The maximum dimensions of the rock-cut reservoir were established in the new architectural survey: they are 13.0-20.7 m when measured north – south, 25.2 m east – west and 8.8 m deep at the western end. If filled all the way up to the brim, it would have been able to contain c. 3,700 m^3 of water. The reservoir at Pleuron is very difficult to document using traditional methods or even photogrammetry because of its size, depth and the presence of closely set partition walls inside. In 2015, the first attempt to build a three-dimensional model based solely on handheld digital photographs was not fully successful: from the top it was not possible to cover all features of the structure. Therefore, a new digital survey was carried out in 2016 using a combination of UAV-borne and handheld photography. Total station documentation for a line-drawing of the plan was also completed during this field season.

Figure 6.9a presents the locations of the aerial and handheld photographs: it was possible to fly the UAV between the walls and the bedrock in all of the compartments with the exception of the western-most one which has a width of only c. 1.4 m. Terrestrial photos were taken all around the monument and a total number of 410 images were used to produce the model in Figures 6.9a and 6.9b.

The reservoir plan, elevation of the second partition wall from the west, and the section in Figures 6.10a-c are directly derived from the three-dimensional model.[294] Aerial and terrestrial images can be combined to produce a single model, but the orthomosaics derived from the model need to be carefully checked: some photos can produce blurred sections and have to be excluded.

294 For an initial publication of the plan, elevation and section, see Kolonas and Stamatis 2016, 190.

Figure 6.9a: Finnish Institute Three-Dimensional Development Programme, 2016. Hellenistic reservoir at Pleuron. Combining land-based and aerial digital photography to produce three-dimensional models using photogrammetry. Model with locations of the UAV and hand-held camera photographs indicated by blue rectangles (image by Jari Pakkanen).

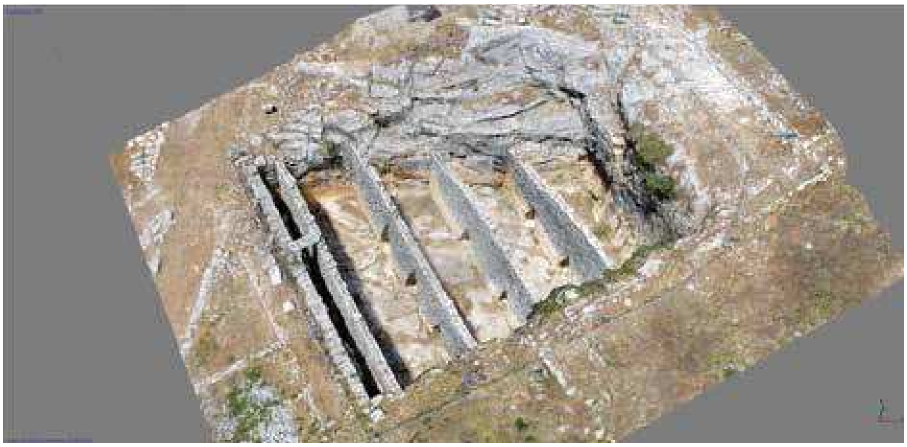


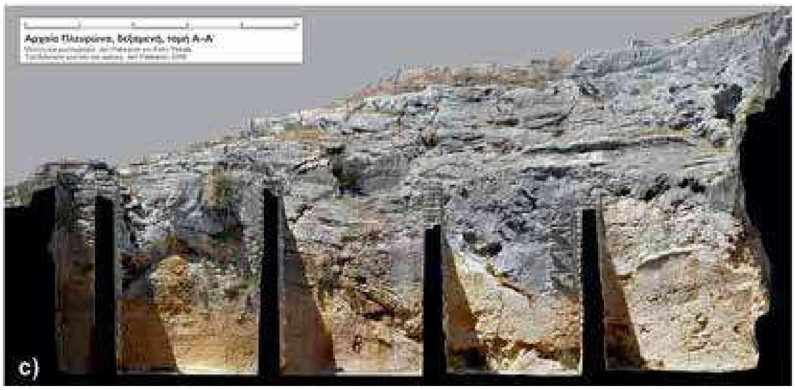
Figure: 6.9b: Finnish Institute Three-Dimensional Development Programme, 2016. Hellenistic reservoir at Pleuron. Textured photogrammetry model (image by Jari Pakkanen).

6.3.4 The shipshed complex at Naxos in Sicily

Since 2012, the city-scape project at Naxos in Sicily has concentrated on a thorough re-evaluation of the whole urban territory. The project has had three main aims: documenting the architectural remains unearthed since the 1950s, carrying out geophysical prospection inside the city walls, and excavating new small-scale test trenches at strategic locations.[295] The settlement was the first Greek colony in Sicily and it was founded in 734 B.C.E. by *oikists* from Chalcis on Euboia and Naxos in the Cyclades. The town was completely destroyed by Syracuse in 403 B.C.E. and subsequently abandoned. The Classical orthogonal city-grid is the best-known urban aspect of the town. The agora

295 Lentini *et al.* 2015.

Figures 6.10a-c: Finnish Institute Three-Dimensional Development Programme, 2016. Hellenistic reservoir at Pleuron. Plan, section and elevation derived from the three-dimensional model (JP in Kolonas and Stamatis 2016, 190). a) Plan. b) Elevation B-B′. c) Section A-A′ (image by Jari Pakkanen).



and the shipshed complex are both located in the northern sector of the town next to one another.[296]

Naxos had only a modest fleet of triremes and this is reflected in only having four slipways in the shipshed complex. The ships would have been pulled up the sand ramps to protect them from the elements and also from shipworms. The complex is an example of monumental utilitarian architecture. The size of the four slipways is more than twice the size of the largest temple in the city, Tempio B in the southwest sanctuary; also, the roof of the first phase of the shipsheds was decorated with gorgon and silenos-mask antefixes which are more often associated with sacred and civic than utilitarian architecture.[297] The Naxian shipsheds provide a case study of the possibilities of integrating total station line-drawings and a photogrammetry model with a digital reconstruction. Having an accurate three-dimensional model speeds up considerably the process of superimposing a reconstructed digital model on site documentation and fitting it with the features on the ground.

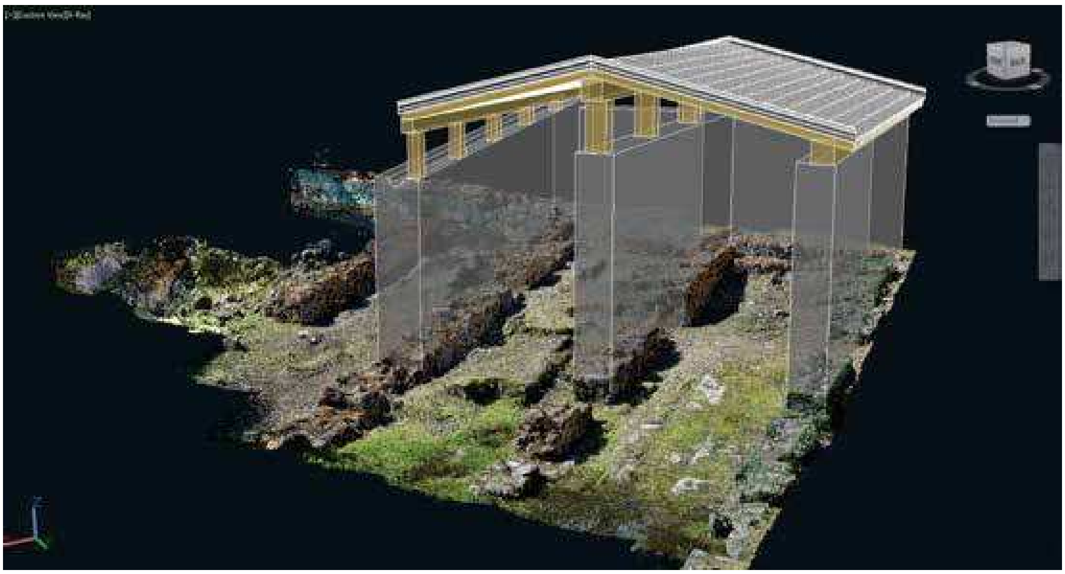
The shipshed complex in the northern part of the city was cleaned and documented in the spring of 2016. All walls were drawn using three total stations, but the delicate sand ramps were left covered with geotextiles. The produced photogrammetry model is based on 556 photographs and 40 georeferenced markers. Figure 6.11a presents the total station survey superimposed on the site orthomosaic and the different phases are marked with colours following the period classification in general use at the site: the late Archaic walls are drawn in orange, the north wall constructed as part of the Classical remodelling is green and the late Roman wall cyan. During the cleaning it was revealed that the diagonal wall at the back of slipways 3 and 4 is only related to the late Roman phase of the site and not to the Classical shipsheds: the previously presented interpretations of the architectural complex and its relation to the street behind it will need to be revisited.[298]

In Figure 6.11b the total station line-drawings are integrated with the dense point cloud of the photogrammetry model. The three-dimensional reconstruction in the northwest corner of the shipsheds covers only parts of slipways 1 and 2. The point cloud, line-drawing and reconstruction are combined in CAD. An earlier version of the reconstruction has been previously published,[299] but in order to produce Figure 6.11b it was georeferenced: this will make its future use in digital reconstructions of the city easier. Using photographs as the background of reconstructions has been the traditional approach of communicating to the wider public what the site looked like in the past, but finding the correct perspective to fit the model with the site photo can be time-consuming and it is limited to one particular view. When the digital reconstruction is integrated with the three-dimensional field documentation, the production of any projection or an animation of the target becomes a straightforward matter.

296 Pakkanen 2013a, 52-59.
297 Lentini *et al.* 2008, 379-385.
298 Lentini *et al.* 2008, 375-379; Lentini *et al.* 2015, 26, figure 9.
299 Lentini *et al.* 2008, figure 55.

Figure 6.11a (left): Urban Landscape Project of Naxos in Sicily 2016-2017. Shipshed complex. Orthomosaic of the complex with total station data (image by Jari Pakkanen).

Figure 6.11b (below): Urban Landscape Project of Naxos in Sicily 2016-2017. Shipshed complex. Reconstruction of the north-west part of the complex superimposed on the photogrammetry point cloud and total station line-drawing of the in situ architecture (JP image by Jari Pakkanen).



6.4 Conclusions

Photogrammetry has fast established itself as the mainstream method of documenting architecture and archaeological features in the field. This is largely due to low costs in hard- and software and also the user-friendly software which makes experimenting with sets of photographs feasible. The plans, elevations and sections are fast to do and they contain more information than traditional drawings. Being able to produce the documentation more rapidly could potentially result in more time devoted to the actual study of the monument. If traditional-looking line-drawings are preferred for publication, total station documentation using reflectorless laser produces more precise data than traditional two-dimensional drawings derived from hand-measurements and estimating the positions of the features. Using the laser setting on the total station decreases the time needed for recording to a fraction compared to surveying with a prism, and there is no need for the second person. Also, the relevant plans, elevations and sections can conveniently be exported from the CAD program into the preferred vector-based drawing program for final editing.

Aerial photography has the advantage of being able to rapidly record large areas and to obtain better views of the recorded targets. The relatively low resolution of most UAV images compared to hand-held digital cameras can be compensated for by flying at low altitude. Despite refraction between air and water, even underwater targets can be modelled using aerial documentation when careful attention is paid to the time of day and conditions when the photography is carried out.

One of the main advantages of superimposing total station data on top of the photogrammetry point clouds or textured models is enhancing the readability of the produced image. It is a good way of separating features and chronological phases of the documented monument, and it is possible to highlight certain elements of the recorded targets. In the completed three-dimensional models and orthomosaics subtle changes in colour and texture can be difficult to distinguish: when features are recorded in the field with total station line-drawing, this method of documentation can be combined with photogrammetry in the post-processing phase.

Acknowledgements

All research conducted in Greece has been carried out with the support of the relevant local Ephorates and permissions from the Hellenic Ministry of Culture. The largest funding bodies over the ten years of the archaeological work at Kyllene have been the Foundation of the Finnish Institute at Athens, the Kostopoulos Foundation, the Finnish Cultural Foundation, the Emil Aaltonen Foundation and the Ella and Georg Ehrnrooth Foundation. The project director is the author of this paper and the representatives of the Ephorate of Underwater Antiquities are Angeliki Simosi and Dionysios Evangelistis. Kalliopi Baika has been a vital team member all through the years. The team from the Laboratory of Marine Geology and Physical Oceanography is directed by George Papatheodorou and Maria Geraga (Department of Geology, University of Patras) and they have been responsible for the marine geophysical surveys. In addition, Andreas Vött's Eastern Ionian Sea Tsunami Research Project (University of Mainz) has taken geomorphological cores at the site.

The finance for the project *The Greek colony of Naxos in Sicily – mapping the town plan and geophysical survey* has been from the Jenny and Antti Wihuri Foundation, the Foundation of the Finnish Institute at Athens and the Finnish Institute in Rome. In Sicily the project has been carried out as part of the research collaboration agreement between the Museum at Naxos and the Finnish Institute at Athens; the project directors at Naxos are the author of this paper and Maria Costanza Lentini.

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7

Set in stone at the Mycenaean Acropolis of Athens

Documentation with 3D integrated methodologies

Elisavet P. Sioumpara

7.1 Introduction

The SETinSTONE project (hereafter SETinSTONE) aims to investigate how ruling classes in various regions of Mycenaean Greece utilized human, animal, and natural resources, in order to implement their monumental building programmes.[300] To answer such questions, the project's methodology is based partially on 'architectural energetics'.[301] This approach measures energy in terms of the time invested by the labour force in a building project, and is expressed in hours of work per person. This is further combined with a *chaîne opératoire*[302] approach. An energetics approach can investigate Mycenaean monumental architecture through the perspective of the costs required by all aspects of its construction(*e.g.* extraction, transportation, levelling, building, decoration).[303]

This paper presents one of the sub-projects of SETinSTONE: the monumental fortification wall of the Acropolis at Athens. Its aim is to give a report of the work conducted there so far, and to explain the applied methodology. The paper first reviews previous architectural studies on the Mycenaean fortification wall of Acropolis, in order to highlight the current state of knowledge on this structure. Then it explains how new data on selected sections of the Mycenaean wall were acquired through 3D

300 Earlier studies of Brysbaert on the subject, see Brysbaert 2013, 49-96; Brysbaert 2015a, 69-90; Brysbaert 2015b, 91-105.

301 Abrams 1994; Abrams-Bolland 1999, 264-269; DeLaine 1997, 106.

302 After Leroi-Gourhan 1943-1945. Regarding the compatibility of both referred methods, see Brysbaert 2011, 1-11; Brysbaert 2013, 49-51.

303 On applied architectural energetics, see Brysbaert 2015a, 91-105.

In: Brysbaert, A., V. Klinkenberg, A. Gutiérrez Garcia-M. & I. Vikatou (eds) 2018. *Constructing monuments, perceiving monumentality and the economics of building: Theoretical and methodological approaches to the built environment*. Leiden: Sidestone Press, pp. 141-168.

integrated and non-destructive methods. Lastly, it presents a preliminary report of the work carried out to date. The goals of this paper are twofold: to present the 3D documentation methodologies applied to certain sections of the Mycenaean fortification wall of the Athenian Acropolis, and to offer some initial results of these investigations.

7.2 The Late Bronze Age Mycenaean wall of the Acropolis at Athens. Current state of research

The Mycenaean citadel of the Athenian Acropolis was built on the summit of a high rock outcrop, which consists of a large ellipsoidal mass of Upper Jurassic/Lower Cretaceous limestone with neritic traces, lying above a layer of Athenian schist (*kimeliā*).[304] To the west and east, deposits of breccia adhere to the limestone which elsewhere is found on the argillaceous schist mass in surface slides. The hard and highly fractured limestone is bluish to light grey in colour, but it is also frequently tinged pink with irregular streaks of almost blood-red marl or calcite.[305] The brecciated, veined character of the stone is especially clear in the exposed portions of the rock that have been heavily worn by passing feet over the centuries. This 'Acropolis Limestone' (*Acropolites Lithos*) caps the other outcrops and is the native limestone of the hills of Athens.

Above this outcrop lies the Acropolis citadel, comprising an area of c. 30,000 m^2. It is c. 270 m long, c. 156 m wide, and rises 156.17 m above sea level. There is evidence of occupation on the Acropolis and at different places around its base since the Neolithic Period. The North Slope contains a number of wells from the Neolithic, Early and Middle Helladic periods. The Mycenaean phase of the Acropolis is still visible today, mainly through the remnants of its fortification wall, which was built at the end of the 13th century B.C.E. The circuit wall follows two previous Mycenaean habitation phases on the rock. Several previous archaeological studies focused on this LBA fortification wall and identified the highly fragmented remains of this wall (see below).

The Mycenaean fortification wall existed for around 700 years, until the Persian army severely damaged and almost destroyed it in 479 B.C.E. Successive occupants completed the destruction, the last being the Ottomans.[306] Most remaining sections of the Mycenaean fortification wall are inaccessible. In many cases they were covered directly by the later Classical fortification wall (mainly in the north sections). Preserved sections that lie to the north of the southern section of the Classical wall are preserved at a very low level and were mostly covered with soil after the great excavation of the Acropolis (1885-1890 C.E.).[307] The best preserved parts of the Mycenaean wall still visible above the ground are in the western entrance area, and the southeastern corner of the citadel. A comprehensive picture of the wall and a general reconstruction of its contour line can be identified from several kinds of archaeological data. In addition to the known wall sections, much smaller preserved areas are scattered all around the rock. Indirect indications of the wall's position come from the configuration of the

304 On the geology of Acropolis, Athens and Attica, see Judeich 1931, 43-49; Andronopoulos and Koukis 1976; Higgins and Higgins 1996, 26-30.

305 Hurwit 1999, 4.

306 Regarding the several phases of destruction of the Acropolis circuit wall, see Korres 2015, 177-185.

307 Kavvadias and Kawerau 1906.

rock, surface cuttings, and the orientation and location of Mycenaean and later buildings that presuppose the existence of the Mycenaean wall.

Early architectural studies of the Mycenaean wall in Athens are still fundamental, even though they often focused on the topographic problem concerning the location of the *Pelargikon*.[308] Moreover, they were often restricted to general observations, and the documentation of the fortification wall through traditional architectural drawings lack completeness (see below). The history of research of the Mycenaean wall of the Acropolis had several important stages.[309] The first of these was the large excavation of Kavvadias and Kawerau (1885-1890 C.E.),[310] during which most of the preserved remains were brought to light and documented; this project mapped the distribution of the wall's fragments onto the overall plan of the Acropolis.[311] Secondly, the period of the 1930s[312] was crucial with Broneer,[313] Stevens,[314] Balanos,[315] and Kolbe[316] expanding the initial plan of the wall. They added finds from the north slope, traced the continuation of the northeast ascent, and identified the north 'fountain' and the bastion inside the tower of the temple of *Athena Nike*. These studies provided crucial information regarding the formation of the western entrance, the water supply of the fortress, and the date of the Mycenaean wall. A major study of The Mycenaean wall was carried out by Spyridon Iakovides in 1962.[317] He researched all the remains of the Mycenaean wall in detail, and carried out smaller-scale excavations.[318] Iakovides's study remains the standard work on the subject until today.[319] His architectural study produced a series of very detailed and accurate drawings of the wall stretches all over the Acropolis, and incorporated them in the existing plan of the Mycenaean fortification wall. Lastly, the 1990s saw a renewed interest in the monument. The studies of Mark[320] and Giraud[321]

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308 For a summary of the different theories, hypotheses, and speculations concerning the *Pelargikon*, which rely mainly on literary sources rather than archaeological data, see Judeich 1931, 113-114.

309 For a brief history of the excavations and research history on the Mycenaean wall, see Iakovides 2006, 25-39; Travlos 1971, 52-55. For comparisons between Mycenaean fortifications, see Scoufopoulos 1971; Wright 1978; Iakovides 1983; Küpper 1996; Loader 1998.

310 Kavvadias and Kawerau, 1906, plate A.

311 Concerning the reconstruction of its contour line, Köster 1909 firstly found it to run around the entire surface of the rock. However, he reconstructed a straight line continuing from the section preserved south of the *Propylaea*, without accepting the existence of an entrance or a bastion on the western side. He did propose a northwest entrance, but he placed the main entrance on the northeastern side. Objections to Köster's thesis focused on the reconstruction of the west side. Heberdey 1910, 1-4, followed by Pfhul 1911, 299-307, used excavation data to prove that the west wall formed a curve, and that the entrance there was later destroyed by the *Propylaea.*

312 Before that, Holland 1924 had studied the remains under the pavement of the north court of the *Erechtheion* in detail. He divided the remains into three consecutive phases, and attributed them to terraces on which a palace must have been built.

313 Broneer 1939, 317-429; Broneer 1948, 111-112; Broneer 1956, 9-13.

314 Stevens 1936, 499-503; Stevens 1946, 73-79 revealed another retaining wall behind the pedestal of the statue of *Athena Promachos*. He also uncovered and studied part of the west fortification wall, where he isolated the bastion from the west wall, leaving it unconnected.

315 Balanos 1956, 785-791, 795-800.

316 Kolbe 1936, 1-64; Kolbe 1939a, 227-236; Kolbe 1939b, 393-394, 427-429.

317 Iakovides 1962.

318 Iakovides 1962; Iakovides 1973, 113-140; Iakovides 1983, 73-90.

319 His 1962 monograph was translated and printed in English: Iakovides 2006.

320 Mark 1993.

321 Giraud 1994, was the architect who studied and published the restoration proposal for the temple of *Athena Nike*.

dealt with the prehistoric remains under the tower of the temple of *Athena Nike*, and Wright[322] and Mylonas-Shear[323] researched the reconstruction of the whole western entrance area. General studies on Mycenaean fortification architecture in mainland Greece by Iakovides,[324] Küpper,[325] and Loader[326] added to a more detailed understanding of these as a wider phenomenon. The publications of Maran[327] have contributed to understanding their symbolic value.

The erection of the Mycenaean fortification wall of Acropolis dates to the end of the 13th century B.C.E., and took place after two earlier phases of Mycenaean habitation of the Acropolis. The first phases dates to LH I,[328] and consists of a room with a packed white clay floor located north of the *Erechtheion*.[329] The second phase dates to LH IIIB,[330] comprising five extensive artificial terraces with retaining walls up to 1.5 m wide.[331] These are in the northern part of the plateau, close to the later *Erechtheion*[332] (compare Figure 7.1). The unequally sized terraces were reached from the main gradual ascent at the west, and by two ascents from the north. The northeast ascent ends between terraces I and II, and the northwest ascent continued only as far as the plateau of the caves.[333] From the buildings erected on the terraces, only three blocks are preserved: a column base and two steps.[334] They were found *ex situ* and are traditionally interpreted as the only Mycenaean palace remains on the Acropolis.[335] Whether there was a palatial centre at Athens and on the Acropolis

322 Wright 1996.

323 Mylonas-Shear 1999.

324 Iakovides 1983.

325 Küpper 1996.

326 Loader 1998.

327 Maran 2006.

328 Mountjoy 1995, 14 proposes an alternative date in LH II, perhaps LH IIA, for this room.

329 Regarding the excavation of this room, see Kavvadias and Kawerau 1906, plate 6, no. 36 and Holland 1924, 151-156, figure 12. Holland (1924, 151, footnote 1) dated the room is based on ceramics found above and below its floor, dated by Wace and Blegen, as Holland 1924, 151 footnote 1 says, which is now lost. For a full description, see Iakovides 1962, 69-70; Iakovides 1983, 75; Hurwit 1999, 71; Iakovides 2006, 73-75.

330 Mountjoy 1995, 22-24 sees a possible date of LH IIIA, without excluding a date of LH IIIB for the terraces. If she is right, then the terraces and a possible palace on them would be simultaneous with the palaces at Mycenae and Tiryns, and not later, following the standard interpretation.

331 Iakovides 1962, 71-105; Iakovides 2006, 76-114. The walls of the terraces are of large unworked stones; only their outer face is regular, while the inner face was uneven and adapted to the shape of the rock. Also, the borders of the terraces established based on cuttings in the bedrock, are not universally accepted: compare Hurwit 1999, 72-73 and 337, footnote 29 with earlier bibliography.

332 Travlos 1971, figure 67 reconstructs another large terrace further south, part of the space where the later Parthenon was erected. He believes that the whole palace complex must have occupied the area of the later temples and shrines. Iakovides 1983, 112-113 footnote 21, underlines that this assumption does not rely on excavation findings. If one looks carefully at the plan, it is obvious that this sixth terrace to the south, according to Travlos, practically occupies the rest of the space of the highest and widest natural terrain of the rock, according to the altitude contour lines. Its borders practically surround the contour lines. This plan has not been reproduced in the bibliography.

333 Iakovides 1962, 97-101; Iakovides 2006, 105-111.

334 Iakovides 2006, 190-196. The well-known base of hard limestone and the two steps made of Poros stone were once located northeast of the *Erechtheion.* These blocks were removed by the Membra Disiecta project of the Acropolis Restoration Service in the Old Acropolis Museum in June 2017, in order to prevent further erosion. The service will also perform conservation measures.

335 Iakovides 1962, 173-178; Iakovides 2006, 190-196.

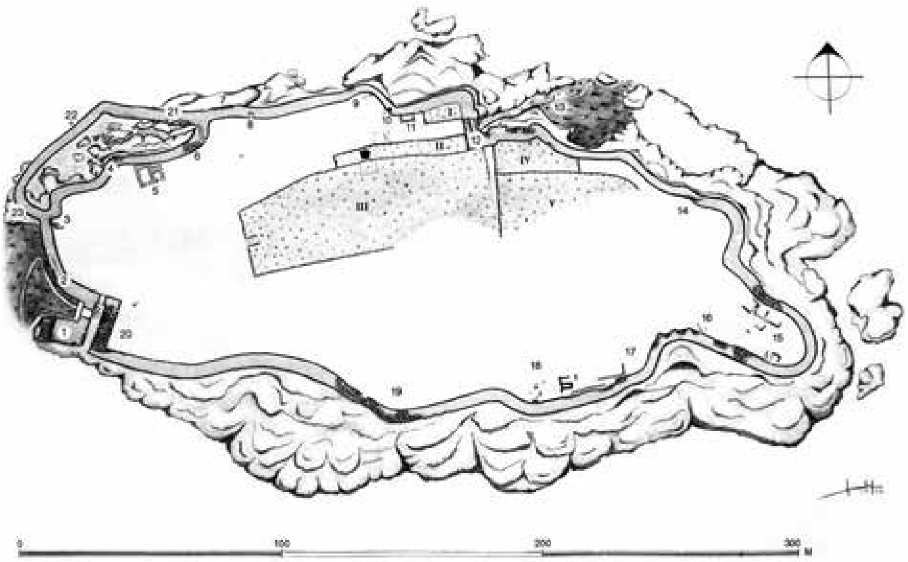

Figure 7.1: Plan of the Mycenaean Fortification Wall at Acropolis (after Iakovides 1973, plan 13).

at that time or later continues to be debated.[336] The third construction phase saw the erection of the fortification wall.

The Mycenaean fortification wall of Acropolis follows the entire brow of the natural rock, and enclosed an extensive area that covered the terraces of the previous phase (compare Figure 7.1). It was about 760 m long, most probably up to 10 m high, and ranged from about 3.5 m to 6 m thick. Its LH IIIB date, around 1200 B.C.E., places its construction after the impressive LH IIIA fortifications at Mycenae and Tiryns. The wall's state of preservation is not equivalent to that of the fortifications at Mycenae or Tiryns, and its fragmentary remains are partly invisible and inaccessible after the big excavation of the Acropolis (1885-1890 C.E.). Nevertheless, the architectural ground plans of the sections are present on the general plan of the Acropolis. This contribution follows the 1973 plan of both visible and invisible preserved stretches of the wall by Iakovides[337] (Figure 7.1).[338] He clearly distinguished between the *in situ* preserved sections and the reconstructed path of the walls based on the contour lines.[339] (Figure 7.1). Iakovides begins his description from the southwest with the bastion (No. 1), continuing clockwise and concluding with the best-preserved section on the southwestern corner of the wall (No. 20).

336 Compare Maran 2014, 123-130; Kosmopoulos 2014, 173-188.

337 Iakovides 1962, 204, drawing 38. The reconstruction of the contour line of the fortification wall and the *Pelargikon* on the northwest, do not discern between the wall sections found *in situ* and the reconstructed contour line. See also Dinsmoor 1947, figure 3.

338 Iakovides 1973, plate 13; Iakovides 1983, 79 plan 15.

339 Travlos 1971, 57, figure 61 was the first to discern between *in situ* remains and the reconstructed contour line. Travlos gave a different reconstruction of the connection between the bastion and the west wall, of the contour line of the *Pelargikon*, and of the terraces of the second phase.

The preserved remains of the Mycenaean bastion at No.1 (Figure 7.1, No. 1) are not structurally connected to the foundations of the circuit wall. It forms an irregular construction, about 16 m long,[340] 9.7 m wide and 3.8 m high,[341] in order to protect the main entrance of the citadel.[342] Parts of the west and south side are preserved, while a very small section of the north wall also survives. A cross wall with a north-south direction is also preserved, which runs parallel to the west wall and lies around 4.5 m to the east of it.[343] To the east, a wall with only one course was excavated first by Bohn,[344] and was later recorded by Kavvadias and Kawerau.[345] Mark considers this to be from a second phase, and not from the original, construction.[346] On the western front face of the bastion, Balanos[347] recorded that the bedrock was worked back to receive the lowest course of the Cyclopean sheathing. At this spot, there was a large, now inaccessible niche built into the lower courses. The roof of the niche is supported by two small pillars (and later by a column) and shows traces of burning; it is likely a gate shrine. The best-preserved section of the bastion is the west facade, and its upper part still visible today.[348] It clearly shows the tendency of the Mycenaean stonemasons to pay particular attention to corners and important facades. The blocks are set in regular courses and the interstices are filled with smaller stones and mortar.[349] The rubble stonework in the upper courses of the west facade seems to be part of a later rebuilding of its crown. This rebuilding perhaps dates to the early Archaic period,[350] as it belongs to the same phase as the wall to the east. On the south side of the bastion, large blocks are stacked together next to the corner, but to the east the masonry is only preserved in two courses. It is constructed with smaller stones, and the courses are less carefully arranged. After being cleared during the seventh century B.C.E., the bastion was used to establish a cult for *Athena Nike*,[351] which underwent two later phases. The bastion existed in this way until it was incorporated into the tower built here in the fifth century B.C.E.[352] On this Classical tower stands the marble temple of *Athena Nike*. Many questions remain regarding the reconstruction of the bastion and if

340 The length of the bastion given here refers to the preserved length of the south part. The east wall was previously thought to belong to the east wall of the bastion. As a result of this interpretation, a length of 19.5 m is often given in published research before Mark 1993, 16, who dated this wall to the second Geometric Archaic phase of the bastion.

341 Compare Balanos 1956, 789-790 and plate 1.

342 Iakovides 1962, 106-113; Mark 1993, 12-19; Wright 1994, 338-341; Iakovides 2006, 115-123.

343 Bundgaard thought that this north-south cross wall retained an upper terrace, but its two faces make this hypothesis unlikely. Compare Wright 1994, 340.

344 Bohn 1880, 311-312.

345 Kavvadias and Kawerau 1906, 139-140. Compare also Iakovides 2006, 116 and plan 17.3.

346 Mark 1993, 16, believes that this small eastern wall is the eastern limit of the rebuilt crown of the terrace. Eiteljorg 1995, 53-57 and Wright 1994, 340 both independently concluded that this wall is not Mycenaean in date. The wall is cemented and cannot be inspected today.

347 Balanos 1956, 789-790.

348 Regarding the 2012-2013 restoration and arrangement of all the remains from the Mycenaean, Archaic, and early Classical phases by the Acropolis Restoration Service, see Eleftheriou 2013, 4-5; Michalopoulou and Mamalougkas 2013.

349 Welter 1939, col. 6; Balanos 1956, 787.

350 Mark 1993, 15-17; Wright 1994, 340.

351 Mark 1993, 20-30.

352 For a very detailed description, see Mark 1993, 123-140. See also Giraud 1994, 12-15 and 34-38.

and how the bastion was structurally bound to the Cyclopean fortification wall. This is even more the case following the creation of several graphic reconstructions of the bastion and the whole western area.[353] This will be discussed further below.

At point No. 2 (Figure 7.1, No. 2) there are only a few small stones of the outer face of almost 5 m long, from an initially outer low-coursed layer.[354] Directly to the east two small 'terraces' have been identified where the bedrock has been dressed to receive the foundation course.[355] These stones have been interpreted as the outer face of the wall itself,[356] which follows closely the brow of the rock here.[357] Alternative interpretations view these stones as part of a wider terrace in front of the wall, the northwest section of which was reconstructed further to the east.[358] This point will be further discussed below.

A short distance to the north, at point No. 3 (Figure 7.1, No. 3), the line of the wall is attested by a number of stones uncovered inside the later *Pinakotheke* of the Mnesiclean *Propylaea*.[359] These stones support a Mycenaean deposit around 1 m thick and following the line of a Mycenaean house wall, which was built parallel to the inner face of the fortification wall.[360] There is a triangular space just beyond the north-western corner of the *Pinakotheke*, where the rock is sheer and the wall changes direction. Here, the western section of the Mycenaean wall ends and the north section begins.

At point No. 4 (Figure 7.1, No. 4), several stones on the levelled rock form a c. 3 m long line with two or three courses of the outer face of the wall. These are still *in situ*, and are located directly to the east of a large Medieval buttress that supports the Classical wall.[361] The presence of these stone courses in the Classical wall is supported by the existence of the Archaic cistern and drainage channels that are built directly south of them and lie inside the Classical wall.[362] The remains at No. 5 (Figure 7.1, No. 5) do not come from the Mycenaean wall, but perhaps from a Mycenaean structure.[363]

The next surviving wall fragment is around 3 m long at No. 6 (Figure 7.1, No. 6), and lies under the foundations of the Classical wall.[364] Some *poros* blocks of the

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353 Compare Dinsmoor Jr. 1980, 1-7. Wright 1994, 325-335 with previous literature on the subject and his new proposal on pp.342-349; Mylonas-Shear 1999, 86-91; Hurwit 1999, 76, figure 56, detaches the bastion from any monumental installation in the wall itself. He proposes once more a freestanding structure below the west wall, more or less like the *Athena Nike* bastion, which technically lies outside the Acropolis' main line of defence.

354 Stevens 1946, 73-75, figure 2 was the first to identify these remains as coming from the fortification wall, who also dated the structure according to ceramics found there.

355 Iakovides 2006, 123-128 with plan 19.

356 As suggested by Stevens 1946, 73-75 and Iakovides 1962, 113-117, drawings 19-20.

357 A feature common to almost the entire section of the fortification wall, Iakovides 1983, 81.

358 Bundgaard 1957, 47-87 and Dinsmoor Jr. 1980, 1-7 supported this terrace interpretation, as did Wright 1994, 342-351. For a contrary view, see Mylonas-Shear 1999.

359 Excavated in 1889 by Kavvadias and Kawerau 1906, 59-60. For its interpretation, see Hurwit 1999.

360 These observations by the excavators were accepted by Heberdey 1910, 2-3, who argued against Köster 1909 and his reconstruction of the western line. Stevens 1946, 73 also accepted this interpretation. Bundgaard 1957, 47-48 supposed the stones might originate from a terrace wall.

361 Iakovides 2006, 129-136.

362 See Tanoulas 1992, 129-160; Wright 1994, 351-356; Korres 1997, 244-245.

363 Iakovides 1962, 123; Iakovides 2006, 135.

364 Kavvadias and Kawerau 1906, Tafel 1.

Classical wall are cut precisely to fit the shape of the underlying Cyclopean blocks.[365] At this point, the wall turns to the north and there must have been a stepped gallery running through it to form the beginning of the descent to the caves.

Beyond this point, the wall turns to the east again and there are a number of stones at No. 7 (Figure 7.1, No. 7). These are from the foundation courses preserved on the edge of the rock, and lie north of the Classical wall. The stones followed the inner side at the beginning of the descent (No. 8) (Figure 7.1, No. 8) to the subterranean north 'fountain'. This 'fountain' is actually an underground well, and was one of the most ambitious installations engineered by Mycenaean architects at any of the Mycenaean citadels.[366] From this point to the north-eastern ascent, the wall line must have followed the brow of the rock, like the Classical wall.

No. 9 (Figure 7.1, No. 9) indicates three *in situ* blocks of the wall's filling. It does not indicate the faces of the fortification wall,[367] which at this point follow the brow of the rock and project to the north.[368] No. 10 (Figure 7.1, No. 10) indicates three blocks of the inner face of the fortification wall.[369] No. 11 (Figure 7.1, No. 11) forms the remains of the LH I house from the first habitation phase of the Mycenaean Acropolis (see above). After this house, the wall likely accommodated the northern and eastern sides of terrace I of the second habitation phase, on which it is partly supported.

No. 12 (Figure 7.1, No. 12) forms the passageway at the top of the northeastern ascent, the main ascent between terraces I and II. The northeastern ascent to the terraces, constructed in the previous phase, was blocked by the erection of the fortification wall. At the same time, the northwestern descent to the caves remained open and became a secondary entrance.[370] Three parallel walls blocked the northeastern ascent completely. The three walls were divided by two narrow spaces and were clearly part of a staircase built within the thickness of the wall. It led to the top of the wall precisely above the end of the northeastern approach, which was no longer used at this time. The staircase ended where the wall was highly exposed to attacks.

At No. 13 (Figure 7.1, No. 13) are house remains, which lie above the pathway of the northeast ascent and made its use impossible (see Figure 7.1). Nothing else has survived from the northern leg of the wall, which, without a doubt, followed the line of the rock for the next 30 m, like the later fortification wall. This section continued at least until the so-called *Belvedere Tower*. Here, at No. 14 (Figure 7.1, No. 14), blocks from both faces of the Mycenaean wall are preserved because they do not stand under the Classical wall.

365 Iakovides 1962, 122; Iakovides 2006, 135.

366 Regarding the Mycenaean north fountain, see Broneer 1939, 317-433 and especially pp. 326-346. For a critical review of Broneer, see Küpper 1996, 47-48.

367 Iakovides 1962, 131-132 with drawing 25.

368 Regarding the two cist graves close to No. 9 north of the north porch of the *Erechtheion*, see Gauss-Ruppenstein 1998, 1-60.

369 Kavvadias and Kawerau 1906, 85, Tafel C, No. 35.

370 Regarding the reconstruction of *Pelargikon* to the northwest, see Iakovides 2006, 210-221. According to his reconstruction, the *Pelargikon* functioned as a second fortified zone at the northwestern base of the Acropolis, and defended the plateau below the caves of the northwest slope. However, Travlos (1971, figure 71) reconstructed the *Pelargikon* as defending the entire western half of the citadel, from the descent all the way around to the middle of the south slope.

From this point on, the wall turns to the southeast and follows an orientation well within the area enclosed by the Classical fortification. On this side of the hill, the Classical wall does not closely follow the brow of the rock. The fact that most of the preserved remains of the wall are on the eastern and southern sides is a consequence of their position within the Classical defences. Thus, they were covered and preserved by the thick deposits on the south side of the Acropolis. Between the northeast and southeast, only beddings on the rock are preserved, indicating a width of around 5 m for the wall here.[371] The southeast corner of the wall forms a closed elliptical curve dictated by the natural rock formation. Two roughly parallel sections are preserved, with the rest destroyed by the Classical wall. At No. 15 (Figure 7.1, No. 15). A very well-preserved part of the wall is still visible. It forms a wide angle, with both the outer and inner faces preserved; it is around 3.5 m to 4 m thick at its southeast section, and up to 5 m at its northwest section, and almost 19 m long.[372] Even if the preserved height is only 2.22 m, it is still very impressive to see the adaptation of the fortification wall to the natural rock. A still-visible part of the inner face of the wall demonstrates its skilful inclination, its curving angle, and the construction method. Remarkably enough, any sign of the east and west elevation of this section is missing, and it is only known from a ground plan.[373]

At point No. 16 (Figure 7.1, No. 16), long stretches of the Mycenaean wall were recovered during the excavations to create the old Acropolis museum.[374] A small section of the inner face of the wall is still visible only inside the basement of the museum, where a small architectural depot exists. The rest is covered by modern cement.[375] At No. 17 and No. 18 (Figure 7.1, No. 17, 18), the remains of Mycenaean structures are preserved inside the Classical Wall, but not the Mycenaean Wall itself.

The next surviving wall fragment lies directly south of the southwest corner of the Parthenon, at point No. 19 (Figure 7.1, No. 19).[376] It is a continuous c. 40 m long section of massive, imposing masonry, and its thickness ranges from 4 m to around 5.5 m.[377] The foundations of the *krepidoma* of the Pre-Parthenon were laid on the top of this part of the wall. Behind the corner of the Pre-Parthenon, the wall becomes 5.5 m thick, but it was dismantled to make way for the stairway to the west of the Parthenon; the *Chalkotheke*[378] destroyed all the traces. Only a small part of it is still visible today through the constructed 'Well' (*phréār martyras*).

The best preserved and most impressive section stands along the western part of the wall, at point No. 20 (Figure 7.1, No. 20),[379] which abuts the Classical *Propylaea*. It is a small part of the inner face of the western inner corner. It is around 10 m long and preserves only one course before turning north at an acute angle. From this

371 Iakovides 2006, 163-171.
372 Iakovides 2006, 160-165.
373 Regarding the differences in plans from Kavvadias and Kawerau 1906, plate E, and Iakovides 2006, plan 30, see Iakovides 2006, 161, footnote 275.
374 Kavvadias and Kawerau 1906, plate E.
375 Compare Iakovides 2006, 165-171.
376 Iakovides 2006, 171-176. Tschira 1972 with drawings of the Mycenaean Wall and its interaction with S2 and S4 Wall.
377 For a detailed report on this part of wall, see Kolbe 1939a.
378 See Hurwit 1999 for its interpretation.
379 Iakovides 2006, 177-182.

point, a straight section of wall follows, which is 5.85 m thick. This is also the strongest, thickest stretch of Cyclopean masonry on the Acropolis, which suggests that it formed part of a major defensive installation on the west side of the citadel. This section is preserved today for a length of around 18 m and to a height of 3.92 m. Plans of this have been published many times, but only Bohn (1882) shows the elevation of both parts of its western face.[380] It remained visible throughout antiquity, and was not buried after the Persian destruction; it functioned also as the eastern *Temenos-Peribolos* wall for the sanctuary of Artemis Brauroneia.[381] The Pre-Mnesiclean marble *Propylon* cut the Mycenaean wall and then constructively interacted with it. There is still a large cut on a Mycenaean boulder for the blocks of the southeast *anta* of the first *Propylon.*[382] Mnesicles left the Mycenaean wall intact, and adjusted the southern wing of the Classical *Propylaea* to it. According to Dörpfeld,[383] the wall stood at least 10 m high during the fifth century B.C.E. At the southern wing of the Classical *Propylaea*, several corner blocks of its southeastern corner were trimmed back to accommodate the still-standing fortification wall.[384] The depth of this cut created some confusion concerning the previous interpretation. This cut at the corner of the marble blocks has a depth of 0.9 m at the lower courses, until the height of 3.45 m; from this height until a height of 10 m, the cut has a depth of only 0.4 m.[385] This differing depth could mean that the marble blocks were cut as the 'negative' of a recessing Mycenaean wall after 3.45 m. However, White[386] and Iakovides,[387] rejected this hypothesis. White claims that following the Persian wars, the Mycenaean wall was only preserved up to a height of 3.45 m. After 479 B.C.E. and before 432 B.C.E., a thinner wall was constructed directly above the Mycenaean wall to act as a *Peribolos* wall on the western edge of the *Brauronion*. The Mnesiclean *Propylaea* then adjusted the upper part of its corner blocks upon contact with this newly erected thinner wall, which is why the cut was less deep here.[388] Iakovides discounted the idea of a Mycenaean retaining wall, since it lacks any parallels in Mycenaean fortification architecture. One thing is certain: this wall was repaired and modified regularly until Medieval times.[389]

The reconstruction of the southwest section of the wall, the bastion, and the remains at point No. 2 (Figure 7.1, No. 20, 1 and 2) have impacted past reconstructions of the whole western entrance area.[390] Different reconstructions of the western entrance are based on different interpretations of two sets of data: 1) the remains at No. 2 belong either to the wall itself or to a terrace wall. This causes the course of the northwest section to be restored further to the west and on top of No. 2, or more to the

380 Bohn 1882, plate X; Dinsmoor Jr. 1880, plate 10, published an elevation only of the northern section of the western. Tanoulas 1997, 39 and 41 gives an excellent overview of the state of this wall section of 1990.

381 It remains unknown up to what height this wall existed in antiquity.

382 Compare Dinsmoor Jr. 1980, plate 10.

383 Dörpfeld 1885, 139, was the first to observe this.

384 This was universally accepted, see also Judeich 1931, 115.

385 Clearly visible in Dörpfeld 1885, plate V, 3; and in Tanoulas 1997, drawing 39 and 41.

386 White 1894, 49-51. Against White already Judeich 1931, 115, footnote 2.

387 Iakovides 2006, 178-179 follows White 1894, 50-51 in this interpretation.

388 I do not know of any further reference on this point after Iakovides' publication.

389 See Tanoulas 1997, 222-224.

390 Mark 1993; Wright 1994; Giraud 1994; Eiteljorg 1995; Mylonas-Shear 1999.

east; 2) whether or not the bastion was structurally connected with the southwestern section of the west wall. Important to the entire debate are the different levels of the whole western area, as well as the exact remains of the rock-cut steps[391] in front of the northwestern corner of the Classical tower of the temple of *Athena Nike*. These features co-determine the main access route. Stevens, Travlos, Iakovides, Giraud, and Mylonas-Shear restore the fortification wall further to the west and on top of the remains of No. 2. Stevens, Iakovides, and Giraud leave the bastion unconnected with the fortification wall. Dinsmoor, Bundgaard, Dinsmoor Jr, Wright, and Eiteljorg restore a terrace in front of the wall that lies on top of the remains at point No. 2, and place the fortification wall further to the east. The latter group also the bastion also unconnected to the wall, except Wright, who restores a tower at the east end of the Mycenaean bastion. This contribution leaves the debate over the reconstruction of the Mycenaean western area at this point.[392] It remains an open issue and demands a re-evaluation of all data. However, for the purposes of the present research, different reconstructions influence subsequent calculations of the required labour costs, which will be discussed in greater detail.

The material used for the construction of the Mycenaean wall, particularly the large boulders used for the Cyclopean masonry, is either the native limestone, so-called *epichorios lithos* ('on-the-spot' stone),[393] or the *Acropolites Lithos* (Acropolis stone). Previous researchers have stated that this Acropolis limestone was also extracted from the hill of the Acropolis for the Mycenaean wall.[394] The hills of the Nymphs or the *Asklepieion* have been suggested as alternative sources, but never as exclusive extraction locations.[395] Only Wycherley[396] argued that the material for the Mycenaean fortification wall came almost exclusively from other hills and not the Acropolis hill. It seemed impossible to him that the sacred hill of Athena would be defaced or weakened by quarries. At this point, the volume of the stone material required for the construction of the entire Mycenaean Fortification wall has not yet been calculated. Nevertheless, we can be certain that, if all this material was extracted only from the Acropolis hill, the entire natural outcrop of the Acropolis rock would have been excessively altered, transformed, and eroded. The lack of any such indication or evidence leads me to agree with the argument of Wycherley, that the Mycenaean wall of the Acropolis must have been almost exclusive built with native limestone from the other hills of Athens, such as the Pnyx or the hill of the Nymphs.[397] Following this hypothesis produces dramatic differ-

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391 For the most reliable documentation of the rock-cuttings, see Tanoulas 1997, 239 with figure 318 and drawings 46-47.

392 The terrace that Mylonas-Shear 1999, figure 1.19 and figure 2 reconstructs further southwest of the bastion is not based on archaeological data. See also Tanoulas 1997, drawing 43 and 47.

393 There is no terminology for this material in ancient sources. It was also used after the Mycenaean period, for example, for the inner foundations or the cellar foundations of the so-called 'Dörpfeldfundament', and for the temple of Athena Polias in the late sixth century B.C.E., see Wycherley 1978, 7-10, 269.

394 Hurwit 1999; Iakovides 2006, 235.

395 Welter 1939, 1-9 describes the material of the bastion as great blocks of Acropolis limestone and others as being from the hill of the Nymphs. Miller 1893, 476-484 attributed the quarrying of the rock in the area to the *Asklepieion*.

396 Wycherley 1978, 269.

397 Regarding the ancient extraction of limestone in the western hills of Athens and the *Barathron* created there because of quarries, see Kourouniotis and Thompson 1932; Korres 2008, 73-74. Regarding the 19th century quarries there, see Bogiatzoglou 2013, 202-204.

ences in the question of labour costs, especially in terms of transportation costs. The exact identification of the material employed remains one of the most crucial questions to be answered. The smaller fill stones must have come from the masonry work on the large boulders used in the wall. The stone material is extremely hard and is suitable for Cyclopean or rough polygonal masonry. The use of native stone had a special meaning, and the walls almost seem to grow out from the Acropolis native rock itself.

The Mycenaean fortification wall of the Acropolis[398] was constructed directly on the very edge of the rock. Because the rock was uneven, its surface had to be modified to support the foundations and the Cyclopean blocks, or needed a layer of smaller stones to create a level surface. The latter technique was employed mainly for the inner faces. The wall itself was built with irregular blocks of native limestone of various sizes, and were unworked or roughly dressed mostly in irregular courses. Small stones were inserted into the gaps between these blocks , and a yellowish clay and sometimes mortar were also used to connect the blocks.[399] The blocks were set in regular courses, like at the western front of the bastion, where they were filled with smaller, often flat stones, clay,[400] and mortar.[401] In general, the circuit wall has two outer parallel faces of Cyclopean masonry, with a depth ranging from 3.5 m to 6 m. Although the blocks of the inner face sometimes are smaller and less carefully constructed than those of the outer face, they both were positioned in a similar manner. The two faces are separated by an inner fill of earth and small stones, and without any internal cross walls. Sufficient strength was provided by the massive boulders, and flexibility was created by the minute spaces between the blocks and smaller stones. Large boulders reinforce the corners and important facades are given more attention, both of which are known from other prominent Mycenaean structures.[402]

Since both sides of the wall are very carefully built from its bottom on the rock, it has been frequently said that it was meant to stand free,[403] even if this construction with big, well cut boulders was required mainly for static and technical reasons. However, it is most probable that certain sections of the Cyclopean wall were not free-standing, but, were back-filled with earth to form a flat terrace; this would be almost flush with the top of the wall itself.[404] Mycenaean citadels (*e.g.* Mycenae and Tiryns), do not have the free-standing and high walls characteristic of Classical and Hellenistic fortifications, which hide the habitation behind a high protecting wall. Instead, they are raised high above any possible attackers to stop the use of weapons against the defenders.[405]

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398 Especially Iakovides 2006, 234-239.

399 Earth was packed between the blocks, which contained LH ceramics. Stevens 1946, 75-106 refers also to mortar between the blocks at section No. 2, around 7 m west of the central entrance of the *Propylaea*, containing prehistoric sherds. Judeich 1931, 115 excludes mortar in the construction.

400 Welter 1939, col. 6. Balanos 1956, 787 compares the western front of the bastion with the masonry of the Cyclopean bridge at Agios Georgios at Mycenae.

401 Mark 1993, 15-17 argues that the rubble stonework is part of another rebuilding of the wall's crown that dates to the late Geometric-early Archaic period. These courses consist of smaller stone-built dry walls with a reddish earth fill behind them, which are visible also in the elevations at the west face.

402 Wright 1980, 66, 70, 75-76.

403 Kolbe 1936, 12; Heberdey 1919, 233.

404 Bundgaard 1976, 19-20; Hurwit 1999, 75.

405 Bundgaard 1976, 20.

Lastly, the dating of the Mycenaean fortification wall around 1200 B.C.E.,[406] was established from three groups of ceramics.[407] It is also commonly accepted in previous research that the fortification wall was built in one construction phase,[408] although some scholars argue for more construction phases.[409]

How important was the Acropolis, Athens, and Attica at the end of 13th century B.C.E. in order to create this impressive fortified citadel, and who lived there? A local ruler or a king? These are still open issues, which need further investigation[410] and go beyond the limits of the present research. The construction of the Cyclopean walls and northern 'fountain' at the end of LH IIIB surely formed a response to a perceived threat, according to *communis opinio*. The Athenians feared a siege: that much is clear. The monumentalisation of the Acropolis was so sudden, and the similarities of its defences and 'fountain' to analogous structures at Mycenae and Tiryns is very striking. These features appear not to be the result of an organic or internal process, but rather the result of external forces. The impetus may have come not from a local hero such as Erechtheus or Theseus, but rather from the kings of Mycenae and Tiryns, who sent builders to Athens to make it the dominant site of Attica. The decision to fortify the Acropolis would have been, in this view, part of a grand defensive scheme devised in the Argolid, the undisputed centre of power in LBA Greece. As part of a coalition of Mycenaean states, the role of the Acropolis could have been to protect the eastern flank of central Greece.[411]

7.3 Gaps and discrepancies in the research of the Mycenaean fortification at Acropolis

Despite the systematic and thorough research conducted so far on the Mycenaean fortification wall, there are still gaps to fill and discrepancies to be explained. I now attempt to explain some of them and how they connect with this sub-project of SETinSTONE.

The most important missing element from past research on the Mycenaean wall is the inadequate documentation of all its remains. Even if the ground plan of these remains is accurate, as seen from the latest plan by Travlos and Tanoulas,[412] it lacks almost all the elevations of the remains, even of the still visible ones.[413] Further architectural

406 Iakovides 1962, 205-206.

407 Mountjoy 1995, 40-41 with previous bibliography on the subject.

408 Iakovides 2006, 227-231; Pantelidou 1975, 24-27; Hurwit, 71-80.

409 Travlos 1960, 22, 24-26, postulated two construction phases of the wall, a first one on the top of the rock from the 15th century B.C.E., with one entrance at the west and another where the northeast approach ends. In the second period, in the 13th century B.C.E., the wall encloses the entire rock, the northeast entrance is closed, the northwest access to the caves is opened, and the west bastion is built. Mylonas 1966, 37-39 suggested that the whole bastion was later than the fortification wall, but this was rejected by Iakovides 1983, 79-82. For the two construction phases on the bastion and especially on its west side, see Mark 1993, 15-17; Wright 1994, 340.

410 See 'Athens and Attica in Prehistory', a conference held at the American School of Classical Studies, Athens, 27-31 May 2015.

411 Immerwahr 1971, 153; Hurwit 1999, 80-81.

412 Tanoulas 1997, plan 42. The first plan to incorporate most, but not all the remains is Kavvadias and Kawerau 1906, plate A.

413 Iakovides 1962 and 2006 published all the plans of the investigated sections, but not all the elevations, even where it was possible to measure these figures.

drawings of details are also missing. These data are fundamental for any further study, and its absence is the result of several factors, but three in particular: 1) Remains of the wall that were revealed after the large excavation of the Acropolis at a great depth that were lying deeply (either south of the Parthenon or under the old Acropolis museum) and were reburied directly after the excavation.[414] These were documented almost exclusively through ground plans so as to incorporate them into the general plan of the Acropolis.[415] The great efforts of Bundgaard[416] to reconstruct most of them based on archival material may be the best we have, but it still lacks thoroughness. Since the remains are invisible today, this gap is impossible to fill. The same issue applies to the remains lying mostly under the Classical wall, and to remains of the bastion now under the tower.[417] 2) Remains are still visible outside the north section of the Classical wall, where the terrain is difficult for fieldwork. I refer mostly to the remains at No. 4 and No. 7, which are known only from the detailed plans of Iakovides.[418] Even if the terrain were more accessible, to record these remains would require special equipment.[419] 3) Even for the best-preserved sections on the western and southeastern sides (No. 15 and No. 20), documentation is lacking. There is currently only one western elevation of the southwestern part, which was came from Richard Bohn's research on the Mnesiclean *Propylaea*.[420] No elevations have been published of the southeastern section and still visible part of the Mycenaean wall. One of the most important *desideratum* in the research of the Mycenaean Acropolis fortification wall is to completely document all the still visible and accessible parts of the wall. This documentation now being undertaken by the author as part of SETinSTONE will be an important source for further investigations or implementations of conservation works.

The second main lacuna in research on the Mycenaean wall of the Acropolis deal with identifying the material used in the fortification. These data are crucial for this sub-project of SETinSTONE, as they greatly impact the transportation costs and the energetics of the whole building project (see above). Wycherley's his issue should also be seen in combination with the extraction of the Acropolis limestone, in order to construct the Mycenaean 'fountain' at the north, which also dates to LH IIIB.[421] The extraction of the native limestone of the Acropolis hill had already taken place during the second habitation phase. As this quarrying occurred at the same time as the construction of the northwest descent and the northeast ascent, these issues should be considered together to reach better overall results.

An additional unanswered question in researching the Mycenaean wall is the reconstructed height of the fortification wall. Dörpfeld's proposed height of over 10 m for the southwestern section was generally accepted, but was opposed by White and

414 I refer to the remains mostly at the south section of the wall: No. 16, No. 17, and No. 18.

415 Kavvadias and Kawerau 1906, plate A with details at the other plates.

416 See the restored plans in Bundgaard 1976, plates A-G.

417 The bastion on the south-west has still today the best documentation, based mostly on the plans, archival material, and photos published by Balanos 1956; see also Mark 1993 and Wright 1994.

418 Iakovides 2006, plans 21, 22, 23, and 24.

419 During 2008 the whole rock under the Classical wall of the Acropolis was cleaned of vegetation, a task performed by professional climbers, compare Ioannidou 2008.

420 Bohn 1882, plate X, at a scale of 1:75.

421 Regarding the 'fountain', see especially Broneer 1939; Broneer 1956, 9-18.

Iakovides.[422] The data provided from the cut of the blocks of the *Propylaea* should be reconsidered in this context. As it is the only place of the wall with an approximately preserved height, this section can be used as the basis to reconstruct the height of the whole wall. Further examination of this section can assist the present study in its estimate of how much volume of material was needed for the erection of the entire fortification wall. This information is one of the most crucial factors for estimating the labour costs of the whole building project.

The question of the reconstruction of the west entrance area also remains open, and it affects the calculations of SETinSTONE in the same way as the previous point. The extant reconstruction of the western contour line of the fortification wall affects its length and consequently the material needed. All the data will be reconsidered by the present project in order to formulate a secure reconstruction of the contour line.

The final research gap concerns the construction method of the wall, especially as measurements of the form and the size of the limestone blocks used has not been carried out. The use of large boulders on both faces of the wall clearly proves the need to study this aspect in preserved sections and those only visible in archival photographs. These measurements will have a profound effect on calculating the architectural energetics for the wall. If the implementation of different construction methods (*e.g.* building in courses), corresponds to different construction phases, this will greatly affect the questions of our study. It is, therefore, important to clarify where the wall was free-standing or where it required a terrace on its inner side. In the latter case, this study can then estimate the volume of earth needed for the terraces behind the wall.

7.4 Three-dimensional integrated methodologies for the documentation of the LBA fortification wall of the Acropolis at Athens.

Highly accurate documentation and 3D reconstructions of monuments are fundamental to better analyse and interpret them. For the investigation of the LBA fortification wall at the Acropolis of Athens,[423] SETinSTONE follows two specific methods to record the architectural remains. These complement each other and increase the representative efficacy of the final results. The 3D digital analysis of the architecture of the fortification wall of the Acropolis was carried out using active and passive techniques (range-based and image-based methods). This dual approach produces basic data for analysis and interpretation, which can then be used to construct 3D models of the actual state of preservation of the monument. From these accurate models, further reconstructive hypotheses can be formed. Using digital instruments has the benefit of applying current digital technologies and are non-invasive to the architectural remains. They also provide quick results with a high degree of accuracy, when compared to more traditional methods for the recording of architecture, and avoid the high costs involved in 3D scanning. The methodologies used in the documentation consist of 3D laser 'drawings' captured with a total station (employed in the reflectorless mode), together with 3D models generated by terrestrial photogrammetry.

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422 See above.
423 See also Brysbaert *et al.* 2018.

Firstly, the wall is documented using a total station to produce 3D line drawings in AutoCAD software.[424] This method was applied as follows: Firstly, a network of several chequered targets was set up along every section of the Mycenaean fortification wall, which were then measured with the total station (Leica, Model T1000). The obtained network can rely on at least three points in different directions in every possible position, in order to measure the remains. As a result, we are able to obtain a dense grid of fixed points. In order to achieve a homogenous reference system in which the acquired data is oriented to each surveyed structure, the grid of fixed points is connected to the official reference system at the Acropolis Archaeological Site. This system was created by the Acropolis Restoration Service of the Greek Ministry of Culture, and follows the Greek geo-reference system (EGSA 87). The current project thus ties into the official reference system, ensuring that the newly acquired data are compatible with the official data on which all the Acropolis works are based. The network of newly created fixed points on every wall section guarantees two important conditions for the workflow: a) accuracy to the millimetre, and b) frequent changes in the position of the total station in order to record all the remains efficiently and from the right angles. The distances between the wall remains and the total station are insignificant, since the laser bridges these easily without losing high accuracy. The aim of using the total station is to record the architectural remains principally as outlines, using different codes for open or closed lines, so that the data can be 'read' later.[425] In order to 'draw' each stone's outline, I recorded a point on average every 5 to 10 cm along this outline to create an accurate polygonal outline of boulders and smaller stones. The smaller stones filling the gaps between the boulders were not recorded in detail to avoid an overload in unnecessary lines. In one day, it was possible to document 2,000 to 3,000 points. A coding programme[426] developed by the Finnish Institute at Athens converted the total station measurements into line drawings. AutoCAD displays the line models in 3D, and line widths, types, and colours then can be modified to indicate differences in the recorded architecture for the final publication. Thus, our data are based on a wider and verified set of georeferenced metric data. At the end of each working day, all exported data were double-checked and the resulting drawing was printed. This allowed to immediately verify what had been recorded and was carried out in the field.

Next, digital terrestrial photogrammetry was used, which allowed us to acquire precise metric data for 3D surface models, virtual reconstruction, and visualization of the remains of the monuments. Using a digital camera (model NIKON D 7200), and software based on ad hoc algorithms, it was possible to survey the analysed features and to reconstruct a 3D digital model. A network of photo points was created on several sections of the wall. In order to geo-reference the models, the photo points were integrated into the Acropolis master grid of the fixed points at every single section of the Mycenaean fortification. We used Agisoft Photoscan, the main commercial software of Structure from Motion, which estimates the parameters of the internal and external orientation of the photographs. The programme then re-creates a 3D model that

424 Pakkanen 2009; Pakkanen 2013.

425 In case mistakes were made in the coding, these could be corrected in the exported data in .txt format.

426 The windows console program for interpreting total station data into a CAD drawing developed as part of the Finnish Institute 3D Development Programme, see Pakkanen, this volume.

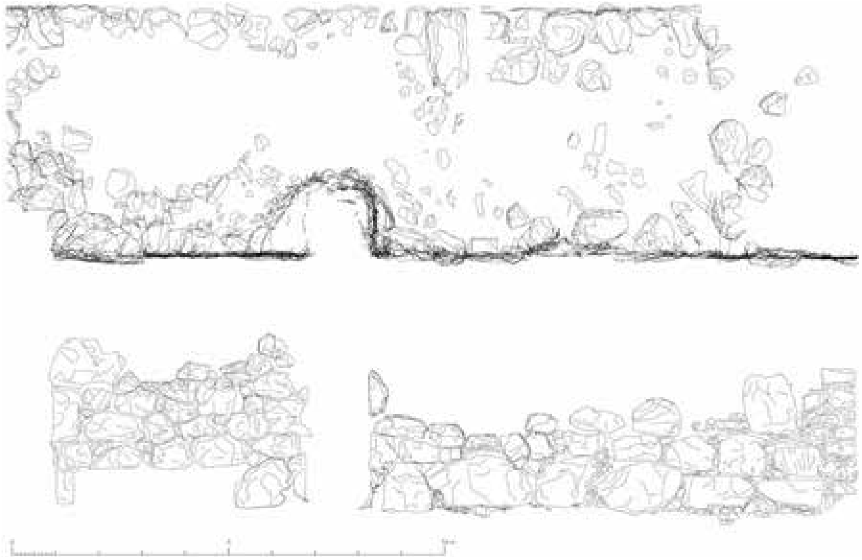

Figure 7.2: New plan and west elevation of the remains at southwest corner of the Mycenaean Fortification Wall at Acropolis (3D line-models in AutoCAD with reflectorless laser total station, without processing, E. P. Sioumpara).

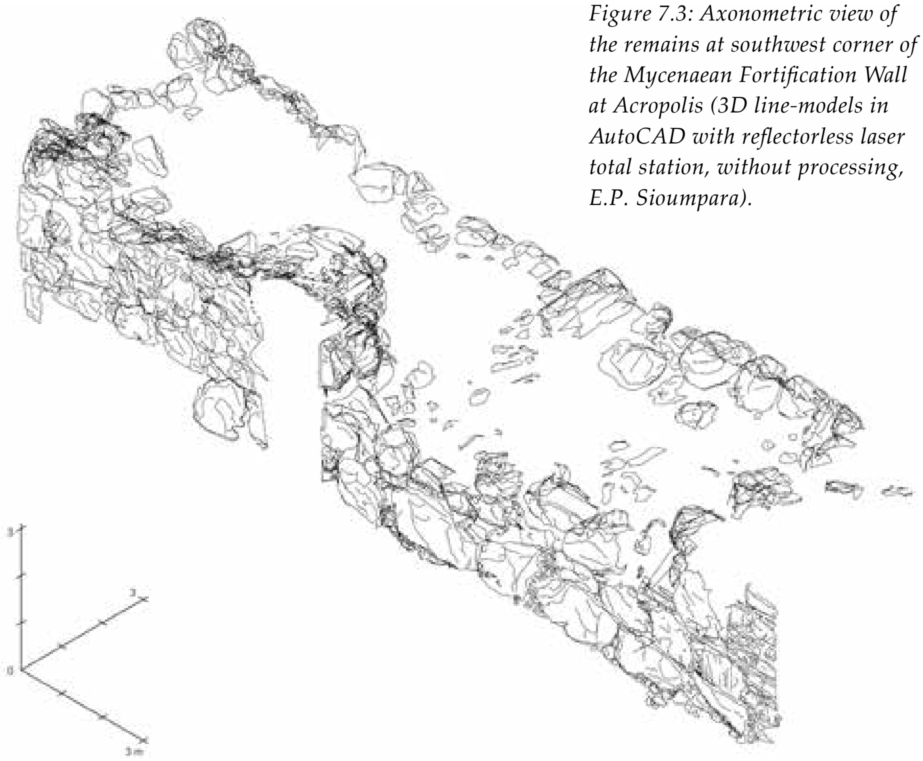

Figure 7.3: Axonometric view of the remains at southwest corner of the Mycenaean Fortification Wall at Acropolis (3D line-models in AutoCAD with reflectorless laser total station, without processing, E.P. Sioumpara).

Figure 7.4: 3D Photogrammetry Model of the remains at southwest corner of the Mycenaean Fortification Wall at Acropolis (E. P. Sioumpara and V. Klinkenberg).

can be subsequently analysed.[427] After measuring the photographed points with the reflector-less total station, the software complements the total station data by creating 3D surface models using ground-acquired images. A digital camera (Nikon D7200) was employed to acquire the images which were resampled to 2,000 × 3,000 pixels; this produced manageable photographs while maintaining the quality needed for the texture of the model.

In order to create a 3D photo model of sections that have a large geometrical complexity and large differences in height levels, it is important to acquire photographs from different heights, for example, to have both the front and upper sides present in one image. In order to achieve this without using aerial photographs, high ladders of 6 m to 7 m were required. For the remains of the Mycenaean wall at the southwestern corner (Figures 7.2 and 7.3, compare also Figure 7.1, No. 20), for example, we took around 500 photos and 80 photo points to create the 3D surface model (Figure 7.4). Next, the dense cloud and the triangle mesh were created, thus obtaining the 3D models of section 11 of the Mycenaean fortification wall. After processing the photographs, we found the precision of the oriented final models to be less than one centimetre. Therefore, they were considered to be adequate for a detailed architectural representation. The next goal of this study is to combine measurements from both the AutoCAD 3D drawings and the photogrammetry models of the volumes of stone building materials. These data can then be added to task rates to estimate labour costs. This stage of the research will be carried out when all the field work is completed, and will be presented in a future paper.

In order to start with the recording of the remains of the Mycenaean fortification wall of the Acropolis, specific criteria were established, regarding which sections would be analysed, and in which order. Seven of the 16[428] points on Iakovides' map were chosen to be recorded (No. 1, 2, 12, 15, 16, 19[429] and 20) based on their accessibility and preservation. The other nine points were excluded because they are covered by earth or by the north Themistoklean wall,[430] or they lie at the edges of the rock brow outside the

427 Balletti *et al.* 2014 with earlier bibliography on the subject.

428 From the 20 points at figure 7.1, No. 5, 11, 17, 18 do not belong to the fortification wall itself.

429 The remains at No. 16 and No. 19 are covered by earth and only small parts of them are accessible in the basement of the old Acropolis Museum and in the 'Schacht' southwest from the Parthenon.

430 I refer to the remains at No. 6, 8, 9, 10 and 14. See also under section 2 above in this paper.

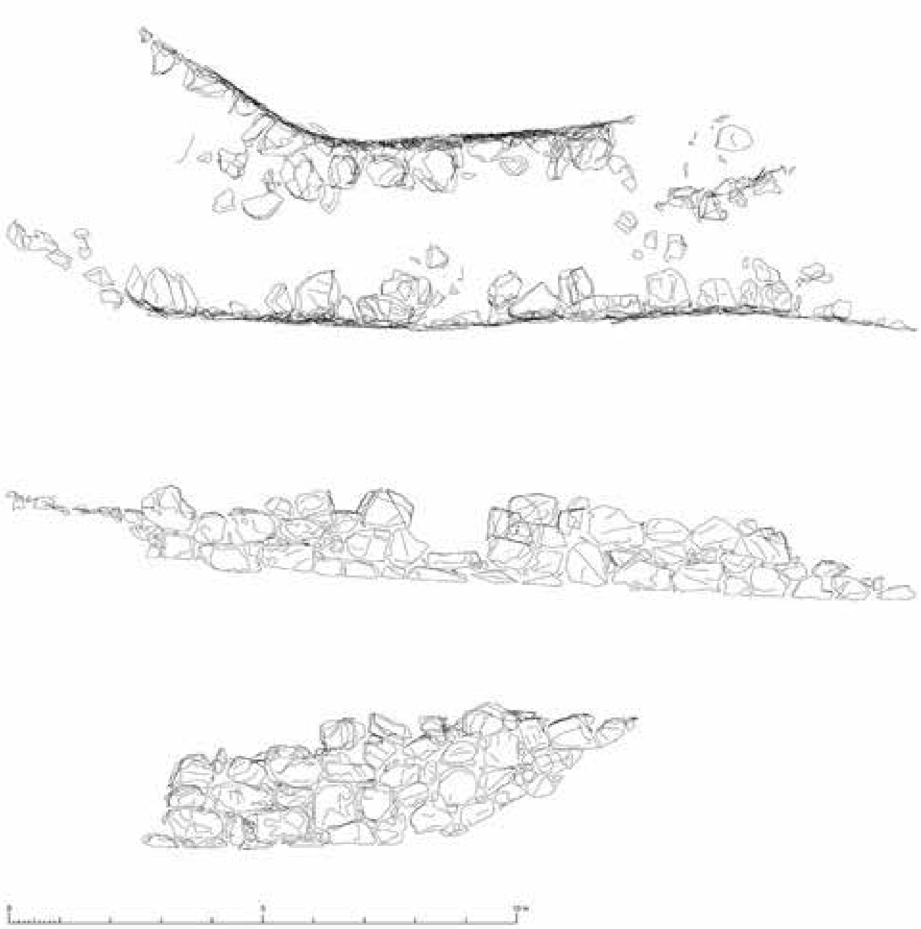

Figure 7.5: New plan, west elevation and southeast elevation of the remains at southeast corner of the Mycenaean Fortification Wall at Acropolis (3D line-models in AutoCAD with reflectorless laser total station, without processing, E. P. Sioumpara).

north Classical wall, and are inaccessible without special equipment.[431] The northwest descent to the caves was added to those seven sections.[432] The calculation of the labour costs of carving the stairs into the rock is crucial to understand the construction method of carving bedrock. Since the wall adjusts its form on this descent, the stairs will be also recorded, in order to gain a more comprehensive idea about all the work involved in the wall's construction.

We initially focused on three sections (see Figure 7.1, No. 15, 16, and 20), with positive outcomes despite the limited accessibility. These three sections represent more

431 Especially points Nr.4 and No. 7. For this reason Iakovides, the first to identify and record them, is to be lauded. The remains at No. 3 (under the *Pinakotheke* of the *Propylaea*) are not accessible because different materials are stored there, which cover the remains today.

432 It is studied even though it dates to the second phase of the Mycenaean citadel, and its construction does not belong to the LH IIIB construction phase of the fortification wall. Documentation work will take place there only if the area is going to be cleaned from the extremely dense plant-growth.

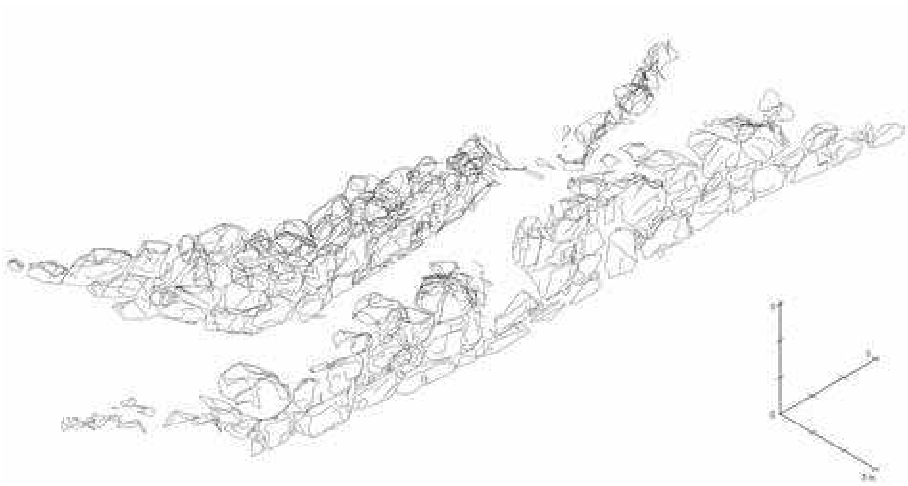

Figure 7.6: Axonometric view of the remains at southeast corner of the Mycenaean Fortification Wall at Acropolis (3D line-models in AutoCAD with reflectorless laser total station, without processing, E. P. Sioumpara).

Figure 7.7: 3D Photogrammetry Model of the remains at southwest corner of the Mycenaean Fortification Wall at Acropolis (E. P. Sioumpara and V. Klinkenberg).

than half of the remains that will be recorded for SETinSTONE. Their accessibility and good state of preservation led us to focus on the east and southwest sections.

The southern end of the west fortification wall (Figure 7.1, No. 20), was recorded first. Its integration within the first marble *Propylon*, the later Mnesiclean *Propylaea*, and later with the large Medieval tower makes this section very interesting. This is especially the case as it is the only section of the wall that interacts with the later monuments. The topographical survey produced a 3D model: a plan (Figure 7.2) and a 3D view of the whole section from the southwest corner (Figure 7.3) are presented here. Figure 7.4 shows the 3D surface model with terrestrial photogrammetry, seen from the southwest and northwest corner. The section of the wall at the southeast part (Figure 7.1, No. 15) was recorded next. The plan, the west and east elevation, and also 3D photogrammetry and drawing models, constitute the new documentation material (see Figures 7.5 to 7.7). The small section in the basement of the museum (No. 16), was the third section to be recorded (Figures 7.8 and 7.9).

Figure 7.8: Elevation of the remains at east corner of the south section of the Mycenaean Fortification Wall at Acropolis (3D line-models in AutoCAD with reflectorless laser total station, without processing, E.P. Sioumpara).

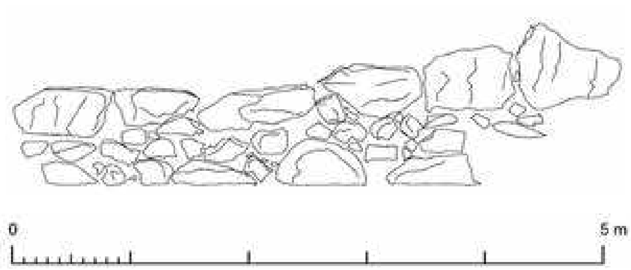

Figure 7.9: 3D Photogrammetry Model of the remains at east corner of the south section of the Mycenaean Fortification Wall at Acropolis (E.P. Sioumpara and V. Klinkenberg).

7.5 Summary and preliminary results of the work

The documentation of the three sections described has produced some preliminary results which are summarized below:

i. Regarding the construction, we found that the size of the boulders of native limestone used in the wall can vary. The reinforcement of the corners of the construction using large boulders is therefore confirmed. The biggest boulders were found in the lowest course of the south part of southwest section. They range in size from 1.50 m × 0.56 m up to 2.08 m × 1.30 m with a calculated average depth around 1 m, and a volume of around 0.84 to 2.74 m^3. This confirmed that the construction of the outer corners needed the largest boulders for stability reasons, and that these were built directly on the rock.

ii. The average size of the boulders is around 0.70 m to 1.50 m × 0.50 m to 0.80 m with a depth around 0.75 m. They are found in the outer and inner faces of the wall, as seen in the southeast section of the wall. Therefore, they correspond to the sizes known from other LBA fortification walls with Cyclopean masonry.[433]

iii. Smaller stones were used to fill the gaps between the boulders, but not in all cases. In the north part of the wall section, only small stones are used, without big boulders. The boulders could also be cut in such a way as to fit to each other with minimal or no gaps at all. In this case, small stones were used only to fill in the space between the outer and inner faces of the wall.

iv. At the southeastern section, the north part of the east front was fitted perfectly onto the rock and its slope; the wall here uses large and small boulders, and small stones to fill the gaps. It is the only place where we can follow exactly how the line of the wall changes direction. Also, the difference in the depth of the north and south section is discernible here.

433 Compare the sizes of boulders at other LBA Mycenaean fortification walls in Wright 1978, 181, and Loader 1998, 75. For Tiryns see also Brysbaert 2015a, Table 3.

v. At the southwest section, we can observe different phases, for example the medieval phase is clearly visible in the upper part of the middle west front, where spolia, bricks and mortar have been used in its construction.[434] The assumption of two phases at this section from Kavvadias and Kawerau[435] is based on a different construction technique and could not be verified. In my opinion, the use of rather big boulders at the bottom and of smaller stones at the preserved top is due to reasons of stability and does not indicate two different chronological or construction phases. Conservation measures, where cement has been used to strengthen the wall, are clearly visible at the southwest corner and around 5 m north of the southwest corner.[436]

After the seven sections of the fortification wall and the northwest descent are recorded, the calculation of the labour cost for this monumental building project will follow, using the architectural energetics method.

Acknowledgments

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434 See also Tanoulas 1997, figure 39-41, before the last project of the restoration of the south wing of the *Propylaea*.

435 Kavadias-Kawerau 1906, 129.

436 For the time being it was not possible to know exactly when these interventions took place and by whom.

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8

Labour mobilization and architectural energetics in the North Cemetery at Ayios Vasilios, Laconia, Greece

Sofia Voutsaki, Youp van den Beld, Yannick de Raaff

8.1 Introduction

When discussing human investment in large-scale constructions, finding ways to measure labour input, and evaluating the impact of building projects on economic and social relations, the emphasis is inevitably on impressive fortifications, monumental temples, or urban building programmes. In our paper we would like to pay attention to more modest constructions. We believe that these more unassuming building projects have to be studied for three reasons: to start with, they may have required more work than we have hitherto assumed, as we have not always paid sufficient attention to their construction process. Secondly, studying variation in labour input may help us understand social strategies of distinction or conformity, exclusion, or inclusion. Finally, the initiation of building projects can help us understand the processes of social transformation in periods when the division of labour and the circulation of resources undergo radical change. Our main argument is that the mobilization, manipulation, and centralization of labour can be important components in the transformation of social relations and the emergence of aspiring elites and regional centres.

Our discussion is based on the Early Mycenaean (*i.e.* early Late Bronze Age; approx. 1700-1420 B.C.E.) cemetery at Ayios Vasilios, Laconia, southern Greece.

In: Brysbaert, A., V. Klinkenberg, A. Gutiérrez Garcia-M. & I. Vikatou (eds) 2018. *Constructing monuments, perceiving monumentality and the economics of building: Theoretical and methodological approaches to the built environment*. Leiden: Sidestone Press, pp. 169-192.

Figure 8.1: Plan of the North Cemetery (Prepared by Gary Nobles, Irene Koulogeorgiou and Erwin Bolhuis).

The North Cemetery[437] presents a very interesting case-study, because it was in use in the Early Mycenaean period, when pervasive changes can be observed, especially in the mortuary sphere. Extramural, organized cemeteries such as the North Cemetery replaced the intramural burials which were used in the Middle Bronze Age (2100-1700 B.C.E.). Larger, deeper, and more complex graves such as large cists, shaft graves, built tombs, and eventually rock-cut chamber tombs and monumental *tholos* tombs, replaced simple cists and pits; multiple burials replaced single inhumations; re-use and secondary treatment spread; and richer offerings accompanied the dead.[438] It is generally accepted that these changes are part and parcel of the transformation of the mainland societies at the onset of the Mycenaean period, *i.e.* the emergence of social elites and regional centres across the entire southern mainland.[439]

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437 The Ayios Vasilios North Cemetery is being excavated as part of the Ayios Vasilios Project, which is directed by A. Vasilogamvrou, Director Emerita of the Laconia Directorate of Prehistoric and Classical Antiquities, under the auspices of the Athens Archaeological Society. The excavation of the North Cemetery is directed by Sofia Voutsaki, and is financed by the Groningen Institute of Archaeology, the Ammodo Foundation, the Mediterranean Archaeology Trust and the Institute of Aegean Prehistory.
On the North Cemetery: Voutsaki *et al.* in press a; Voutsaki *et al.* in press b; Voutsaki *et al.* in press c.

438 On mortuary practices in this period see Cavanagh and Mee 1998, 23-60.

439 For syntheses on this period see Wright 1998; Voutsaki 2010.

Ayios Vasilios is one of these newly emerging centres. The site is located on a low hill, at a distance of about 12 km south of modern Sparta. Systematic excavations carried out since 2009 have revealed spectacular findings such as monumental architecture, rich finds, and Linear B tablets,[440] which leave no doubt that the site can be identified as the palatial centre of Mycenaean Laconia at least during the later Mycenaean period (approx. 1400-1270 B.C.E.). It is very difficult at this moment to understand how and why Ayios Vasilios rose in significance, since the early Mycenaean layers have hardly been reached in the excavations so far. Luckily the North Cemetery can give us insights into the early formative stages, as the graves are in use from the end of the Middle Bronze Age to the period when the palatial complex was constructed, and, therefore, allow us to observe changing social relations during this crucial period.[441]

The North Cemetery is located at the northern edge of the hill, at a distance of c. 50 m from the palatial complex. Twenty-two graves and two burials (bones assembled on top of a grave) have been excavated (Figure 8.1). Most graves are built cists, though a few simple pits, which were used most often for small babies and children, have also been found, as well as one large built tomb, tomb 21. As we will see later, the cist tombs are relatively large, carefully built and covered by heavy slabs. Most graves contain multiple burials, and many contain a combination of primary inhumations and 'secondary' burials, *e.g.* scattered, heaped, and sometimes selectively removed and/or reburied remains of earlier burials. Therefore, the North Cemetery follows all the new customs which will become the norm in the Mycenaean period, but with one exception: the graves are often unfurnished or poor. This is in contrast to most cemeteries in the southern mainland where, by that period, more burials are accompanied by a vase, a simple ornament or a tool, and even more so to elite precincts, such as the contemporary shaft graves at Mycenae, in which enormous amounts of valuable and exotic finds were deposited with the dead. While differences in wealth are minimal, the North Cemetery graves show some interesting variation in size and quality of construction.[442]

We (aim to) demonstrate below that the new tomb types used in the North Cemetery (large cists, built tomb) required substantial labour input for the quarrying, transporting and rough working of the stones. Usually this kind of considerations are made for the truly monumental *tholos* tombs[443] whose much larger size and corbelled construction required not only substantial labour investment, but also advanced engineering skills.[444] Needless to say, the construction of the cist and built tombs was less demanding than that of *tholos* tombs. However, these first building projects enabled

440 On the palatial complex in Ayios Vasilios, see Vasilogamvrou 2010; Vasilogamvrou 2011; Vasilogamvrou 2012; Vasilogamvrou 2013.

441 The palatial complex must have been built around 1450 B.C.E.; see Vasilogamvrou *et al.* in press, while the North Cemetery must have been in use from c. 1700 to 1400 B.C.E. The chronology is still tentative as the finds are still being processed.

442 We will not address the discrepancy between the careful construction and the absence, or poverty of offerings here. On this point, see Voutsaki *et al.* in press a; Voutsaki *et al.* in press b; Voutsaki *et al.* in press c.

443 The first *tholos* tombs are built in a period more or less contemporary with the foundation of the North Cemetery, i.e. around 1700 B.C.E. However, the first *tholos* to be built in the area of Laconia, the one in nearby Vapheio, is built slightly later, i.e. while the North Cemetery is in use. See Wright 1987, 173-175; Wright 2010, 246.

444 Cavanagh and Mee 1999.

the people in the early Mycenaean period to acquire technical knowledge and to experiment with methods of quarrying, transportation and construction which must have proved indispensable in the construction of the more monumental *tholos* tombs.

Our aim in this paper is to reconstruct the labour input invested in the North Cemetery tombs, to detect variation among them, and to attempt to reconstruct social strategies in this period of shifting social relations. Our research questions shape (and are shaped by) our theoretical and methodological approach. We do not want to reconstruct labour investment in order to calculate energy expenditure as such, but in order to understand variation between tombs. As a result, we are mainly interested in relative rather than absolute measures of labour input – a point which will be developed more in the methodological discussions below. It is not uncommon for studies on labour cost to establish relative measurements or ranges.[445] However, our choice is dictated also by our material, which does not consist of one large construction project (*e.g.* a fortification wall), but of tombs which can be treated as single and separate analytical units and can be compared with each other in terms of size and quality of construction.

Our emphasis on relative rather than absolute labour measures arises also from theoretical considerations – specifically the question whether our economic concept of labour can be projected on prehistoric societies. This takes us back to complex theoretical discussions starting with Baudrillard's critique[446] of Marx's notions of labour and value. As Baudrillard pointed out, in the free market economy labour is the measure of cost, because labour is a commodity. However, this is not the case in pre-monetary, kin-based societies, where there is no all-pervasive measure of value, and where labour is not a commodity, but may also be exchanged reciprocally along kin lines. This critique may be irrelevant when one discusses the construction of aqueducts in the Roman world, but needs to be taken into account in the case we are studying: the southern Greek mainland in the transition to the Late Bronze Age where we have no evidence for institutionalized social asymmetries.

The interpretation of labour investment has a long history also in archaeology, notably in mortuary studies. The principle of energy expenditure[447] was introduced in the heyday of the New Archaeology and assumed a central position in mortuary studies. Energy expenditure in graves, presented as an objective and universal measure, was thought to reflect status and social complexity. The reaction against reflective reasoning was the starting point of the post-processual critique[448] which emphasized that the elaboration of the mortuary sphere – whether by means of impressive monuments, complex ritual, or rich offerings – should be seen as a social strategy of display and self-representation. In this approach, the investment of labour is seen as a social practice, rooted in specific social and cultural conditions. As a result, labour should not only be measured in order to calculate energy expenditure on the basis of some abstract and universal criteria but examined within its physical and social context.

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445 See for example Turner, this volume. D. Turner also suggested that the following were closest to suggesting ranges in energetics studies: ECAFE 1957; Erasmus 1965; Milner *et al.* 2010.

446 Baudrillard 1975; Baudrillard 1981. These arguments are more extensively presented in Voutsaki 1997. Baudrillard's critique has inspired studies such as Appadurai's (1986) *Social Life of Things* volume which had a seminal influence on archaeology.

447 As formulated by Saxe 1970; Tainter 1978.

448 Hodder 1982; Parker Pearson 1982.

Seeing labour as a social practice implies that we should not only measure labour input, but also attempt to understand the purposes it is used for, and the *forms* it takes. For instance, it is not sufficient to measure the labour gone into the construction of a tomb; we also need to examine which aspects of the tomb design and construction vary, which parts of the tomb are elaborated upon (the façade? the entrance? the interior? etc.), and how this is achieved.

Finally, seeing labour as a social practice implies that construction processes are seen as establishing a social relation between people – indeed, buildings are made *by* someone *for* someone else. For this reason, we need to study how labour is exchanged and controlled – for example, whether it is exchanged reciprocally, within the nexus of kin relations, or as part of asymmetric relations between social groups, or between a centre and its hinterland.[449] We therefore need to reconstruct not only the forms labour takes, but also its *flow* in social life.

To summarize our approach and research questions, in this paper we address three different questions:

- A theoretical question: how to *interpret* labour investment?
- A methodological question: how to *measure* and *compare* labour investment?
- A historical question: how to *explain* labour mobilization in processes of social change, and specifically in the transformation of relatively simple kin-based societies to differentiated and centralized formations?

The emphasis in this paper is on the methodological discussion, as the theoretical argument, the shift from reciprocal to asymmetric relations, has been presented elsewhere.[450] Our discussion starts with a critical discussion of the methods of architectural energetics which is followed by the presentation of our own methodology, concluding with the analysis of the North Cemetery graves.

8.2 Architectural energetics: a critique

Architectural energetics is a method which translates constructions into labour cost estimates by investigating the entire construction process and its distinct parts. The labour costs of construction stages serve as the analytical unit of measurement upon which comparative assessments can be made. Central to architectural energetics is the assumption that labour investment can be measured and quantified into absolute values measured in a labour-time unit, *e.g.* man-hours or man-days.[451]

This method forces researchers to exhaustively reflect on the construction process, and to outline all the different tasks and stages. Additionally, it requires them to be explicit about their assumptions and calculations. The proponents of the method are quick to point out that these absolute figures are – as any reconstruction of past activities – an approximation. According to Abrams and Bolland this is not a problem, as

449 Several such aspects have been discussed in some detail, also in the Mycenaean context. See Santillo-Frizell 1997-1998; Maran 2006a; Maran 2006b; Maran 2016; Brysbaert 2013; Brysbaert 2015a; Brysbaert 2015b.

450 Voutsaki 2016.

451 For a complete explanation of the method see Abrams and Bolland 1999.

the analysis of the building process itself contains certain degrees of freedom that are determined by the researchers themselves. [452] While we agree that all reconstructions are approximations, we still need to assess whether these approximations are plausible. Therefore, in this section we would like to discuss some problems arising when estimating labour investment in labour-time units.

The first difficulty is that the seemingly abstract and universal measures used for the calculations are often based on subjective choices.[453] To start with, the definition of the workforce – in terms of age and sex – can be heavily influenced by the social and cultural background of the researchers themselves. The same can be said about the calculation of working hours per day. The figure of 220 working days per year with a 10-hour workday[454] is often employed to average out seasonal differences,[455] though this does not fully account for differences between periods, regions and socio-cultural contexts. At a deeper level, the organization of the work force is taken into account by means of these abstract calculations or averaged figures, but with little attention to the specific social conditions – for instance, all calculations would be affected if kinsmen or slaves rather than free workers are employed. This entails the risk of a circular argument whereby the social relations of production are assumed and fed into our calculations and interpretations.

In addition, such subjective choices are made at different, if not at every stage of the investigation. Brysbaert's attempt to calculate the labour costs (termed man-days, abbreviated md) for the quarrying of 1 m^3 of stone, used to build the Cyclopean fortification walls of the Mycenaean citadel in Tiryns, reveals great discrepancies between studies.[456] She consulted several sources: Bessac estimated that 1 md/m^3 was required to quarry unworked limestone; De Haan suggests 1.1 md/m^3, based on modern experiments with very experienced workers; Abrams calculates between 1.1 and 2.2 md/m^3 for unworked small stones, again based on modern experiments; and Pakkanen proposed similar figures, *i.e.* between 1.1 and 2.2 md/m^3, for Athenian limestone masonry blocks.[457] Brysbaert concluded that a ratio of 1 md/m^3 would be a plausible estimate for the stones quarried around Tiryns, as they were (mostly) unworked.[458] This ratio is, however, the lowest of all; in fact, it is more than twice as low as the maximum effort estimated by two of the four studies, which also concern (mostly) unworked blocks. This calculation is followed by an estimate of the total volume of the walls.[459] Brysbaert decides that it is not possible to differentiate between stones of medium (0.2-0.8 m^3, 500 kg – 2 tonnes) or large (0.8-5+ m^3, 2-13 tonnes) size for their transport costing, as it is not known how many large blocks left the quarry.[460] How reliable are these calculations in the light of so many uncertainties?

452 Abrams and Bolland 1999, 267.

453 *Op. cit.* 264.

454 Derived from DeLaine 1997, 105-106.

455 Brysbaert 2015b, 60, 71, 81 and 99, points out how different seasons will affect work progress.

456 *Op. cit.* 94.

457 Bessac 2007, 136; De Haan 2009, 3; Abrams 1994; Pakkanen 2013.

458 Brysbaert 2015b, 94.

459 *Contra* Loader 1998, 67, who thinks this is impossible to calculate.

460 Brysbaert 2015b, 94. Indeed it should be stressed that Brysbaert's study is the first to take the high costs of transportation into account.

Uncertainty can also be caused by missing information. For instance, when Brysbaert calculates the labour necessary for the transportation of stones from the quarries to the construction site at Tiryns, she notes that moving heavy stones as much as 50 m poses considerable logistical and practical challenges.[461] However, the location of only half of the quarries used at the time is known,[462] in which case the calculation of the transport costs become even more uncertain. Similarly, any decorations on architectural units can be excluded from analyses because of varying preservation conditions, resulting in incomplete comparisons of labour investment.[463]

In addition, other tasks are recognized but not taken into account because they are deemed 'beyond the scope of this paper'. While restrictions of time, space and money need to be acknowledged, sometimes glaring omissions are made. For example, many studies focus only on the construction process, but omit the preparation of the construction site.[464]

Non-recoverable activities compound the problem further. Homsher emphasizes the dependence of construction projects on the community at large, for instance, for the provision of food, tools or work animals.[465] Large-scale urban architectural projects demand so many resources that possibly every individual in the catchment area of the building site can be said to have been involved in the construction project.[466] By only measuring the construction processes architectural energetics only reveals the tip of the iceberg, *i.e.* of the collective labour investment.[467]

A final point: many studies opt to calculate the minimum effort. This has certain advantages, as comparisons between studies are more reliable and researcher's biases can be controlled. Also, it may seem that the estimates are 'safer', especially with regard to a lack of data due to incomplete remains. On the other hand, the risk exists that anachronistic concerns such as maximizing efficiency or minimizing effort considerations, will (consciously or unconsciously) affect the calculations. At times the workers (or at least the person(s) responsible) also decided to invest huge amounts of energy in monumental architectural projects which by far exceeded any functional needs. The Cyclopean fortification at Tiryns provides the obvious example of a labour investment which defies any modern economic considerations: firstly, many different types of stone were used, often specifically chosen for their colour; secondly, large conglomerate blocks were brought from a distance of 15-18 km away from the citadel.[468] Therefore, in this case, calculating the minimum effort can be said to contradict the very purpose of the construction of the Cyclopean wall, which is to convey the power that the palatial elite had over the work force and the community at large.[469]

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461 *Op. cit.* 95.

462 Brysbaert 2015a.

463 Devolder 2015, 244.

464 See for example Fitzsimons 2014, footnote 46, referring to Erickson 2010 who omits the preparations of the construction sites from research into labour costs. These lower costs are hereafter used by Fitzsimons, which in our mind compounds the problem. In contrast, see Brysbaert 2015b, 91, who points out that these costs will be taken into account in further research.

465 Homsher 2012, 22.

466 *Loc. cit.*

467 See Brysbaert 2013 for an extensive discussion of non-recoverable activities.

468 Brysbaert 2015a; Brysbaert 2015b.

469 Brysbaert 2015b, 102.

Let us summarize our discussion on architectural energetics. Clearly the method addresses an important problem: it confronts and explicitly discusses the complexity of construction projects, and thereby forces us to reflect on the entire construction project, all its stages and even the smallest details. Even so, some drawbacks have been noted: the quantification of labour investment into absolute labour-time units, *e.g.* man-days, may appear as an objective and transparent methodology which enables and invites comparison. It often, however, rests on subjective choices, tacit assumptions and unexamined projections, the accumulation of which put into doubt the usefulness of the method. The important problem with architectural energetics is that it *appears* as one method, while in reality every researcher decides for themselves which figures to choose, or which construction stages to take into account – thereby *creating their own methodology* and making comparisons unreliable, or even impossible.

8.3 A new methodology: relative assessment of labour input

The challenge we now face is to find a solution between the two opposed requirements: on the one hand, the very legitimate need to assess, quantify, and measure labour investment, and, on the other hand, the need to understand labour (its form, its flow – see the theoretical discussion above) in its physical and social context. Or, to put it differently, we need to develop a methodology that is both sensitive to local social conditions *and* can be used in other contexts.

We propose not to translate labour investment to absolute labour-time figures such as man-days or man-hours. We suggest instead to assign relative values to our smallest analytical unit, *i.e.* each tomb, by trying to assess all aspects that show significant variation.

We have already noted that the North Cemetery is characterized by some variation among tombs in terms of type, size, and quality of construction. Since there is a clear differentiation between small pits which contain in most cases babies or small children,[470] in this paper we will include only cists and the built tomb.[471]

In our analysis we have taken the following construction elements into account: the *size* of the graves, the *construction quality*, and what we call the *stone value*.

i. The *size* of the grave – *i.e.* the volume of soil removed when digging the pit – was measured in cubic meters on the basis of length, width, and depth of the grave pit. In another study of contemporary tombs, size was used as the sole variable, as it was seen as a direct and reliable reflection of the amount of energy invested in its construction.[472] We disagree on this point; we believe that the act of digging the grave is not the most significant task when compared to the construction of the tomb. Our argument is based on observations on the North Cemetery tombs

470 Age differentiation characterizes the mortuary practices in the transitional period: adults predominate in the extramural cemeteries, while neonates, infants and small children are still buried *intra muros* (Voutsaki 2005; Pomadère 2010).

471 Because of restrictions of space, we do not include all tombs, but only examples from all representative categories. This does not affect our primarily methodological argument, as in this paper we do not carry out any statistical analyses.

472 Fitzsimons 2011, 78.

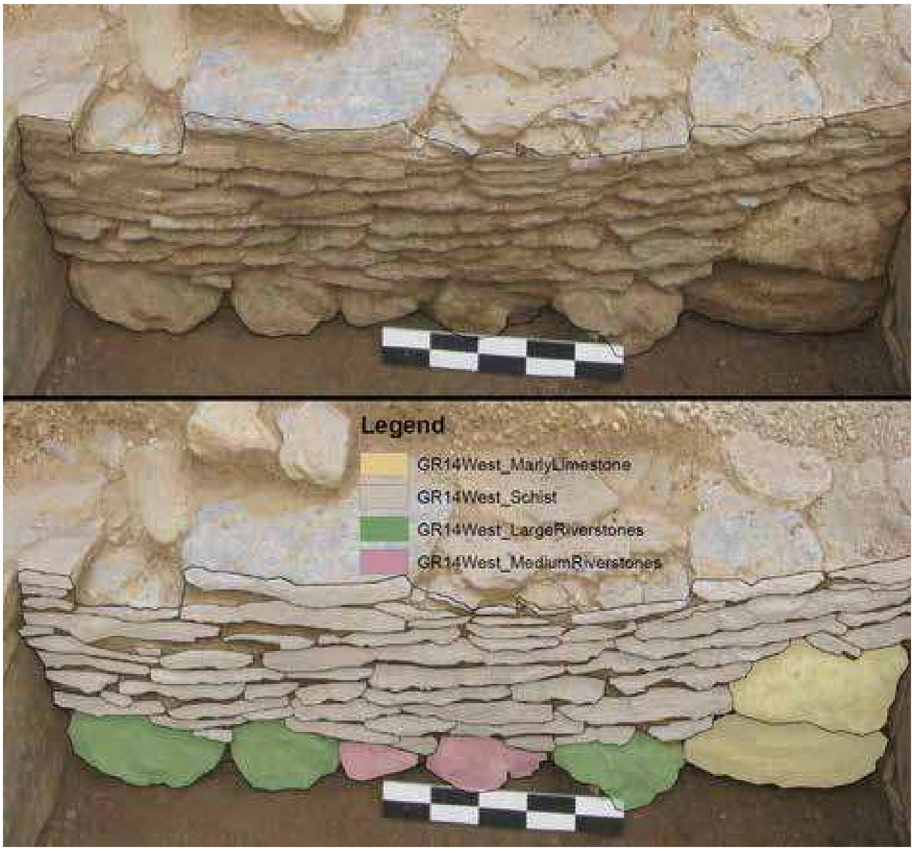

Figure 8.2: The stones digitized per different stone type in ArcGIS. The west wall of tomb 14 before (upper) and after (lower) digitization.

where we see unexpected variation in the quality of construction and in the labour involved in the acquisition or extraction and transport of the stones used. This is why we use two additional criteria.

ii. By *quality of construction* we measure how neatly the walls of the tomb are built and how well the stones fit together. To assess the quality of construction we digitized the photos of the inner sides of the tomb walls in a geographical information system (GIS), and thereby obtained outlines of the wall and of each individual stone (Figure 8.2). We then calculate how much of the wall's surface is covered by stone and how many gaps (now, of course, filled with soil) still exist.[473] By subtracting the surface area of all the stones from the surface area of the entire wall we could express the quality of construction as a percentage. This was done for all four tomb walls, and the average was used as the indicator for the quality of construction for the specific tomb.

473 It is not possible to say if the walls were built as dry walls, or if the local soil was used to make the walls more solid. We certainly have no evidence that soil was brought to the site for this purpose; at the most, the local soil may have been used. This aspect was not used in our method.

stone value = volume of stone × extraction value × transport value

Figure 8.3: The formula used to calculate the stone value.

iii. The third criterion, the *stone value,* is a composite measure, which takes into account the acquisition of raw materials and their transport to the building site. Despite the relatively unassuming size (with the exception of the built tomb 21) and the simple construction of most tombs, a surprising variety of stone types were used in the North Cemetery (Table 8.1).[474] We should stress that our observations are based on a report on the building materials used in Ayios Vasilios produced by Polymenakos, the geologist-geophysicist attached to the project.[475] These various stones have different physical characteristics and according to Polymenakos originate from different locations. To our surprise, some of these stones had to be quarried and transported across a long distance – from 4 to 8 km away. In our methodology, therefore, the stone value consists of the sum of the calculated volume of each particular type of stone in a specific tomb, multiplied by the extraction and transport values for each specific stone type (Figure 8.3).

We used the following method to determine the *volume of stone* used in the tomb: we first calculated the volume of the walls by comparing the outer dimensions of the grave wall, *i.e.* the contour of the grave pit, and its inner dimensions. We paid close attention to how the four walls joined in order to accurately reconstruct the volume of individual walls and avoid miscalculating the corners. Subsequently, we multiplied the percentage of stone coverage (the calculated quality of construction) with the volume of the wall to estimate the total volume of stone in each wall. To be able to reconstruct the stone value of a single wall, the assumption was made that the stones visible from the inner side of the wall resemble the stones behind them, which are usually not visible.[476] All stones were digitized per stone type; in this way, we could calculate the proportions in which different stone types occur in each wall, and eventually in the entire tomb. These calculations were expressed in cubic meters for each stone type (Table 8.1).

All tombs[477] were covered with phyllite cover slabs (with the exception of tomb 21). The dimensions of the individual slabs were not measured during excavation. Therefore, to estimate the volume of the phyllite cover slabs, an overall thickness of 10 cm was assumed and the length and width were calculated on the basis of the outer dimensions of the tomb walls, upon which the slabs were laid.

The *extraction value* given to each stone type is primarily based on how the stones were obtained, *i.e.* picked up or extracted/quarried, and whether additional cutting or working was necessary at the tomb site. Values ranging from 1 (picking up loose

474 See also the built chamber tomb 73 in Mitrou which is built with sandstone not used anywhere else on the site; Van de Moortel 2016, 101.

475 Polymenakos n.d.

476 This assumption was confirmed in a few partly destroyed cist tombs where the stones in the outer layer of the wall were visible.

477 A couple of tombs which had no cover slabs were found very close below the surface; we assume that their slabs were removed by ploughing.

Stone type	Characteristics	Extraction	Transport
Small-/medium-sized river stones	This category comprises a variety of stone types, *i.e.* crystalline limestone, marble, quartzite and chert, which can be found in the riverbed at the foot of the Ayios Vasilios hill, at a distance of c. 200 m.* These stones could easily be picked up.	1	2
Large-sized river stones	This category comprises the same variety of stones as the previous one, though larger than c. 30 cm in one dimension. According to Polymenakos, the larger river stones probably originate from the stream bed in the Rassina creek some 2-4 km to the east of Ayios Vasilios,* but we have observed larger blocks near the Ayios Vasilios hill. Either way, the larger stones were more difficult to lift and place in location.	2	3
Conglomerate	Grey to black colour; both fine-grained and coarse-grained varieties occur on the Ayios Vasilios hill.* It was fairly easy to quarry, which was done locally at the surface from rocky outcrops in the area of the North Cemetery and in other locations on the AV hill.*	3	1
Marly limestone	Pale beige to whitish colour; it occurs locally on the Ayios Vasilios hill. It is a soft stone that was easy to quarry. It could be extracted from rocky outcrops in the same way as conglomerate.*	3	1
Schist	Grey, greenish, with sometimes a reddish hue or even a striking light blue colour. Schist is found in the slopes of the Taygetos mountain range at about 4 km east of the Ayios Vasilios hill.* A layered rock type that is fairly easy to quarry because it breaks off into flat slabs. However, it required additional cutting to neatly fit the tomb walls.	4	4
Phyllite	A grey/beige coloured rock type which was exclusively used for the cover slabs of the cist graves. It was most likely quarried in the Fteroti gorge in the Taygetos mountain range at a distance more than 4 km away from Ayios Vasilios (exact quarrying location unknown).* Phyllite slabs are larger, thicker, and heavier than schist slabs.	5	5

*Table 8.1: The stone types used in the construction of the tombs and their corresponding extraction and transport values (*Polymenakos n.d., 3-4).*

stones) to 5 (more difficult quarrying, harder stone, necessitating additional shaping, cutting, or working) are given to the different stone types (Table 8.1).

A different *transportation value* is given depending on the distance from the nearest source to the Ayios Vasilios hill.[478] We assume that the further away the source, the more effort has to be put into the transport of the stones to Ayios Vasilios. We distinguish five zones of stone provenance, corresponding to values ranging from 1 (locally quarried at the Ayios Vasilios hill) to 5 (the higher slopes of the Taygetos mountains; Table 8.1).

We should clarify that our scoring system is schematic and relative rather than absolute. We do not imply, for instance, that a stone which receives an extraction value of 5 is five times more difficult to extract than one which has a value of 1. We emphasize again that we are interested in variation and in relative rather than absolute measures which we can use to compare tombs and study variation. Perhaps the multiplication factors can be improved upon with experimental research, but that is beyond the scope of this paper.

478 As identified by Polymenakos n.d.

To summarize: in order to compare the labour investment of the different tombs we use three criteria: the *size* of the tomb, the *quality of construction*, and the *stone value*, itself a composite variable based on the volume of the stone and the effort necessary to obtain and transport the stones. Each criterion is expressed in different measures. We have made the conscious decision not to combine the three variables into one total score. Keeping them apart avoids the problems arising when combining qualitative and quantitative dimensions and allows for a more nuanced analysis and a better interpretation of the construction process.

8.4 The analysis: homogeneity and variation in the North Cemetery

Based on the types of stone used, the construction method and size of the tomb the following types of tombs can be distinguished in the North Cemetery: regular cists, elab-

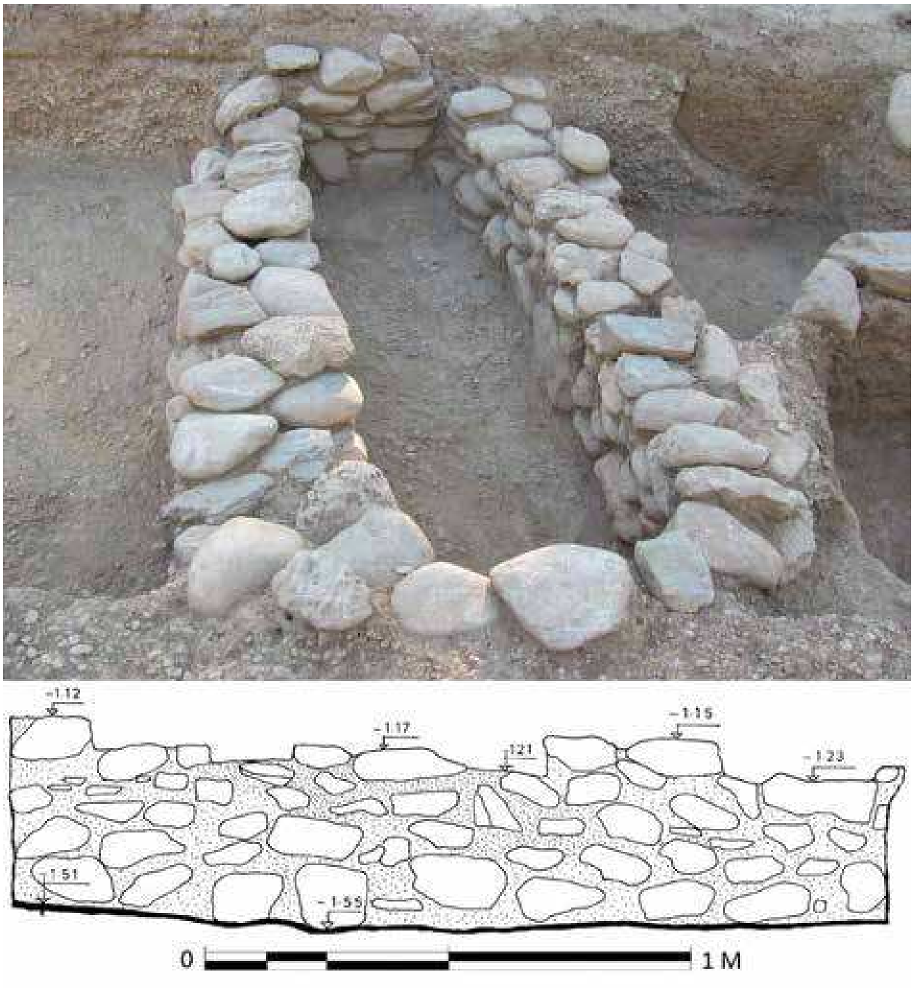

Figure 8.4: An example of a regular cist tomb: General view of tomb 1 (Photo: Vasilis Georgiadis) and drawing of its northern wall (Drawing: Irene Koulogeorgiou).

orate cists, and a built tomb. The regular cists (which are the majority) were mainly built from small- and medium-sized river stones (Figure 8.4). A few cist tombs, which we call 'elaborate cists', were built in a more careful and labour-intensive way: they had neatly fitting schist orthostates in their short sides and small schist slabs, neatly trimmed to fit the width of the tomb wall, as their uppermost course (Figure 8.5).

One tomb (21) differs from all others not only in terms of its size and construction, but also its use. It is substantially larger and deeper than cist tombs. Three of its walls were built like those of some regular cists, *i.e.* the lower course(s) consist of large boulders and the upper courses of small- and medium-sized river stones.[479] The southern short wall was built of small and medium-sized river stones and resembles the more hastily built walls which always block the entrance of chamber and *tholos* tombs (Figure 8.6). It is likely that this side formed a pseudo- rather than a real entrance, as we have evidence that at least some of the burials were placed in the tomb from above. The tomb was not covered by phyllite slabs, but by a mass of small and medium-sized

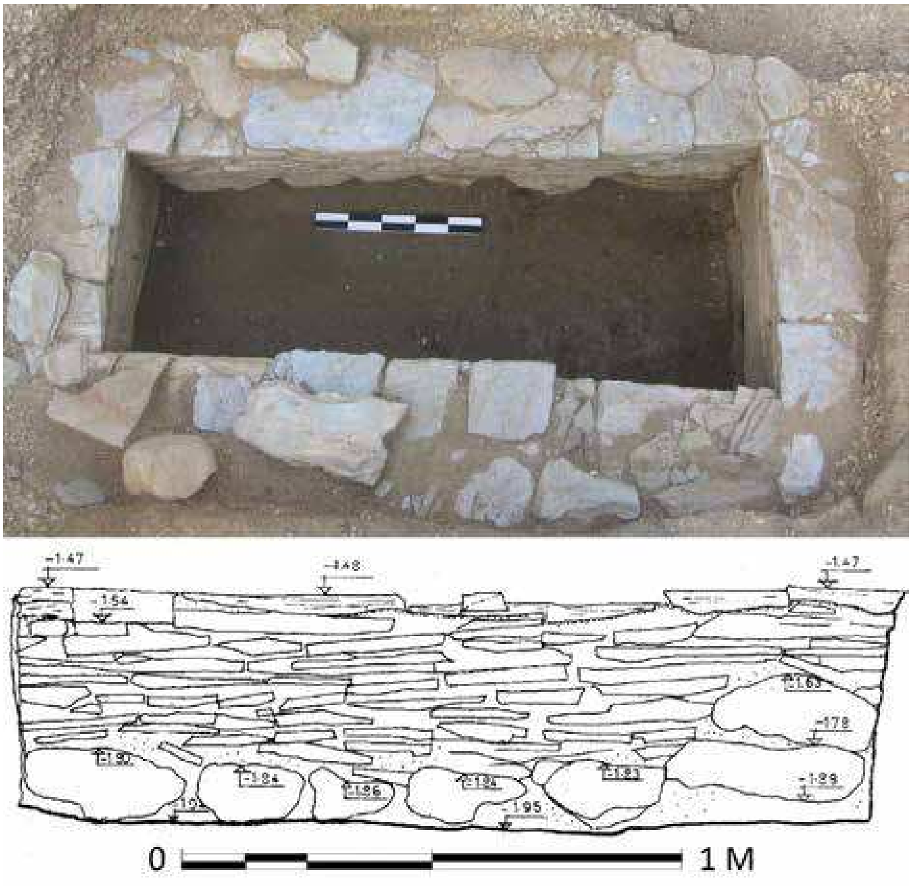

Figure 8.5: An example of an elaborate cist tomb: Aerial view of tomb 14 (Photo: Vasilis Georgiadis) and drawing of its western wall (Drawing: Irene Koulogeorgiou).

479 Referred to as the 'progressive technique'; Papadimitriou 2001, 344.

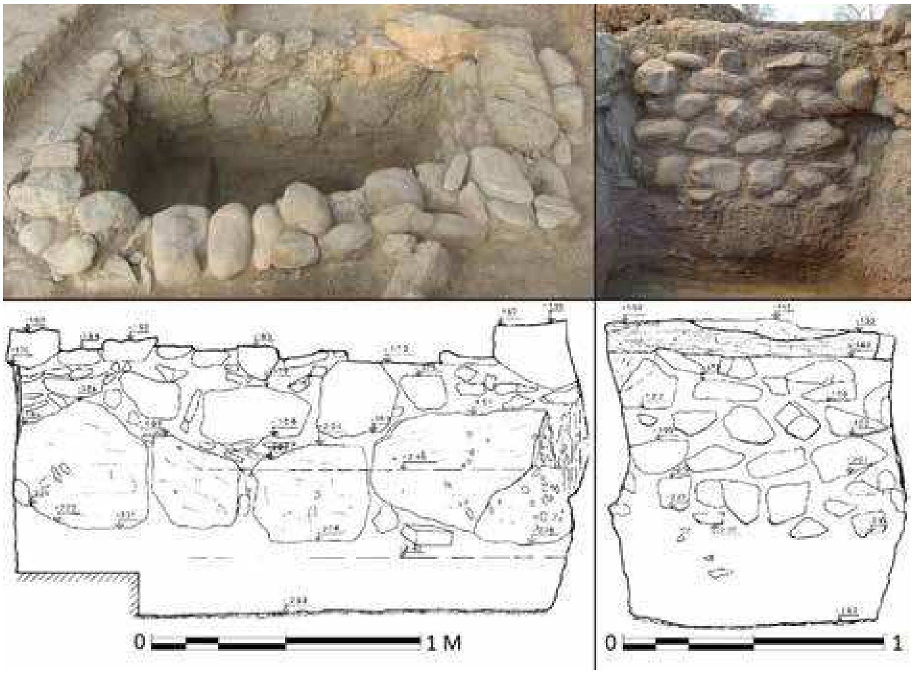

Figure 8.6: The built tomb 21. General view (upper left) and photo of southern wall (Photos: Vasilis Georgiadis). Drawings of eastern wall (lower left) and southern wall (lower right; Drawing: Irene Koulogeorgiou).

stones and slabs which were found inside the tomb in its uppermost layers. This tomb is, therefore, a so-called *built tomb*,[480] a hybrid category, introduced in the transition to the Mycenaean period, which forms the link between the cist tombs, entered from above, and the chamber / *tholos* tombs, entered from their side. The tomb was used for more than 26 burials which were found in successive layers. Therefore, it differs also in this respect from the other tombs (which usually contained one to four burials), and resembles the chamber and *tholos* tombs (which were used for multiple burials).

Let us now examine more systematically the variation along the three variables that we use in our analysis.

8.4.1 Size

In terms of size, the cist tombs show overall uniformity (Table 8.2); most tombs range between 1.30 m^3 [481] and 1.56 m^3;[482] we, therefore, see a clear increase in size from the previous period, the Middle Bronze Age. Only two tombs are significantly smaller.[483] The built tomb 21 is up to five times as large as the other tombs, reaching a volume of 7.67 m^3.

480 Papadimitriou 2001.
481 Grave 14.
482 Grave 20.
483 Grave 1: 1.06 m^3; grave 19: 0.76 m^3.

Internal dimensions				
Tomb	Length (m)	Width (m)	Depth (m)	Volume (m³)
1	1.76	0.55	0.48	0.46
4	1.92	0.59	0.49	0.55
8	1.79	0.70	0.58	0.72
14	1.79	0.62	0.49	0.54
18	1.70	0.66	0.51	0.57
19	1.70	0.43	0.36	0.26
20	1.76	0.60	0.58	0.61
21	2.15	1.21	1.10	2.86
23	1.56	0.66	0.58	0.60
External dimensions				
Tomb	**Length (m)**	**Width (m)**	**Depth (m)**	**Volume (m³)**
1	2.05	1.08	0.48	1.06
4	2.36	1.30	0.49	1.49
8	2.15	1.20	0.58	1.50
14	2.14	1.24	0.49	1.30
18	2.12	1.30	0.51	1.41
19	2.10	1	0.36	0.76
20	2.15	1.25	0.58	1.56
21	3.10	2.25	1.10	7.67
23	2.02	1.24	0.58	1.45

Table 8.2: Tomb dimensions.

8.4.2 Quality of construction

Larger built cists appear at the transition to the Mycenaean period. The quality of construction among the North Cemetery cist tombs shows similar uniformity (Table 8.3). The stone coverage of the tombs ranges between 61.71%[484] and 75.20%.[485] There are two exceptions: the built tomb 21 has the lowest value (55.37% stone coverage). Indeed, the tomb is not very carefully built, though the very low value is largely due to the grave floor having been dug deeper than the grave walls, probably in order to accommodate the large number of interments. Tomb 14, the most elaborate cist, shows the highest quality of construction: the entire tomb is built of neatly cut schist slabs which are horizontally stacked and tightly fitted together, leaving few gaps, and forming a more or less vertical face (89.16% stone coverage). In addition, the schist slabs in the uppermost course had a striking light blue colour (Figure 8.5).

It is interesting to note that our category of elaborate cists (see definition above) shows a certain range in quality of construction. While elaborate cist 23 has the highest percentage of stone coverage (75.20%) after grave 14, elaborate cist tomb 8 has a percentage of 65.86%, which is lower than that of some regular cists. While there

484 Grave 19, a regular cist.
485 Grave 23, an elaborate cist.

Tomb	Tomb type	Size (m^3)	Quality of construction	Stone value	Minimum Number of Individuals
1	Cist	1.06	68.98%	35.80	3 (1 secondary)
4	Cist	1.49	68.88%	54.06	4 (all commingled)
8	Elaborate cist	1.50	65.86%	49.88	1
14	Elaborate cist	1.30	89.16%	69.40	7 (4 secondary)
18	Cist	1.40	63.00%	47.16	5 (3 secondary)
19	Cist	0.76	61.71%	30.80	1
20	Cist	1.59	72.42%	55.27	1 or 2 (second = secondary)
21	Built tomb	7.67	55.37%	154.03	26+ (at least 6 primary)
23	Elaborate cist	1.45	75.20%	58.05	4? (3 secondary)

Table 8.3: Overview of results.

are, therefore, differences between regular and elaborate cists, they form a continuum rather than distinct and rigid categories.

Similarly intriguing is that all elaborate tombs have neatly worked slabs as their uppermost course – *i.e.* the most visible part of the tomb at the moment the cover slabs were removed, and thereby the boundary between the dead and the living. It cannot be a coincidence that this period witnesses the introduction of formal cemeteries *at a distance from* the settlement which replace the old intramural burials. Therefore, the mode of construction tells us not only about social strategies of differentiation or conformity, but also about cultural concerns about the boundary between life and death.

8.4.3 'Stone value'

The composite 'stone value' once more confirms the picture of general homogeneity (Table 8.3) and limited but significant variation. The majority of tombs are comparable, with a stone value ranging between 47.16[486] and 58.05.[487] Interestingly, the small and shallow tombs 1 and 19 score relatively low (35.8 and 30.8, respectively) because they are almost exclusively built with river stones. Conversely, two tombs are distinguished by a high score: as we would expect, elaborate cist 14, the one built almost exclusively of schist slabs, has a relatively high stone value (69.4) despite its relatively small size. The situation for built tomb 21 is exactly the opposite: while it was primarily built of river stones and locally obtained marly limestone, its great size, and hence large volume of stone, results in a stone value of 154.03, which is up to five times as high as that of the lowest scoring tomb 19 (30.8).

It is worth dwelling for a moment on the use of phyllite cover slabs (Figure 8.7). Interestingly, the volume and stone values attributed to the use of phyllite, a stone type transported from afar, consistently make up a substantial percentage of the total volume of the tombs (31.8% on average) and stone value (50.4% on average, excluding built tomb 21). This investment is striking because phyllite was used only for the construction of cover slabs, which had to be removed and placed back with every new

486 Grave 18, regular cist.
487 Grave 23, elaborate cist.

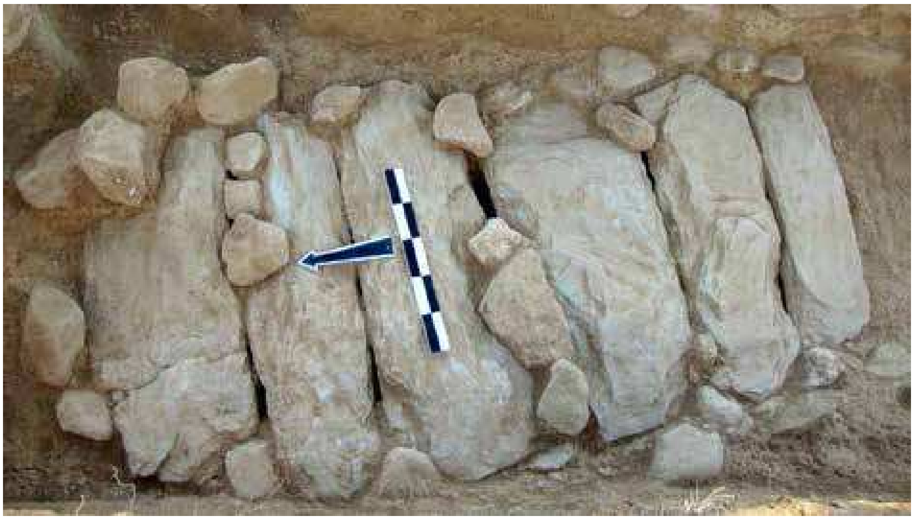

Figure 8.7: Cover slabs made of phyllite (tomb 4) (Photo Vasilis Georgiadis).

internment, since the majority of the tombs contained multiple burials. The fact that the only mobile part of the tomb is also the most labour-intensive shows that considerations of efficiency and effort minimization are unimportant in the construction of early Mycenaean tombs. It is obvious that cultural considerations dictated that the tombs should be closed off with these particularly heavy slabs, some of which require up to four men to be lifted and transported. This conclusion is strengthened by the fact that small stones were used to seal the interstices between the slabs (Figure 8.7). This observation strengthens our remarks about the growing emphasis on the boundary between the dead and the living.[488]

To summarize: our analysis of tomb size, quality of construction and stone value has shown an overall uniformity in the North Cemetery tombs. In this respect, the North Cemetery continues the Middle Bronze tradition of relative uniformity, at least among adults.[489]

At the same time, the analysis has also shown limited, but consistent variation. Differences between regular and elaborate cists exist, but remain subtle. Only two tombs, elaborate cist 14 and built tomb 21, differentiate themselves more clearly from the others, but do so in different ways.[490] Tomb 14 differs because of the almost exclusive use of schist slabs, whilst tomb 21 stands out because of its large size and different construction. We can, therefore, conclude that differentiation in the North Cemetery is achieved by means of two different strategies: an increase in size or an increase in quality of construction. The two tombs differ in many respects, but also share some characteristics. As we see in Table 8.4, neither of them are rich; in fact, 14 was found empty. Most importantly, both contain multiple burials: built tomb 21 contains an

488 On this point, see Voutsaki 1998.

489 We mentioned above that neonates, infants, and small children are heavily underrepresented in the cemetery, and when found, are usually buried in small pits.

490 A parallel can also be attested in Mitrou in the contrast between the large cist 51 and the built chamber tomb 73; Van de Moortel 2016, 101-102.

	Offerings	Number of burials	Primary burials	Secondary burials
Tomb 14	-	7	3	4
Tomb 21	1 bronze tweezers 3 clay cups	26+	6	21

Table 8.4: Offerings and number of interments in graves 14 and 21.

exceptional number of burials, but so does tomb 14 if one considers its relatively small size. We mentioned already that the adoption of multiple burials, re-use and secondary treatment are characteristics of the new, Mycenaean mortuary practices, and indicate a renewed emphasis on descent and kinship relations.

Both tombs also share the same tendency to adopt innovative practices and to experiment: the built tomb with the pseudo-entrance and the new type of cover, and the elaborate cist with the extensive use of schist, orthostates, and notably the choice of the striking light blue schist for the uppermost course of the tomb walls.

If we combine the measurements of size, quality of construction, and stone value with the number of burials in tombs 14 and 21, we can easily conclude that these tombs cannot have been built immediately after the death of a member of the community. It would have been impossible to quarry and transport the necessary stones in the time before the decay of the body would set in. We therefore propose that the tombs were planned and constructed in advance, possibly by a group of people connected with kin ties. It is logical to suggest that labour was initially arranged in the nexus of reciprocal relations within kin groups. However, the initiation of the building project and the very act of construction of the tombs, including the quarrying at more distant locations and the transportation of heavy stones to one location,[491] must have altered the flow of resources, and of labour in particular. The channelling of labour to one social group or site must have promoted asymmetrical relations between the various kin groups that inhabited the Ayios Vasilios hill by bringing about what has elsewhere been described as the *centralization of reciprocities*.[492]

8.5 Conclusions

Let us conclude and summarize our argument. Our paper started with three questions:

8.5.1 A theoretical question: how to interpret labour investment?

In our paper, we suggested that we should view labour investment as a social practice, and not only as a measure of energy expenditure. We proposed that we should study labour investment in its physical and social context in order to reconstruct social strategies of differentiation or conformity. In the North Cemetery, we have identified two main strategies of elaboration: the increasing size and complexity of the tomb

491 We do not imply that these acts were taking place only in Ayios Vasilios; a few elaborate cists and built tombs have been found in other sites in Laconia, probably signalling competition between different social groups and emerging regional centres in the early Mycenaean period. A comparison of the North Cemetery tombs with contemporary tombs in Laconia is beyond the scope of this paper.

492 A concept introduced by Sahlins 1974 and applied on the early Mycenaean period by Voutsaki 2016, 76.

represented in built tomb 21, and the improved quality of construction, exemplified in tomb 14.

Our method also allowed us to distinguish which parts of the tomb received special attention. The emphasis on the boundaries of the tombs – the uppermost course and the cover slabs – reveals interesting concerns about the relation between the dead and the living.

8.5.2 A methodological question: how to measure and compare labour investment?

The methodology we proposed aimed at a relative assessment of labour input in tombs rather than absolute measurements in labour-time units, such as man-hours or man-days. Our method takes into account different stages of the tomb construction (digging and removing the soil, obtaining, transporting and working the building material) as well as different axes of variation (size, quality of construction), but also pays attention to tomb design and forms of elaboration. We have used both qualitative and quantitative measures in order to do justice to the complexity of labour assessment and labour mobilization. The variables we used are flexible and can be adapted and used in other cases and situations.

8.5.3 A historical question: how to explain labour mobilization in processes of social change?

We have argued that the appearance of larger and more complex tombs marked the initiation of more ambitious building projects, which brought subtle, but significant changes in the circulation of resources, and of labour in particular. We suggested that at the absence of institutionalized power asymmetries labour was first mobilized within the kin group. However, the very act of tomb construction with resources brought from afar to one specific location subtly distorted the flow of resources. We therefore proposed that the mobilization, manipulation, and centralization of labour are part and parcel of the transformation of kin-based and relatively undifferentiated societies to asymmetrical and centralized social formations.

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Part Three

Architectural energetics methods and applications

9

Comparative labour rates in cross-cultural contexts

Daniel R. Turner

9.1 Introduction

This paper focuses on the logistics of preindustrial construction and the potential for a comparative method. A comparative method is advocated here due to the proliferation of isolated approaches that have led to false equivalencies in labour costs. Simply put, future labour studies would benefit from a quick-reference guide of task rates, and this paper aims to jump-start that process with the least problematic–and most prominently reported–task rates in manual earthmoving. Labour or task rates are combined with the dimensions of a built feature in a process known as architectural energetics, a phrase coined by Elliot Abrams in the 1980s to describe a concept recorded since at least the Early Dynastic Period (2900-2350 B.C.E.): the measuring of construction output or potential via time and personnel required.[493] Energetics in its current form offers labour time estimates for past construction, which authors globally have stretched into models of demography and power.[494] One major challenge to the validity of energetics has been the use of single task rates, which, depending on the source, can skew the picture of the past that archaeologists attempt to sketch through interpretative models based on labour predictions.

Labour predictions falter foremost in selecting appropriate task rates for modelling simplified acts or stages of construction, such as digging a ditch, shaping a wooden post, or setting a stone block into place. Since task rates dictate construction efficiency, arbitrary selection of rates yields arbitrary results: useful for thought exercises and isolated case studies but not for posterity and progress in empirical labour methods. While both adherents and opponents of architectural energetics have already written at length on its advantages and limitations, a summary of the consensus suffices here. Although actual rates from prehistory are inevitably lost without direct recording, pre-

493 Abrams 1987, 489-490; Abrams and Bolland 1999, 264; Ristvet 2007, 198-199.
494 See Abrams 1994; Kolb 1997; Arco and Abrams 2006; Lacquement 2009; Murakami 2015; Picket *et al.* 2016.

In: Brysbaert, A., V. Klinkenberg, A. Gutiérrez Garcia-M. & I. Vikatou (eds) 2018. *Constructing monuments, perceiving monumentality and the economics of building: Theoretical and methodological approaches to the built environment*. Leiden: Sidestone Press, pp. 195-218.

dictions remain viable through the use of convincing ranges and midpoints in manual labour efficiency.[495] Analogous rates from history, ethnography, and experimental archaeology allow such predictions, but published compilations of these rates are rare and regionalised in archaeology if they exist at all.[496] It is proposed herein to list as many observations of manual labour as access permits to allow for more off-the-rack comparisons in the future. This paper highlights earthmoving task rates, outlining problems of variability in transportation and manufacture of other building materials.

Exploring manual labour efficiency, I will offer three case studies, one using the old method of targeted single task rates at Moundville (Alabama, United States) and two others showing a comparative range for earthmoving at early medieval Dublin (Ireland) and Repton (Derbyshire, United Kingdom). Earthmoving for enclosures at these sites required communal effort and rapid completion, making them ideal for labour cost analyses by narrowing the window of variability. These examples will help compare task rates and begin modelling labour with restraint: that is to say, modelling labour without spreadsheets or computer-aided algorithms,[497] for the goal is not the unknowable exact cost of construction, but rather a comparative range for basic tasks more readily transferable to other studies.

9.2 Comparative labour and repetitive tasks

If architectural energetics is a way of quantifying labour invested in the built environment, then comparative labour is a way of linking studies in architectural energetics together. Both operate on the uniformitarian assumption that physiological capabilities and building mechanics are essentially the same now as in the distant past. So, digging in medieval Europe is relatable to digging in the Pacific islands during the Second World War. Indeed, both long- and short-handled digging implements are morphologically similar in shape and technique, since ergonomics and logic limit our preferred methods of shifting soil.[498] We model our tools as extensions of our hands, increasing leverage, sparing our skin direct contact with abrasive materials, and removing our bodies to a safer distance should the weight we are moving become an unbalanced threat to fingers and toes. Transferring power to larger core muscles also reduces fatigue, which is easily proven first-hand if one attempts to hold a weight at arm's length rather than cradle it to the chest. Cutting surfaces and their associated labour rates differ as technology progresses, with metallurgy offering the clearest advantages in labour efficiency over tools with wood, bone, or stone working edges. Even so, the average 3:1 ratio for efficiency of a metal shovel over a digging stick, for instance, allows

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495 For European contexts, see Webster 1991; Ashbee and Jewell 1998; Squatriti 2002; Squatriti 2004; Tyler 2011; Pakkanen 2013; Harper 2016. For the Americas, see Erasmus 1965; Abrams 1987; Abrams 1989; Hammerstedt 2005; Lacquement 2009; Ortmann and Kidder 2013.

496 For the Aegean, see Burford 1969, 248-250; Devolder 2013, 42-47; Harper 2016, 519-530. For historical building manuals, see Hurst 1865; Rankine 1889; Cotterell and Kamminga 1990, 294. For experimental observations too narrow to extrapolate into comparative rates, see Xie 2014, 281-286.

497 Compare with Abrams and Bolland 1999, 282-284; Harper 2016, 72.

498 For examples of digging sticks, chert hoes, and separate-bladed shovels, see Morris 1980; Morris 1981; Kirch *et al.* 2005; Milner *et al.* 2010; Xie 2014, 100-112. Illustrated, side-by-side comparisons of these tools were drawn by Bogdan Smarandache and featured in Turner 2012, 29.

for comparisons using surrogate rates where tools are unknown except through analogy.[499] The flexibility to draw comparisons from experiments with a variety of tools is especially useful in contexts where poor preservation or limited intensive study has not given a full picture of the average worker's toolkit. Mycenaean Greece and the pre-Columbian U.S. Southeast are some examples where these analogies prove useful.

Comparative labour with energetics finds its anchor in repetitive tasks. All of the predictions here are reliant on limiting unnecessary detail, rather like emphasising tempo over every note played in a symphony. This translates into tracking incremental action, scaled upward to encompass the full range of steps leading to a built feature. In other words, the steady swing of a tool or the laying of a brick acts as a snapshot of the process that is later extrapolated to the scale of the finished building. Of course, this leads only to entry-level estimates and invites contextualisation in case-specific applications. Since any attempt to track all construction tasks will lead to confusion, such elaborations are abandoned herein as a non-starter in comparative study. A multitude of elaborations must give way to core tasks if communal construction is to find its initial momentum, and the same applies to the intent behind comparative labour.

The semantics of comparative labour, or our language choices in describing each variable in the process of construction, demand a brief aside, particularly concerning gendered pronoun use in modern descriptions of work. Although considered convenient or traditional, there are pitfalls to using the normative adult male shorthand for human capabilities (e.g., manpower, man-day), most notably the subversive invitation to omit active roles by women and children throughout most construction processes. Perpetuating that omission, many historical writers did not share an inclusive perspective on labour, and the familiar archetype of male movers and creators has defined the course of classical and historical studies.[500] For newer research, the usual unit format of man-day has been replaced by the more inclusive (and accurate) person-day. The bodies in motion, whether referred to as labourer, worker, or some other task-defined persona, will assume a male-dominated workforce where this expectation persists but will not preclude contributions from the entire population.

9.3 Production efficiency

Task rates have been calculated for a wide spectrum of traditional building materials. However, variability limits coverage here of rates for turf, stone, and wood, as different production circumstances amplify uncertainty over what constitutes an acceptable midspread for efficiency. The general labourer does not fully grasp the production process for secondary materials requiring more manufacturing steps without some level of practice (trial and error) or instruction (observation). Adequately redressing the deficiency of comparative rates in woodworking and stoneworking requires much more than a paper can deliver. This limitation is not as prevalent in soil movement, since its exhaustive treatment in previous literature can be condensed quickly absent the intricacies seen in working other materials.

499 Atkinson 1961, 295; Erasmus 1965, 285; Ashbee and Jewell 1998, 490; Milner *et al.* 2010, 109.

500 See DeLaine 1997, 106; Brysbaert 2013, 50; Pakkanen 2013, 55-56. Gender bias from classical writers like Theophrastus and the elder Pliny permeated the natural world; for instance, male trees were perceived as stronger and tougher than female ones (Meiggs 1982, 15). Such ingrained thoughts would hardly lead to a progressive recall of a diverse workforce in the absence of debates over inclusivity.

Supplement for Rate IDs					
ID	**Reference**	**Method**	**Material Description**	**Tool Description**	**Original Rate**
1a	Milner et al. 2010:109	experimental	compact silt to clay loam, variable moisture and occasional rocks	Mill Creek chert hoe replica, hafted on short wooden handle with rawhide, scooping assisted by white-tailed deer scapula and excavator's hands	0.202 m^3 in 1.78 hr
1b					0.609 m^3 in 4.05 hr
1c					0.171 m^3 in 1.00 hr
1d					0.131 m^3 in 0.68 hr
1e					0.085 m^3 in 0.42 hr
1f					0.250 m^3 in 1.00 hr
1g					0.367 m^3 in 1.00 hr
1h					0.369 m^3 in 1.00 hr
2a	Ashbee and Jewell 1998:491	experimental	chalk	antler pick, scapula shovel, woven basket	5 cwt/m-h, 1 cwt = 1 ft^3
2b					8.3 cwt/m-h, 1 cwt = 1 ft^3, assisted basketing not counted
2c	Ashbee and Jewell 1998:491, citing Pitt Rivers 1875	experimental	chalk	antler pick	9 cwt/m-h, 1 cwt = 1 ft^3
3a	Squatriti 2002:41, citing Vulpe 1957	ethnographic	unspecified	unspecified	1.5 m^3 in 8 hr
3b	Squatriti 2002:31, citing Hofmann 1965 and the Royal Frankish Annals	historical	unspecified	unspecified	750,000 m^3, 6,000 workers, 55 days
4a	Ristvet 2007:199, citing tablet M.288 in Charpin 1993:196	historical	unspecified	unspecified	2.25 m^3/m-d
5a	Hammerstedt 2005:46	experimental	root-penetrated, compact silty loam	Mill Creek chert hoe replica, metal bucket	0.29 m^3 in 1 hr
5b	Hammerstedt 2005:50, citing ECAFE 1957	ethnographic	dry hard clay	modern hand tools	0.334 p-d per m^3
5c			common soil		0.1 p-d per m^3
6a	Coles 1973:74, citing Pitt Rivers 1875	experimental	chalk	antler pick	1 m^3 in 1.5 hr for 2 men
6b					9 m^3 in 12 hr for 2 men
7a	Bachrach 2005:270, citing Bachrach 1993:65-72	ethnographic	unspecified	19th century hand tools	400,000 m^3 in 850,000 m-h
7b	Bachrach 2005:270, citing Bachrach 1993:65-72	ethnographic	unspecified	19th century hand tools	600,000 m^3 in 850,000 m-h
8a	Erasmus 1965:285	experimental	Las Bocas sandy soil	digging stick	2.6 m^3/m-d, m-d = 5 hr
8b				modern shovel	7.2 m^3/m-d, m-d = 5 hr
9a	DeLaine 1997:118, citing Pegoretti 1865	ethnographic	clay for brickmaking	19th century hand tools	93 m^3 in 14 m-d
9b					49 m^3 in 7 m-d

Table 9.1: Supplement for context IDs used in Table 9.2 showing references cited and original task rates.

Soil, perhaps above all other materials, factors heavily in monumental construction, yet it remains simple enough for children to manipulate into sand castles and rudimentary building blocks. Unless the construction objective involves building an ice palace in a land of perennial snow or cutting directly into bedrock, builders will likely end up displacing, compacting, or otherwise modifying earth. Such as it is, the near-universal occurrence of earthen architecture allows for global comparative examples with an inspiring diversity of approaches (see the contribution by Chris Scarre, this volume). This also brings with it the disadvantage of aligning scattered objectives into a singular purpose, but that common denominator can be found through comparing production efficiency.

Soil extraction rates							
Context		Material	Tool			Rate	
ID	Stamina	Type	Cutting Surface	Handle Length	Description	p-h/m^3	m^3/p-h
1a	average	silt loam	stone	short	chert hoe	8.850	0.113
2a	average	chalk	bone	short	antler pick	7.042	0.142
1b	average	silt loam	stone	short	chert hoe	6.667	0.150
1c	conditioned	silt loam	stone	short	chert hoe	5.848	0.171
3a	conditioned	unspecified	unsp (steel?)	unsp (long?)	unspecified	5.263	0.190
1d	average	silt loam	stone	short	chert hoe	5.236	0.191
1e	conditioned	silt loam	stone	short	chert hoe	4.902	0.204
4a	conditioned	unspecified	unsp	unsp	unspecified	4.444	0.225
2b	maximum	chalk	bone	short	antler pick	4.255	0.235
1f	conditioned	silt loam	stone	short	chert hoe	4.000	0.250
2c	maximum	chalk	bone	short	antler pick	3.922	0.255
5a	average	silt loam	stone	short	chert hoe	3.448	0.290
3b	conditioned	unspecified	unsp (wood?)	unsp (long?)	unspecified	3.030	0.330
6a	average	chalk	bone	short	antler pick	3.030	0.330
1g	conditioned	silt loam	stone	short	chert hoe	2.725	0.367
1h	conditioned	silt loam	stone	short	chert hoe	2.710	0.369
6b	average	chalk	bone	short	antler pick	2.667	0.375
7a	conditioned	unspecified	steel	variable	pre-modern industrial	2.123	0.471
8a	conditioned	sandy loam	wood	long	digging stick	1.923	0.520
9a	conditioned	clay	steel	variable	pre-modern industrial	1.806	0.554
9b	conditioned	clay	steel	variable	pre-modern industrial	1.715	0.583
5b	conditioned	clay	steel	variable	modern	1.667	0.600
7b	conditioned	unspecified	steel	variable	pre-modern industrial	1.416	0.706
8b	conditioned	sandy loam	steel	long	modern	0.694	1.440
5c	conditioned	loam	steel	variable	modern	0.500	2.000

Quick Guide (p-h/m^3)*						
Tool	Soil	N**	Center Index***	Reference ID	Min.	Max.
Non-metal	Loose	1	2.0	8a		
	Compact	14	[4.2]	1a-h, 2a-c, 5a, 6a-b	2.7	8.9
Metal	Loose	2	0.6	8b, 5c	0.5	0.7
	Compact	5	1.8	5b, 7a-b, 9a-b	1.5	2.2
Unsp.	Unsp.	3	[4.5]	3a, 4a, 3b	3.1	5.3

*Table 9.2: Soil extraction rates and quick reference guide (*Round up to nearest 0.1 person-hour; **Number of studies cited; *** Greater of mean and [median]). Supplement to context IDs can be found in Table 9.1 with references cited and original task rates.*

Task rates for soil excavation appear in a variety of sources but are so scattered in the literature that few studies cite more than one rate for each task. Compounding the problem of scattered sources, several critical variables are left implicit where authors believe the information to be self-evident or of no consequence to their stated goals. Table 9.2 serves to illustrate variation in soil excavation rates and how these should be reported, acknowledging tool and material type and converting rates into a standard metric based on person-hours, rather than leaving them in units that are culturally variable, such as a workday. This limits conversion errors, gives researchers alternate options for referencing away from the most popular studies, and can aid experiment design to refine task rates even more. The original rates and references can be found in Table 9.1.

Other task rates are less straightforward. Cutting times for wood, for instance, vary according to species, sap flow (time of year), tool, and technique.[501] Turf- and stone-cutting times also vary based on tool and technique, including the experience and proficiency level of the producer.[502] I have left these out of tabular form for now since they are incomplete, wildly different, and not ready for the same comparative approach applied to soil movement. Placing an arbitrary threshold of ten sources as the minimum sample size for comparative rates in working other materials, patterns should appear with a convincing midspread as we have seen with soil. This, however, must await further study.

9.4 Transport efficiency

Similar to production efficiency in materials other than soil, transport is also variable in its cost and efficiency, but for transport there is more literature available. Journals of physiology and ergonomics have tracked human capabilities for decades, and there are litanies of sources, from 19th century building manuals to farmer's almanacs, that make suggestions about what the appropriate load is for a mule.[503] When cycling through these numbers, it is important to keep a few things in mind. Many sources list maximum carrying capacity by estimating mechanical energy, but since biology is not perfect and joints are not frictionless, mechanical energy does not equate to physiological effort.[504] In raising and lowering our centre of gravity in a single step, one joule of mechanical energy actually ramps up to five joules of physiological effort.[505] Because prolonged exertion over distance amplifies as the distance becomes longer, transport capabilities drop substantially, as shown in timed observations from Charles Erasmus.[506] Differences in load weight are not the only factor at work here, as the unloaded trip back takes progressively longer at greater distances. The people walking the shortest and the longest distances in Erasmus's study are actually carrying a similar load weight, roughly 20 kg. Due to com-

501 Custance 1968, 100; Meiggs 1982, 15; Hammerstedt 2005, 51-62.

502 Erasmus 1965, 293; Burford 1969, 247-250; Coles 1973, 81; Shirley 1996, 124; DeLaine 1997, 120-121.

503 Burford 1960; Heizer 1966; Betancourt *et al.* 1986; Cotterell and Kamminga 1990; Knapik *et al.* 1996; DeLaine 1997; Malville 1999, 2001; Bastien *et al.* 2005; Vaz *et al.* 2005.

504 Cotterell and Kamminga 1990, 193-195.

505 Cotterell and Kamminga 1990, 195.

506 Erasmus 1965, 287.

pounding fatigue over the longer journey, however, it takes the person transporting loads 1 km that much longer to walk back for a new load.

It is partly due to the variability in multi-material construction and transport that I have deferred case studies using a comparative labour range with these to another time. The remainder here will discuss single-stage earthen construction and associated wooden palisades. Multiple task rates for soil are combined with targeted experimental work with wood, a marriage of necessity for old and new labour predictions. The inclusion of woodworking rates in the older single-rate format shows the compatibility of a comparative range in one material (soil) that can be added or subtracted at will. This permits an interpretative model combining each rate format without derailing the comparative enterprise through the nuances of preindustrial labour and the scarcity of rates for more complex tasks.

9.5 Case study 1: Moundville, Alabama

The first case study, Moundville, was one of the largest sites in North America at its peak around 1200 C.E., consisting of at least 32 earthen mounds arranged around an artificially levelled plaza (Figure 9.1). With a resident population estimated at 3,000, Moundville collected agricultural surplus from a hinterland of single-mound centres and smaller settlements scattered across west-central Alabama. Long-distance exchange brought materials like obsidian and copper from as far afield as Colorado and Michigan, and intricately crafted prestige goods showed imagery representative of a highly influential regional iconographic tradition known as the Southeastern Ceremonial Complex.[507]

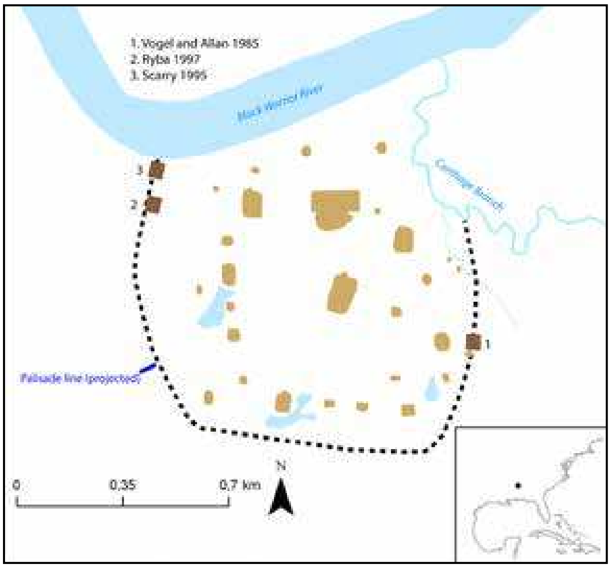

Figure 9.1: Map of Moundville showing the locations of excavations intersecting the former palisade line (c. 1200 C.E.). Mound locations are approximate and not to scale. Based on Turner 2010, 69, original figure by John H. Blitz, 2008.

507 See Knight and Steponaitis 1998; Blitz 2008.

Moundville Defensive Perimeter (c. 1200 C.E.) *							
Wall Trench							
Scenario	****Perimeter (m)**	**Bastions**	**Volume (m^3)**	**Rate (p-h/m^3)**	**Cost (p-h)**	**Workforce**	**Days (10 hr)**
1	2,700	50	1,350	3.45	4,657.5	200	2.3
2	2,890	60	1,445	3.45	4,985.3	200	2.5
3	3,080	70	1,540	3.45	5,313.0	200	2.7
Palisade							
A	2,700	50	6,750	1.6	10,800.0	200	5.4
B	2,890	60	11,075	1.6	17,720.0	200	8.9
C	3,080	70	15,400	1.6	24,640.0	200	12.3
Total							
1A	2,700	50			15,457.5	200	7.7
2B	2,890	60			22,705.3	200	11.4
3C	3,080	70			29,953.0	200	15.0

*Table 9.3: Labour costs of the Moundville defensive perimeter (c. 1200 C.E.) with single-source task rates and variable estimated bastion numbers. (*Scenarios A-C list post count under volume and labor rates as p-h/post; adapted from Turner (2010, 72-75) using rates from Hammerstedt (2005); **Curtain wall plus added bastion length (14 m per bastion)).*

The total soil shifted for Moundville's mounds and plaza amounted to roughly 375 million kg, as recalculated by Cameron Lacquement using a digital gridding method.[508] From the perspective of the soil mover, this equates roughly to 19 million basket loads or, for a modern equivalent, 31,000 cycles with a standard dump truck. Looking beyond this undeniably impressive feat, our energetics focus here is not on the mounds; rather it is on what has not survived. A bastioned wooden palisade over 2 km in length once enveloped this complex, and where traces have been found in excavations in the western and eastern portions of the site, the number of posts used can be extrapolated roughly to a mean of 11,000.[509] The palisade was rebuilt six times according to realignments witnessed in the excavations, and John Blitz's 2008 original map (referred to in Figure 9.1) shows the projected outline citing intersecting excavations and reports from 19th century observers of a low rise following the outer perimeter of mounds.[510]

One of the reasons the palisade needed so many rebuilding episodes is that the climate in west-central Alabama is not kind to untreated wood. Pine and other common species tend to decay within a matter of decades, and the rebuilding phases seen in excavation seem to corroborate this with a close reading of associated ceramics.[511] In any case, the site was walled for at least a century, after which it became less of a

508 Lacquement 2009, 102-103.
509 Turner 2010, 74.
510 Vogel and Allan 1985; Scarry 1995, 178; Ryba 1997, 53-55; Turner 2010, 69.
511 Scarry 1995, 197; Milner 2000, 62; Hammerstedt 2005, 220.

population centre and more a place for people living elsewhere to return to in order to bury their dead. Reconstructed palisades, such as one at the site of Town Creek in North Carolina, approximate what Moundville's would have looked like with wattle-and-daub closing the gaps, reducing fire risk and screening movement, and with the bastions offering an excellent firing platform for bow-wielding defenders.[512]

What does it take to build something like this? Labour-time estimates using Scott Hammerstedt's figures in Kentucky–that is, rates from timed observations using stone tool replicas to chop trees and move soils of a relatable density–allow a prediction of the final cost, which is roughly 30,000 person-hours (see Table 9.3, Scenario 3C).[513] Now what does that actually mean? For a major population centre estimated to have 3,000 people in the immediate area, community security within a matter of weeks is very manageable (15 [ten-hour] or 30 [five-hour] days for 200 workers). Although prohibitive costs were absent in the initial construction of the palisade, issues did arise with the upkeep, especially having to maintain a massive perimeter with a depleted labour pool as people began moving away from the site.

Continuing to explore Moundville through its labour potential, the debate deepens with each new wave of studies. Part of the allure of Moundville for archaeological research is its scale relative to other sites in the region, and indeed, a windfall of recent literature has duly attested the importance of major Mississippian centres like it.[514] One would need to travel over 300 km to witness another multi-mound centre of comparable scale, which raises the question: Why take such steps to fortify? Warfare in the Mississippian period (1000 – 1500 C.E.) has been characterised as endemic raiding in the smash-and-grab fashion rather than conquest, so prolonged sieges are safely out of the question.[515] Seizing food, captives, or rare materials would represent some possible raiding objectives for populations to guard against. Protecting food stores from outsiders sneaking into the perimeter of house groups certainly sounds more in line with valid reasons for Moundvillians to erect a barrier, but again, an estimated 60 bastions for archers seems excessive for repelling simple corn thieves.[516] Fear of abduction must have played a role, and the antagonists, wherever they originated, would need numbers and no shortage of bravado to crack an engorged nut that size. So, one must next ask what internal forces could cause that nut to crack from within, possibly warranting the construction and upkeep of such an overt symbol of power while simultaneously risking collateral blowback from the local environment or leaders with a different vision for communal labour projects.

Before exploring reasons why the population fortified Moundville, reasons not to do so take priority. What risks applied to the inhabitants in erecting a massive timber fortification and rebuilding it again and again? Apart from the obvious labour demand that might force the builders to rethink their cooperation in a moment of heavy lifting, changes to the immediate landscape could pose unintended consequences. Complications from erosion, for instance, famously jeopardised early 20th century crop yields in the region, owing in part to land overuse and deforestation, and that

512 Milner 2000; Keeley *et al.* 2007.
513 Hammerstedt 2005, 227-231; Turner 2010, 75.
514 See Anderson and Sassaman 2012; Blitz 2010.
515 Milner 1999; Milner 2000, 55-61; Krus 2016.
516 Turner 2010, 75; Table 9.3, this volume.

risk certainly applied to those less-developed agricultural systems that made population accretion at Moundville possible. Reliance on fragile crop yields would render the settlement and its exchange network vulnerable if and when food stores failed, triggering population fission back to dispersed smaller settlements.[517] Environmental repercussions from overcutting timber may not have been such a concern but bear mentioning in this context. After all, the Black Warrior River bending north of the site would have allowed floating timbers from upstream, alleviating immediate concerns of deforestation. That possibility does not preclude overuse of local woodland out of convenience or some other motivation, such as clearance for agriculture.

If not used for repelling full-scale assaults and not a liability for the local ecology, what did the Moundville palisade accomplish? The timber, wattle-and-daub wall acted both as a visible deterrent and physical barrier to outsiders and as a reminder to the population inside the perimeter (or with access to the inside) of its own communal labour potential and relative strength, an assumption also made self-evident by the mounds at their impressive final heights. Whether and when the palisade as a symbol of power was co-opted by the elite for their own benefit is another matter to be abstracted and theorised. Firing platforms at regular intervals, however, kept the wall at least partly functional until these were dropped in its final incarnations.

The implication of the task rates used at Moundville is that a single-rate approach is still viable so long as the rates originate in a closely related context. In this instance, Hammerstedt's experimental tree-cutting and soil movement data used replica stone-bladed tools in soils similar to those at Moundville.[518] The estimated labour costs for Moundville's palisade, 30,000 person-hours, or no more than 30 (five-hour) days for 200 workers (see above and Table 9.3), offers a snapshot of the settlement's labour potential in defence, wherein an extended construction period defeats the purpose of a functional deterrent for internal rivals and external threats. Unlike Moundville, the case studies at Dublin and Repton, presented below, do not have single-rate observations that mirror construction circumstances in their earthen settlement boundaries. As with many poorly preserved archaeological features, measurements are incomplete and must be extrapolated. To meet these challenges, measurements and task rates follow a range showing the potential scale of labour involved.

9.6 Case study 2: Dublin, Ireland

Dublin arose in the time of Scandinavian raiding in the mid-ninth century C.E. from an Irish monastic settlement and the Viking encampments that targeted it near the confluence of the Liffey and Poddle (Figure 9.2). Over time the Vikings stayed, and the resulting Hiberno-Norse population dug itself in to withstand local pushbacks and further raiding from latecomers. Earthwork settlement boundaries arose along the landward side of the town, and the phrase *settlement boundary* is deliberately used in place of *defensive rampart* for the earlier incarnations to denote their comparatively smaller size and evident lack of defensive value.[519] The perimeter earthworks did in-

517 Blitz 1999, 578.
518 Hammerstedt 2005, 227-231.
519 Walsh 2001, 94-98; Scally 2002, 17.

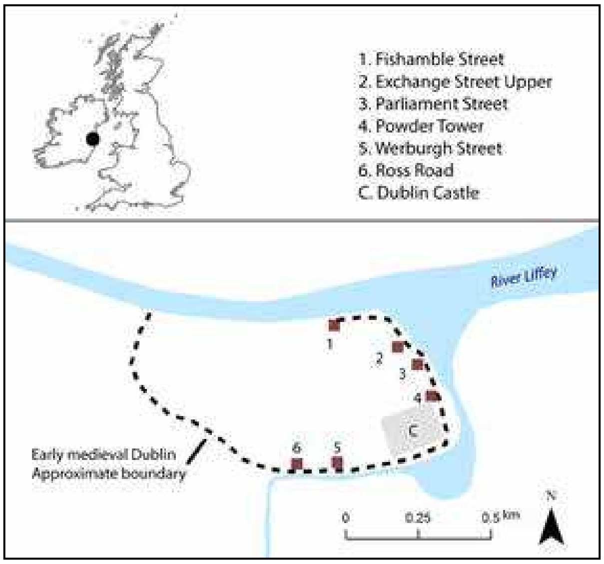

Figure 9.2: Map of Dublin showing the locations of excavations intersecting perimeter earthworks (c. 850-1150 C.E.) in relation to the later Dublin Castle. Based on maps by Wallace 1990 and Clarke 2002.

crease in estimated dimensions over time, roughly doubling in the course of the first hundred years after initial raiding before exploding in size to a full defensive rampart by the time of the early 11th century. These early earthworks were ultimately replaced by a battered stone circuit wall, but circumstances did not afford much opportunity for the population to reap the benefits as the Anglo-Norman invasion of 1170 C.E. ultimately removed control from the entrenched Hiberno-Norse elite.

Part of the comparative spirit of multiple task rates demands the listing of raw data such as that shown in Table 9.4. If in need of a quick reference, focus should fall on the final two columns on the far right of the table showing suggested labour scenarios. The other columns record the variables involved in each choice, a necessity for accountability where rates and dimensions might be disputed. Recall the warning about single-rate predictions leading interpretation in a particular direction and imagine being unknowingly led down that road by a preemptive omission of all other possibilities. What appears in Table 9.4 is a range of dimensions given by excavations for earthen enclosures at early medieval Dublin and Repton (discussed below), combined with a range of task rates for moving earth as recorded in experimental and ethnographic examples. Pairing least volume with maximum plausible efficiency, an absurdly low number results for labour-time investment in Scenario 1. At the opposite end of the spectrum–so most volume and least efficiency (Scenario 7)–the sum is more than 42 times larger than that of the least cost. In a traditional energetics study, only one of the conservative middle rows appears (Scenarios 3-5), but more often than not, a paragraph discussing three cells in particular suffices, the total labour-time estimate and the arbitrary estimate of workers and associated completion time (the three right-most columns in Table 9.4). If the prediction highlighted one task rate but not another, how differently would one interpret the evidence? Whatever Scenarios 1 and 7 show, it does not mesh with reality. Reality probably lies somewhere in the middle (Scenario 4), but if only one side of the story appears, then alternate interpretations that the early medieval Dublin locals cared

<table>
<tr><th colspan="8">Labour comparison of Viking earthen enclosures</th></tr>
<tr><td colspan="8"></td></tr>
<tr><th colspan="8">Dublin Settlement Boundary (c. 950 C.E.)</th></tr>
<tr><th>Scenario</th><th>Dimensions (m)</th><th>Profile</th><th>Volume (m^3)</th><th>Rate (p-h/m^3)</th><th>Cost (p-h)</th><th>Workforce</th><th>Days (10 hr)</th></tr>
<tr><td>1</td><td>940 × 0.7 × 2.5</td><td>V</td><td>823</td><td>1.5</td><td>1,234.5</td><td>100</td><td>1.2</td></tr>
<tr><td>2</td><td>940 × 1.7 × 3.7</td><td>|_|</td><td>5,913</td><td>1.5</td><td>8,869.5</td><td>100</td><td>8.9</td></tr>
<tr><td>3</td><td>940 × 0.7 × 2.5</td><td>V</td><td>823</td><td>4.2</td><td>3,456.6</td><td>100</td><td>3.5</td></tr>
<tr><td>4</td><td>Ranged</td><td>_/</td><td>3,368</td><td>4.2</td><td>14,145.6</td><td>100</td><td>14.1</td></tr>
<tr><td>5</td><td>940 × 1.7 × 3.7</td><td>|_|</td><td>5,913</td><td>4.2</td><td>24,834.6</td><td>100</td><td>24.8</td></tr>
<tr><td>6</td><td>940 × 0.7 × 2.5</td><td>V</td><td>823</td><td>8.9</td><td>7,324.7</td><td>100</td><td>7.3</td></tr>
<tr><td>7</td><td>940 × 1.7 × 3.7</td><td>|_|</td><td>5,913</td><td>8.9</td><td>52,625.7</td><td>200</td><td>26.3</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td>Palisade*</td><td>940 × 0.3 × 0.15</td><td>|||||</td><td>2,090</td><td>1.6</td><td>3,344.0</td><td>100</td><td>3.3</td></tr>
<tr><th colspan="8">Dublin Defensive Rampart (c. 1050 C.E.)</th></tr>
<tr><th>Scenario</th><th>Dimensions (m)</th><th>Profile</th><th>Volume (m^3)</th><th>Rate (p-h/m^3)</th><th>Cost (p-h)</th><th>Workforce</th><th>Days (10 hr)</th></tr>
<tr><td>1</td><td>1,325 × 0.9 × 2.3</td><td>V</td><td>1,372</td><td>1.5</td><td>2,058.0</td><td>100</td><td>2.1</td></tr>
<tr><td>2</td><td>1,325 × 4 × 7</td><td>|_|</td><td>37,100</td><td>1.5</td><td>55,650.0</td><td>500</td><td>11.1</td></tr>
<tr><td>3</td><td>1,325 × 0.9 × 2.3</td><td>V</td><td>1,372</td><td>4.2</td><td>5,762.4</td><td>100</td><td>5.8</td></tr>
<tr><td>4</td><td>Ranged</td><td>_/</td><td>19,236</td><td>4.2</td><td>80,791.2</td><td>500</td><td>16.2</td></tr>
<tr><td>5</td><td>1,325 × 4 × 7</td><td>|_|</td><td>37,100</td><td>4.2</td><td>155,820.0</td><td>500</td><td>31.2</td></tr>
<tr><td>6</td><td>1,325 × 0.9 × 2.3</td><td>V</td><td>1,372</td><td>8.9</td><td>12,210.8</td><td>100</td><td>12.2</td></tr>
<tr><td>7</td><td>1,325 × 4 × 7</td><td>|_|</td><td>37,100</td><td>8.9</td><td>330,190.0</td><td>1,000</td><td>33.0</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td>Palisade*</td><td>1,325 × 0.3 × 0.15</td><td>|||||</td><td>2,945</td><td>1.6</td><td>4,712.0</td><td>100</td><td>4.7</td></tr>
<tr><th colspan="8">Repton Defensive Rampart (c. 873 C.E.)</th></tr>
<tr><th>Scenario</th><th>Dimensions (m)</th><th>Profile</th><th>Volume (m^3)</th><th>Rate (p-h/m^3)</th><th>Cost (p-h)</th><th>Workforce</th><th>Days (10 hr)</th></tr>
<tr><td>1</td><td>160 × 8.5 × 4.2</td><td>V</td><td>2,856</td><td>1.5</td><td>4,284.0</td><td>100</td><td>4.3</td></tr>
<tr><td>2</td><td>160 × 10 × 4.2</td><td>|_|</td><td>6,720</td><td>1.5</td><td>10,080.0</td><td>100</td><td>10.1</td></tr>
<tr><td>3</td><td>160 × 8.5 × 4.2</td><td>V</td><td>2,856</td><td>4.2</td><td>11,995.2</td><td>100</td><td>12.0</td></tr>
<tr><td>4</td><td>Ranged</td><td>_/</td><td>4,788</td><td>4.2</td><td>20,109.6</td><td>100</td><td>20.1</td></tr>
<tr><td>5</td><td>160 × 10 × 4.2</td><td>|_|</td><td>6,720</td><td>4.2</td><td>28,224.0</td><td>100</td><td>28.2</td></tr>
<tr><td>6</td><td>160 × 8.5 × 4.2</td><td>V</td><td>2,856</td><td>8.9</td><td>25,418.4</td><td>100</td><td>25.4</td></tr>
<tr><td>7</td><td>160 × 10 × 4.2</td><td>|_|</td><td>6,720</td><td>8.9</td><td>59,808.0</td><td>200</td><td>29.9</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td>Palisade*</td><td>160 × 0.3 × 0.15</td><td>|||||</td><td>356</td><td>1.6</td><td>569.6</td><td>100</td><td>0.6</td></tr>
</table>

*Table 9.4: Labour costs of Viking earthen enclosures comparing the Repton winter encampment with 10th and 11th century Dublin perimeter earthworks. Multi-source task rates show variability possible when combined with the range of estimated dimensions (*Dimensions listed as perimeter, post diameter, and post spacing; volume reflects projected post count, and rate is p-h per post for cutting, transporting, and setting within 1 km (Hammerstedt 2005; Turner 2010)).*

very little or quite a lot to erect a town boundary could go unchallenged. The same applies for the later defensive barrier, which shows roughly six times the effort of the earlier settlement boundary, at least with reasonable variables.

As with the first case study in questioning the motives behind Moundville's over-zealous defence, questioning the purpose of an earthen bank perimeter not substantial enough to be any significant hindrance to an invader forms a natural line of inquiry.[520] Of course, most settlements situated between watercourses would spark interest in flood control, and such action would not seem unreasonable against the tidal Liffey. However, the perimeter crosses higher ground at Ross Road in the south and stays inland of the tidal marks witnessed in excavations at Exchange Street Upper in the northeast, calling into question the early 10th century embankment's function in water management.[521] When the perimeter expands half a century later, excavators proposed its role as part of a land reclamation programme, supported by post-and-wattle additions to the perimeter seen at Parliament Street in the northeast.[522] This is not uniformly encountered at other excavations intersecting the line, particularly along the southern border of the settlement, with Ross Road and Werburgh Street showing either a denuded form or the steady build-up of domestic refuse as locals took advantage of a convenient place to dump their trash.[523]

By the end of the 10th century, an unambiguous defensive rampart eclipsed the earlier earthen boundaries and doubled the intramural area of the town.[524] Whether triggered by population pressures from within or a need to include a fordable section of the Liffey within the circuit, the town kept this defensive enclosure until its replacement by a stone enceinte around 1100 C.E.[525] The spike in labour demand for increasingly larger earthworks could have coincided with the waxing and waning of Hiberno-Norse fortunes in the area, particularly the return of foreign elites around 917 C.E. after their expulsion by local rivals fifteen years prior.[526] The evidence for this is tenuous, however, and too reliant on historical sources written from the perspectives of unsympathetic Irish chroniclers in the *Annals of Ulster*. In any case, the concurrent wave of building seen in excavations at Temple Bar West does lend credence to the possibility that the Hiberno-Norse return was a boon to the local economy, even if there is no evidence to suggest that the locals suffered a catastrophic setback in the interim.[527]

Questions of motivations aside, what are the implications behind a comparative labour assessment for the Dublin perimeter earthworks? The uncharitable answer is that energetics runs into severe roadblocks in multi-century construction where a modern

520 Observed heights for the first perimeter range from 0.45 m at Exchange Street Upper to 0.8 m at Fishamble Street and Ross Road. The second boundary shows a height range from 0.7 m to 1.7 m in excavations at Ross Road, Parliament Street, Fishamble Street, and Werburgh Street. See report of excavations in Walsh 2001; Scally 2002.

521 Wallace 1990; Walsh 2001, 98; Scally 2002, 17.

522 Scally 2002, 18-21.

523 Walsh 2001, 98-100; Hayden 2002, 66.

524 Excavations under the Powder Tower of the later Dublin Castle give a conservative height for the embankment at 2.7 m, not including the possibility of a timber revetment. See report of excavations in Lynch and Manning 2001.

525 Walsh 2001, 106; Clarke 2002; Scally 2002, 25; Simpson 2010.

526 Clarke 1977; Simpson 2010.

527 Simpson 2010; Simpson 2011.

metropolis occludes investigation of the full perimeter, notably causing unavoidable speculation over the original dimensions of the earthworks and uncertainty surrounding their concurrent construction. With those reservations in mind, however, one can imagine that staggering construction into separate phases that leave an incomplete scatter of lines is less attractive than an unbroken perimeter, no matter its dubious initial purpose. Locking in a convincing volume from scattered excavation evidence is certainly a greater problem than the production efficiency of soil movers.

On the surface, the Dublin examples might appear to present a few hurdles too many in testing the validity of a comparative labour method. However, that is not the case. The labour estimates in Table 9.4, whatever their absolute value, still offer useful relative comparisons with the changing settlement boundaries of a growing early medieval town. As mentioned above, constructing Dublin's 11th century defensive rampart required roughly six times the effort of its 10th century settlement boundary counterpart and four times the cost of the embankment at the temporary encampment of Repton (see below and Table 9.4, Scenario 4). However, without assurances that task rates used in each case are comparable, as might be the case in separate single-rate examples, those comparisons evaporate. Where the maximum volume is used but the task rates differ in the extreme, the settlement boundary (Scenario 7) and defensive rampart (Scenario 2) reflect similar construction costs.

9.7 Case study 3: Repton, United Kingdom

Seeing where complications arise and confidence wavers in multi-century construction and scattered excavation evidence, the final case study simplifies the labour equation through shortening the available timeline for the work in question. The Viking encampment at Repton was occupied for a single season in the winter of 873-874 C.E. (Figure 9.3). This was part of the campaign known from chroniclers as the 'Great Heathen Army', wherein several larger than life characters emerged, such as Ragnar Lothbrok's sons, many of whom continue in popular culture today through television series.[528] At Repton, the army moored their ships and erected a simple defensive earthwork using the local church as a gatehouse. The D-shaped ring with a watercourse as the non-curved edge shows a common form for the Viking *longphort*, the Irish reference for fortified camps such as that postulated for Dublin and confirmed in excavations at Repton and Woodstown, Co. Waterford.[529]

The simple fortifications marked the location for incoming ships to gather and gave the crews a chance to establish camp and consolidate what spoils they had won. For a temporary camp, announcing where buried treasure may lie with an obvious earthwork narrowing the area of search for others does not signify an effective strategy, but neither does burying goods in an inconspicuous location increase one's chances of finding it again.[530]

528 Biddle and Kjølbye-Biddle 1992; Biddle and Kjølbye-Biddle 2001.

529 Sheehan 2008; Raffield 2010.

530 What hoards remain for latecomers to find, however, clearly did not warrant reclaiming by the original owner, either due to their untimely death or some other circumstance that stopped them from withdrawing their deposit, which includes possibilities of votive offerings not meant to be reclaimed by the living.

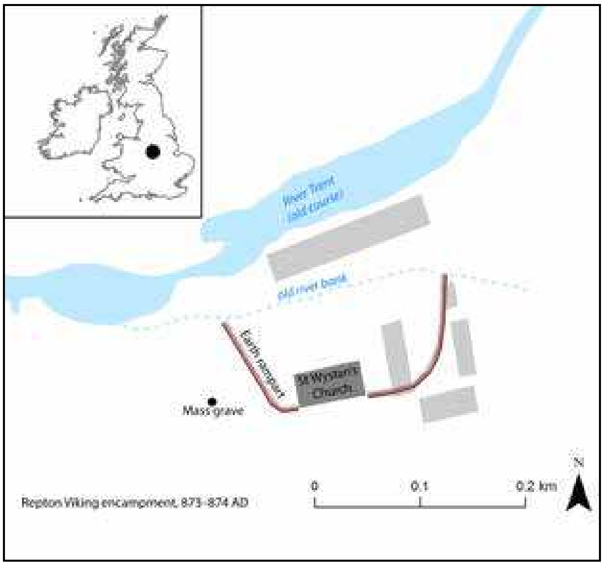

Figure 9.3: Map of Repton Viking encampment (873-874 C.E.) showing the location of earthworks around St Wystan's Church and later buildings of the Repton School. Based on maps by Biddle and Kjølbye-Biddle 2001.

Overshadowing other items that may have been deposited in camp owing to their covetous value among archaeologists as chronological markers and detectorists as unmistakable objects of wealth, coin and silver hoards would certainly have been meaningful for the soil movers to defend in addition to their own lives.[531] Five coins recovered among the finds at Repton support the association of the Viking occupation here with the overwintering noted in the chronicles, but the provenance of these and other finds associated with graves at the site have been hampered by later disturbances.[532]

Excavations at Repton identified the D-shaped earthwork as well as what appeared to be a foreign warrior burial of a prominent individual surrounded by a mass deposit of bones from the locals. Of course, this sparked discussion on whether this represented a mass execution or the vanquished enemy surrounding Ivar son of Ragnar, but a closer look at the bones says otherwise. Very few outward signs of trauma appear, and the interpretation now rests with the bones around the central grave signifying disturbance during the digging of the defences and redeposition in honour of the central burial.[533] Whatever the circumstance, the locals could hardly have missed the subtext of intimidation and humiliation in having their ancestor's bones used as decoration for the internment of an invading warlord, to say nothing of their church's use as a convenient door for an earthen rampart.

The time restriction of the Viking occupation at Repton offers a clear advantage to modelling the labour invested in its earthen rampart. Working down from the four-month maximum, only the rumour of imminent attack would spark continued construction in the final months leading up to a spring departure. It could be argued that discontent sown from boredom would be just as dangerous among the rank-and-file, but encouraging further construction over local raiding may also have proven a mis-

531 Kenny 1987; Sheehan 2000; Richards 2004; Goodrich 2010.
532 Richards 2004, 102.
533 Richards 2001; Richards 2004, 102.

guided strategy for leaders. Whereas plunder or popularity could be wrenched easily enough from locals, nothing could be gained from obsessing over fortifying a temporary camp in their midst. The digging would have stopped when perceived needs were met. It is for these reasons that construction after the initial month of occupation is disregarded as unnecessary or foolhardy. This leaves the question of what tactical value the diggers saw in a simple ditch-and-bank and how willing they were to push it to completion as quickly as possible.

The way we conceptualise early medieval defensive earthworks is typically one of expedient defence, where our view of serene grassy slopes challenges whether these mole hills could have any use in war. Some at least survive near their original height, such as the much larger example at Maiden Castle Dorset, where it is still apparent how slowing the enemy down and screening internal movements from view can produce a serious tactical advantage over sitting in an exposed camp. Again Table 9.4, showing the range of volumes paired against a range of task rates, leaves the middle ground (Scenario 4) as the most pleasing to the eye but not necessarily the one closest to reality. The seasonal occupation at Repton dictates that they dug this in the winter, so Scenario 7 is equally plausible and nearly three times the cost of Scenario 4. This also has important implications for inter-site comparisons. Comparing Scenario 4 to early medieval Dublin, the embankment at Repton was 50% more costly than the 10th century settlement boundary but only a quarter of the cost of Dublin's 11th century rampart. Scenario 7, however, considers the hardship of digging waterlogged soils in an English winter, elevating the cost of the Repton embankment to three quarters of Dublin's rampart (Scenario 4). Variability in volume estimates may account for more variation, but different task rates can multiply costs up to six times the minimum efforts often sought in single-rate labour assessments.

9.8 Comparative labour

In the Fermi or 'cocktail napkin' approach to labour costs and other mathematical exercises, everything outside the final sum stays behind the scenes, and what remains is something more visually pleasing and informative, a graph or a story for instance.[534] Variables and long-form calculations are simply tossed aside. However, keeping this information available, at the very least in a published appendix or endnote, not only provides a way to repeat it for other case studies, it allows others to confirm and cross-check the variables in use, as well as the validity of the calculations. Human error with numbers is quite unavoidable where pride does not suppress honesty.

In any case, there are much safer options for displaying data related to comparative labour investment, and Figure 9.4 makes such an attempt.[535] The palisade at Moundville appears surprisingly comparable in labour intensity to the enclosures at Repton and 10th century Dublin, but all of these are dwarfed by 11th century Dublin where the townspeople took their own defence to heart after centuries of repeated raids. It is not just renewed interest in defence that is at work here. Historical sources tell us that the

534 Peterson and Drennan 2012, 88-89.

535 The chart and its attendant data were adapted and updated from earlier work comparing several earthen enclosures from the early medieval British Isles. See Turner 2012, 81-82.

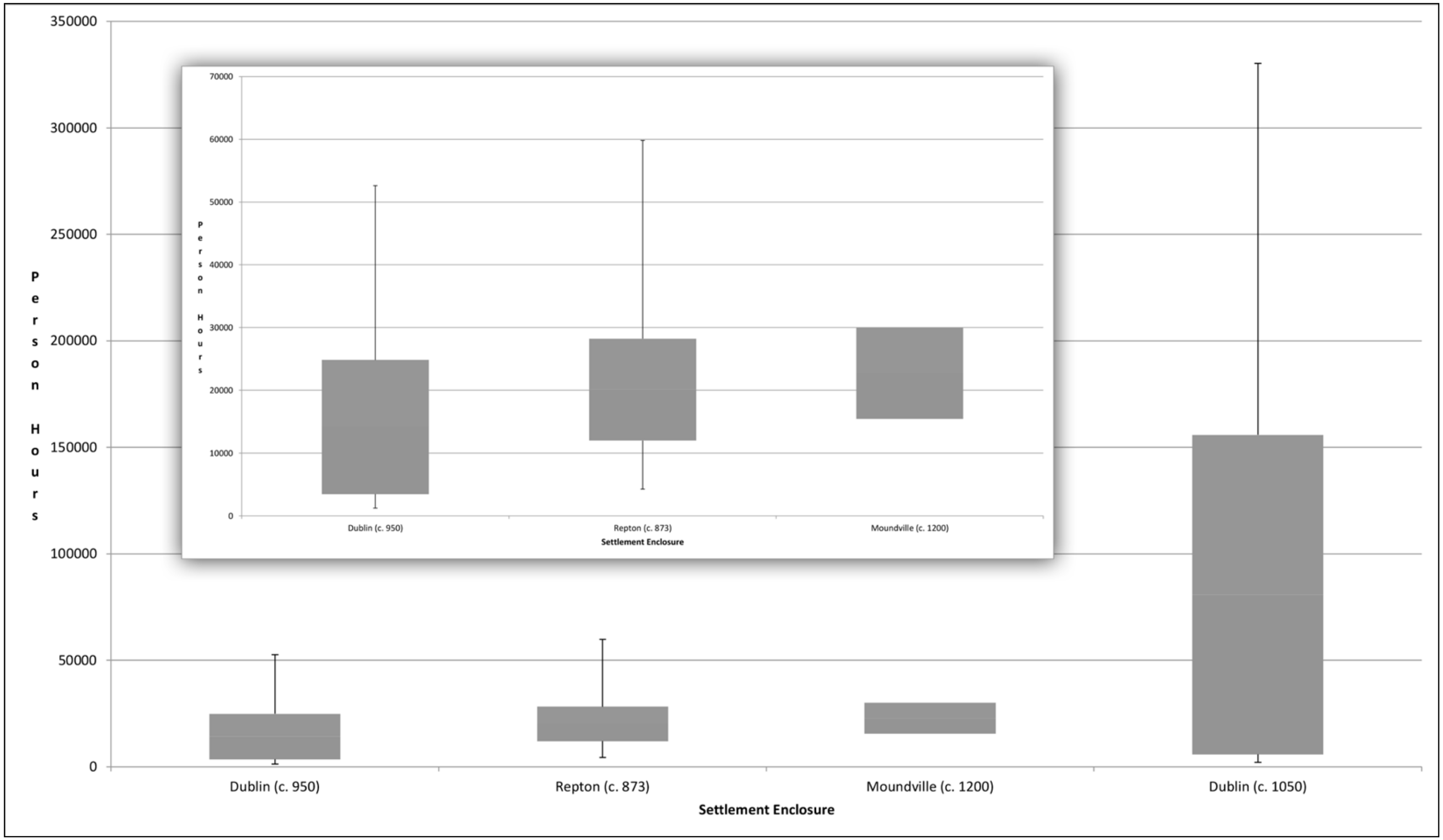

Figure 9.4: Chart showing comparative enclosure costs for case studies discussed herein.

barrier coincides roughly with the return of Hiberno-Norse elites that the locals had earlier expelled, so added to the necessity for community defence is the need for elites to secure their power base once more.

Although not known in detail, the population of each site and its available labour pool would also factor in the scale of its earthworks. Larger populations, such as that of 13th century Moundville and 11th century Dublin, would be capable of costlier architectural projects, though not necessarily inclined to attempt them. The multi-phase construction of Moundville's earthworks, unfortunately, does not allow for direct comparisons. Comparing Dublin and Repton, the population and labour potential of 11th century Dublin appears on the surface to outclass that of the ninth century Repton encampment. Substitute a more strenuous labour rate or maximise the projected volume to the advantage of one site, however, and the story changes. In separate studies unaware of task rate variability, that caveat might go unnoticed where variables are not explicitly stated. Comparative labour ranges may not offer the full story, but they can certainly tamper with the details of what we think we know.

I hope to have shown here that variability in even the simplest task rates (such as single stage earthmoving from ditch to adjacent bank) is excessive. In order for labour-time estimates to remain useful as a comparative proxy, closer attention should be paid to what constitutes an acceptable labour range based on the tools and materials in question. To expedite comparative ranges, work should progress toward the compilation of reported task rates that cover much more than soil movement. Manual work in stone, wood, and metal, as well as transport using humans and draft animals, must be compared in terms transferrable for comparative labour estimates. Case studies will continue to expand in the meantime, and so much the better, for the proliferation of examples strengthens the method and generates a pervasive understanding of how labour has shaped past economies. Further study can also inform how manual labour will shape future economies and the employment pressures of automation. There are still some hurdles to overcome, namely the challenges of multi-variable, multi-stage construction where confidence breaks down in the operational sequence. Also in question is what can be done to digitise labour rates for materials and processes that are not easily replicable anymore, such as quarrying and transporting in sensitive environments. In any case, all benefit from more task rates, readily laid out such that you can select the most appropriate rate for your sites wherever and whenever they are.

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10

Rethinking monumentality in Teotihuacan, Mexico

Maria Torras Freixa

10.1 Introduction

This paper investigates the large-scale building projects of the ancient city of Teotihuacan, Mexico. Its aim is to trace the sequence of events leading up to the construction of its three main monumental pyramids: the Moon Pyramid, the Sun Pyramid and the Feathered Serpent Pyramid. Gaining insights into the building, development, and transformation of these three architectural units can advance our understanding of the political and socio-economic issues involved in the city's urban growth and its architectural configuration. In this context, rethinking the concept of monumentality offers us a deeper perspective on the different spheres of life and sectors of society living in the city of Teotihuacan.

Monumentality is a well-researched topic and a multidisciplinary concept that has many different definitions. Trigger's often-cited definition of monumental architecture characterises it as constructions '(whose) scale and elaboration exceed the requirements of any practical functions that a building is intended to perform'.[536] Sugiyama, with his long experience of excavating the archaeological sites of Teotihuacan, also explores this concept, stating that 'monumentality can be defined as a complex of socially constructed value systems that is created and disseminated to convey particular messages to a mass public through actions including construction projects, rituals, or burial practices repeatedly taking place at physical monuments'.[537]

Smith also proposes an empirical urban theory that can be useful to take the study of monumentality beyond its purely descriptive level. He writes that '(the) concepts (of empirical theories) (*e.g.* monumentality, access, visibility, planning, and levels of meaning) directly link the urban-built environment to the actions of people within cities. (…) "Empirical urban theory" is a collection of theoretical approaches that operate on

536 Trigger 1990, 119.
537 See Carballo 2013, 134.

In: Brysbaert, A., V. Klinkenberg, A. Gutiérrez Garcia-M. & I. Vikatou (eds) 2018. *Constructing monuments, perceiving monumentality and the economics of building: Theoretical and methodological approaches to the built environment*. Leiden: Sidestone Press, pp. 219-219.

a lower epistemological level than grand social theory; they are located somewhere near the centre of the epistemological continuum mentioned above'.[538]

The urban built environment is an important factor in understanding the social identities and networks present in a city, along with the individuals and groups who have the power to shape this urban landscape. The relationships between the urban landscape and its inhabitants are continually shifting.[539] It is in this sense that the monumental architecture at the core of Teotihuacan displays changes or gradual alterations in its form and appearance. These changes offer clues to decipher different aspects of its urban society. In brief, studying the material aspects of monumental architecture can enable us to define non-material facets of culture such as residents' beliefs, cultural symbols, and power relations: this is also called the 'materialization of ideology'.[540] Likewise, re-evaluating theoretical perspectives on and interpretative frameworks of large-scale building projects can provide valuable insights into Teotihuacan's history and society.

The pre-Hispanic urban centre of Teotihuacan, from the period c. 0-650 C.E. (Table 10.1), was situated in the northeast sector of the Basin of Mexico, about 45 km from modern-day Mexico City. This settlement was unique in contemporary Mesoamerica for its size (125,000 inhabitants living in an area of 20 km^2), and its perfectly designed grid plan, which was divided into four sections by two large avenues.[541] The city had a multi-ethnic population and a corporate society.[542] Also it lacked depictions or burials of a ruler or any kind of central authority. Cowgill points out that 'acts rather than the actors' were important in Teotihuacan.[543]

The main pyramids in Teotihuacan's civic-ceremonial centre were built in their monumental form during the Early Tlamimilolpa phase, 200-250 C.E., over a very short period of time and involving a huge input of labour.[544] However, in many previous publications, some of these large-scale constructions are still attributed to the earliest stages of urban construction during the Tzacualli and Miccaotli phases (0-200 C.E.). Several scholars have interpreted this construction as proof that Teotihuacan had a strong central authority at its beginnings and that the city's character was expressed by the Sun Pyramid.[545] As the early phases of Teotihuacan are still not well understood, it is necessary to re-evaluate data from this early time period. A recent reassessment of this early period requires us to reconsider the context in which the city achieved its monumentality, as well as the political and socio-economical processes that triggered these large-scale projects.

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538 Smith 2011, 168.

539 Murakami 2014; Smith 2011; Smith 2014.

540 De Marrais *et al.* 1996, 16.

541 Cowgill 1974; Cowgill 1992; Cowgill 2007; Cowgill 2015; Matos 1990; Millon 1973; Millon 1981; Nichols 2015; Rattray 2001.

542 This has been studied mainly from the Late Tlamimilolpa phase (250-350 C.E.) up until the city's collapse. Manzanilla 2001; Manzanilla 2004; Manzanilla 2006; Manzanilla 2015; Pasztory 1997.

543 Cowgill 1997, 137.

544 Sugiyama 2013; Sugiyama *et al.* 2013; Sugiyama *et al.* 2014.

545 Angulo 1998; Cowgill 1992; Cowgill 2000; Millon 1973, 54; Millon 1981; Millon 1988; Rattray 2001, 362, 366.

Chronology	Ceramic phase
550-650	Metepec
450-550	Late Xolalpan
350-450	Early Xolalpan
250-350	Late Tlamimilolpa
200-250	Early Tlamimilolpa
150-200	Miccaotli
0-150	Tzacualli
B.C.E./C.E.	
150-0	Patlachique

Table 10.1. Chronology of Teotihuacan showing the time range discussed in the text (after Rattray 2001).

To address this question, this contribution first reviews previously published data pertaining to the three pyramidal structures in order to situate these buildings in the later period of construction (200-250 C.E.). The data used for this purpose are: the building sequence, the size of the constructions, building techniques, construction materials, radiocarbon dates, the pyramids' orientations, their location within the settlement, and dedication caches, including human sacrificial offerings.

10.2 Monumentality in Teotihuacan

Large-scale constructions are common in different geographical areas around the world and over a long-time period, thus allowing for a transcultural approach. In the Mesoamerican case, pyramidal structures are seen as a planning principle[546] and as examples of the materialization of large-scale projects. In Teotihuacan, three monumental temple pyramids dominated the central precinct: the Moon Pyramid, the Sun Pyramid, and the Ciudadela with the Feathered Serpent Pyramid (Figure 10.1). The first excavation at Teotihuacan, which was of the central precinct, was undertaken in 1675 C.E. by Singüenza y Góngora at the Moon Pyramid. These buildings were extensively explored in a series of later archaeological studies from the 1980s to the 2010s, providing more accurate construction sequences and a larger corpus of ^{14}C samples.[547]

Until the results of the Sun Pyramid Project were published in 2013,[548] this pyramid was considered to belong to the earliest stages of building, dating from 0-200 C.E. The published data now show that only the Moon Pyramid was started in this early period and was initially very modest in size. The three pyramids arose in their monumental dimensions during a short period, from 200 to 250 C.E. Thereafter, until the city's collapse, construction in the city was geared mainly towards apartment compounds. However, in the current literature, some of these large-scale pyramid projects are still considered to belong to the earliest stages of building.

Very few interpretations have viewed these monumental projects as the result of a single chronological period. Sugiyama,[549] who took part in the archaeological explo-

546 Smith 2017, 176.
547 Cabrera and Cabrera 1991; Cabrera *et al.* 1991; Sugiyama 2004b; Sugiyama 2005; Sugiyama *et al.* 2013; Sugiyama and Cabrera 2007; Sugiyama and López 2006a.
548 Sugiyama *et al.* 2013.
549 Sugiyama 2013; Sugiyama *et al.* 2013.

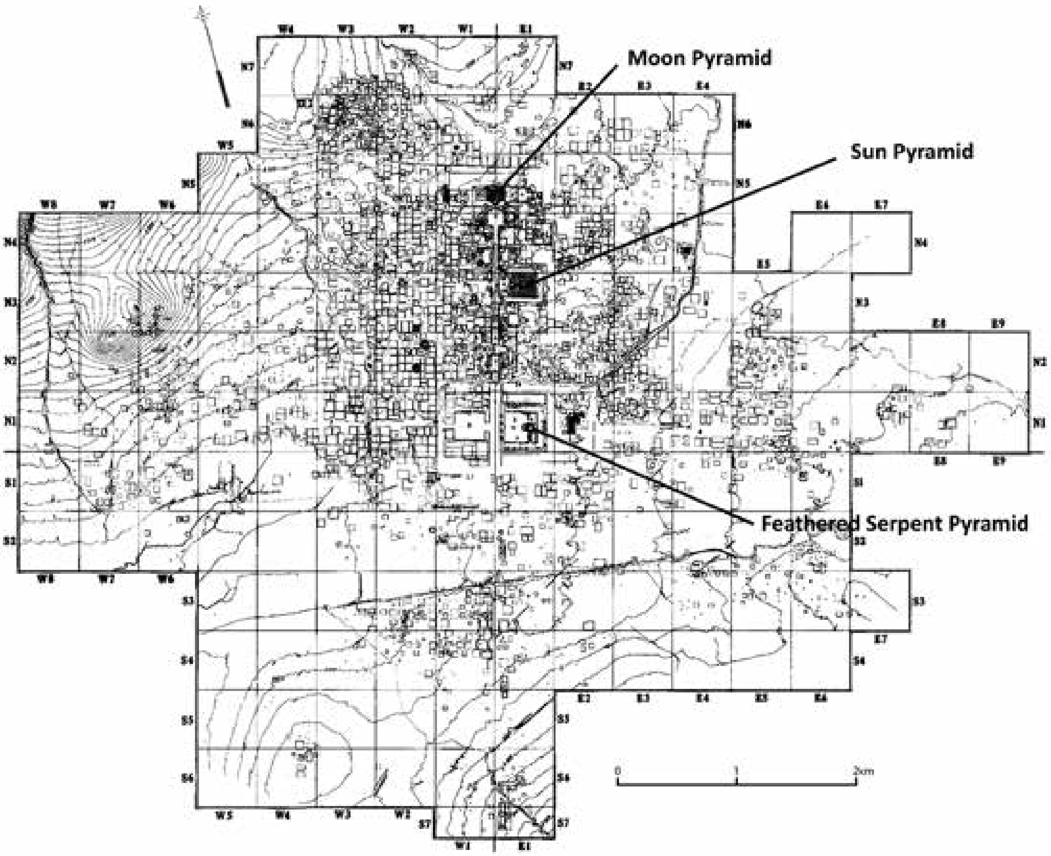

Figure 10.1. Plan of the city of Teotihuacan showing the location of the large-scale buildings discussed in the text (modified after Millon 1973).

rations of the three pyramids, argued that they were built during the same period, 200-250 C.E. In establishing this chronology, he prioritizes ^{14}C results over ceramic sequences. He also stressed the spatial relationships between the pyramids, which show they were created in correlation to each other. They physically embodied the worldview of Teotihuacan and fulfilled a single master plan that symbolized part of the ritual calendar.[550]

Murakami, for his part, suggested a timescale based more on ceramic percentages than ^{14}C results; as a result, he placed the Early Tlamimilolpa phase 50 years later than the date accepted in the current chronology. His model is based on calculations of the energy needed for construction in terms of the man/time ratio,[551] and presents two separate periods. The first includes the construction of Building 4 of the Moon Pyramid and the Sun Pyramid, and the second includes the erection of the Feathered Serpent Pyramid. He argues that a highly centralized authority used the monumental buildings as a legitimising agent.[552]

550 Sugiyama 1993; Sugiyama 2005, 231; Sugiyama 2010; Sugiyama 2013.
551 See section below, 'Rethinking large-scale buildings in the Early Tlamimilolpa phase' for further information.
552 Murakami 2010; Murakami 2014; Murakami 2015; Murakami 2016.

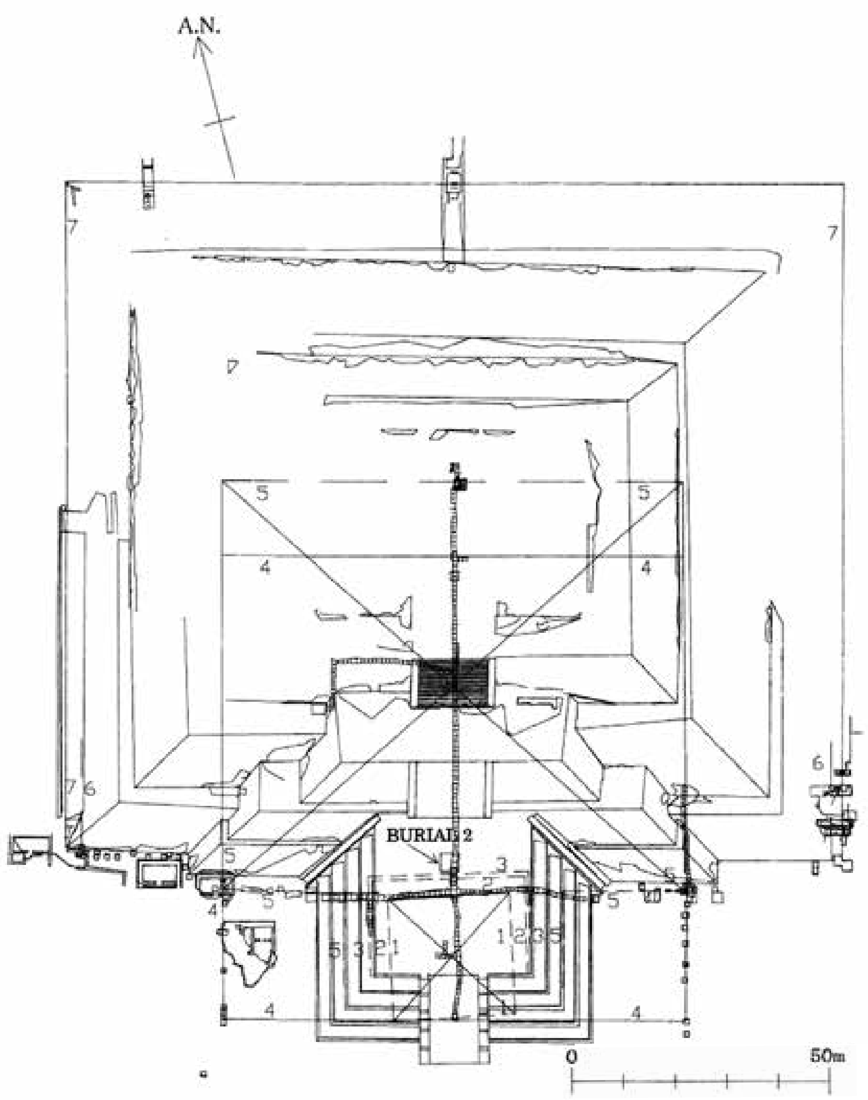

Figure 10.2. Plan of the Moon Pyramid showing the seven superimposed stages. Buildings 1 to 4 and Burial 2 are discussed in the text (after Sugiyama 2004a, 108; Sugiyama and Cabrera 2007, 113).

The remaining sections of this paper describe the three monumental buildings and their construction sequences, offering an overview of the pyramids' features. Subsequently, this paper will discuss and compare them from diachronic and synchronic perspectives. Finally, we draw some overall conclusions.

10.2.1 The Moon Pyramid

Sugiyama and Cabrera directed the Moon Pyramid Project (1998-2004), and excavated the pyramid through tunnelling operations, boring 12 tunnels for intensive exploration. Their research revealed seven superimposed structures, thereby changing our understanding of the Moon Pyramid's construction sequence (Figure 10.2). Their study also aimed to date the seven substructures by ceramic classification, incorporating the results of ^{14}C analysis. Their findings showed that the first three buildings were erected during the second century (between the Tzacualli and Miccaotli phases). Building 1 at Teotihuacan was the oldest construction dated through ^{14}C analysis, to c. 100 C.E.[553]

The first platforms, Buildings 1 to 3, are similar in size, style, and construction materials and techniques. They are square pyramidal structures, very modest in size, measuring 23.5 m at the base (Building 1) and 31.3 m at the base (Building 3) by the third enlargement. These dimensions are quite modest when compared to the monumental dimensions of the subsequent Moon Pyramid stages. An important architectural feature is the use of the stepped *talud* (sloping wall) in their façades and the absence of lime plaster covering. Also, the fill of these three buildings is a mix of stones and earth.[554] Some studies have found Black San Pablo Paleosol, a soil used for agriculture, in the fill matrix of Building 1.[555]

The only difference between these earlier three substructures which can offer us a clue to understanding changes in the contemporary political landscape is their orientation, which shifted gradually clockwise from 11° towards an alignment that is almost exactly the same as the standard orientation of Teotihuacan (15°30' east of the astronomical north). The Teotihuacan Mapping Project named this orientation Teotihuacan North,[556] and it may be related to astronomical and calendrical meanings.[557] The north-south axis of the city (the Street of the Dead), its main civic-ceremonial buildings, its apartment compounds, and its north-south streets all were constructed in line with Teotihuacan North. However, there are some exceptions, such as the East Avenue, or the east-west axis of the Ciudadela. The latter differs from the standard Teotihuacan orientation, as it has an orientation of around 16°50' to 17° south of east.[558] Thus, Sugiyama and Cabrera suggest that Building 1 may have been erected before the currently visible grid plan of the city had emerged, and that it may already have had a religious purpose.[559]

Data on these early structures is scarce, due to the intentional destruction carried out in order to reuse materials for later structures. As a result, we cannot formulate a precise view of the construction sequence of the first three pyramidal buildings. This lack of a full archaeological record hinders our understanding of the city's monumental building process, the implementation of the standard Teotihuacan orientation, and the way these public structures adapted over time into the development of the city's rulership.

One of the most recent and remarkable discoveries is a subsoil-level complex in the Moon Plaza, which is contemporaneous to the initial stages of the Moon Pyramid. Ortega has documented a different morphology of this open space, unearthing more than 400 pits and a possible tunnel leading from the square to the pyramid. Her team also found

553 Sugiyama 2004b; Sugiyama and Cabrera 2006; Sugiyama and Cabrera 2007.

554 Cabrera and Sugiyama 1999; Sugiyama and Cabrera 2000; Sugiyama and Cabrera 2006; Sugiyama and Cabrera 2007; Murakami 2010, 102.

555 Rivera *et al.* 2007; Sánchez *et al.* 2013.

556 Millon 1973, 37.

557 Dow 1967; Sprajc 2000.

558 Cowgill 2005; Cowgill 2008; Millon 1973, 37.

559 Sugiyama and Cabrera 2007, 116-117, 122.

material remains that may symbolise the concept of fertility and water deities.[560] If this hypothesis can be proven, it could offer a key source of information about how the city's inhabitants perceived the Teotihuacan underworld.

Erected around 250 C.E. (Early Tlamimilolpa phase), Building 4 shows a marked change in the construction sequence of the Moon Pyramid. This fourth platform is clearly a large-scale building project, growing to nine times the size of the former three platforms, forming a base of c. 89 m. The architectural style was very similar to the previous substructures: a square pyramidal building with stepped *talud* façades.[561] However, this monumental structure presented some differences that reveal valuable information regarding the ancient city's growth and the socio-political processes involved. Firstly, the construction materials differ significantly. The pyramid's fill is only earth without any rocks, and was probably deposited in a cell system.[562] Secondly, the orientation of Building 4 came closer to the standard Teotihuacan orientation of 15°30' east of astronomical north. Thirdly, a dedicatory cache complex appears as a ritual foundation inside the construction fill's nucleus. This cache (Burial 2) is made up of offerings and a human sacrifice.[563]

Human bone remains found in Burial 2 belong to one foreign adult male, whose hands were found behind his back as if tied, and who was buried with greenstone ornaments.[564] The dedicatory burial/offering also contains animal bones. Nine distinct species have been identified: both local and non-local fauna such as puma, wolf, eagle, falcon, owl, rattlesnake, and other animal remains. The skeletons were buried along with highly valuable items such as Tlaloc vessels, greenstone figurines and objects, a shell necklace with imitations of human maxillae, obsidian artefacts, shells, pyrite, and slate. All of this ritual paraphernalia was distributed in patterns, appearing to represent some type of ceremony exemplifying Teotihuacan's worldview. The burial/offering cache is a ritual deposit representing a dedication for the construction of Building 4. The grave assemblage may be symbolically linked with sacrifice and war given the presence of human sacrifice, raptors, predatory mammals, a shell necklace with an imitation of human maxillae, and some obsidian artefacts such as projectile points, sacrificial knives, and blades.[565] It may also represent the presence of a sacred rulership.[566]

10.2.2 The Sun Pyramid

The Sun Pyramid is the largest and most impressive construction in Teotihuacan and one of the largest pyramids in the world (Figure 10.3). The findings of the 2013 Sun Pyramid Project excavations (2008-2011) revealed a new chronology for this building. Through ^{14}C analysis, it has now been dated to c. 200 C.E. (modelled by Bayesian statistics 1δ 170-310 C.E.).[567] Thus, it is now clear that the Sun Pyramid was erected

560 INAH 2016; INAH 2017.

561 Sugiyama 2004b; Sugiyama and Cabrera 2006; Sugiyama and Cabrera 2007.

562 Murakami 2010, 167; Sugiyama and Cabrera 2000, 166.

563 Sugiyama and Cabrera 2007; Sugiyama and López 2006a; Sugiyama and López 2006b; Sugiyama and López 2007.

564 Spence and Pereira 2007; Sugiyama and López 2006a; Sugiyama and López 2006b; Sugiyama and López 2007; White *et al.* 2003; White *et al.* 2007.

565 Sugiyama and López 2006a, 28, 51; Sugiyama and López 2006b; Sugiyama and López 2007.

566 Sugiyama and Cabrera 2007, 123.

567 Sugiyama 2017; Sugiyama *et al.* 2013.

Figure 10.3. The Sun Pyramid at Teotihuacan (photograph by Maria Torras Freixa).

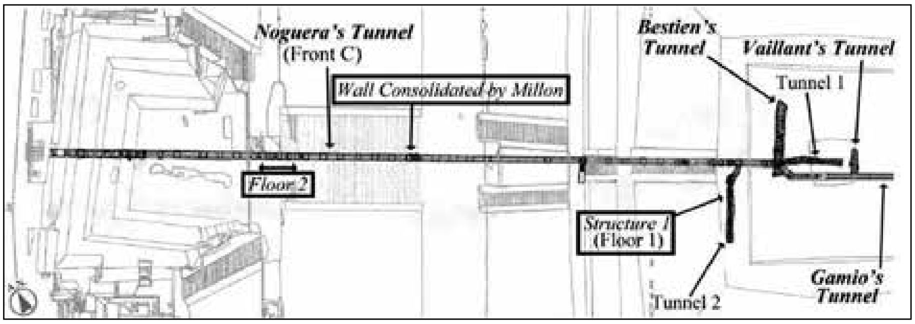

Figure 10.4. Plan with the Pre-Sun Pyramid construction remains framed (modified after Sugiyama et al. 2013, 409, ©Saburo Sugiyama).

more than two centuries later than was previously thought. This more recent chronology, however, has not been entirely accepted by the academic community. Many scholars still see this pyramid as a symbol of a powerful central authority from the earliest era of Teotihuacan, 0-200 C.E.

The Sun Pyramid Project is led by Sarabia and Sugiyama, as are the works in the interior of the pyramid. Within the pyramid's nucleus, they identified several Pre-Sun Pyramid construction remains belonging to the earliest phases of the city.[568] Already in the 1960s, Millon had detected some parts of these architectural units while exploring the monumental platform.[569] Overall, the Pre-Sun Pyramid constructions are small and varied architectural vestiges with a non-domestic function; they consist of walls, floors, and a possible public building (Structure 1; see Figure 10.4). In contrast with Building 1 of the Moon Pyramid, this Structure 1 has a 13.5 m long stone wall with a *talud* on both sides, and is aligned along the standard Teotihuacan orientation. Also, the Pre-Sun Pyramid stage includes small obsidian offerings and one perinatal burial, possibly symbolizing the worship of a water deity.[570]

568 Sugiyama *et al.* 2013.
569 Millon and Drewitt 1961; Millon *et al.* 1965.
570 Millon and Drewitt 1961; Millon *et al.* 1965; Sugiyama *et al.* 2013; Sugiyama *et al.* 2014.

Another feature is the artificial tunnel beneath the Sun Pyramid.[571] Several scholars have suggested that this cavity was an important pole of attraction for other Mesoamerican peoples, representing an essential ritual element of the early urban settlement as a sacred cave.[572] Sload's study[573] presents the most detailed chronology of the long subterranean passageway, dating its construction to the first century C.E. and its use to the first half of the third century, when it was ritually closed. This ritual has been linked with the erection of the Sun Pyramid.

The Sun Pyramid is a square pyramidal structure with stepped *talud* façades reaching 216 m at its base and 64 m in height. As a result of his labour analysis, Murakami argued that the platform achieved monumental dimensions in a very brief time, in less than 10 years.[574] The fill of the main body is an earth and *tepetate* (volcanic tuff) mix containing materials such as ceramics, lithics, and charcoal fragments, which were probably brought in from surface refuse.[575] Samples of the earth employed in the construction's nucleus have revealed botanical evidence pointing to a previous agricultural use of the soil.[576] The building is also aligned with the standard Teotihuacan orientation. Some dedicatory ritual caches, such as offerings and infant burials, have been identified in the foundation and in the fill of the pyramid. The offerings are made up of obsidian artefacts, shells, pyrite, organic materials, greenstone items, Tlaloc vessels, and faunal remains such as eagle, puma, wolf, and red-tailed hawk.[577]

10.2.3 The Feathered Serpent Pyramid

The Feathered Serpent Pyramid, also known until the 20th century as the Temple of Quetzalcoatl, was erected within and in association with a huge civil-ceremonial complex called the Ciudadela. Although it is the smallest structure among the large-scale pyramidal projects in ancient Teotihuacan, the Feathered Serpent Pyramid is considered one of its most iconic monuments. Its structure is stylistically very different from the other two pyramidal platforms, but is similar to Classical Teotihuacan architecture. Like the Sun and Moon Pyramids, this monumental building seems to cover a previous structure.

The pre-pyramid construction was probably in use during the first 200 years C.E.[578] A number of 20th and 21st century archaeological explorations have been carried out in both the Feathered Serpent Pyramid and the Ciudadela, unearthing evidence that supports the possible existence of a previous architectural unit: some scholars suggest this was a pre-temple.[579] However, the archaeological evidence to prove this is scarce and incomplete. The Temple of Quetzalcoatl Project (1988-1989) was directed by Cabrera and Cowgill and examined the pyramid's fill.

571 Heyden 1973; Heyden 1975; Heyden 1981; Manzanilla *et al.* 1994; Manzanilla *et al.* 1996; Sload 2008; Sload 2015; Sugiyama *et al.* 2013.

572 Heyden 1973; Heyden 1975; Heyden 1981; Millon 1973; Millon 1981.

573 Sload 2008; Sload 2015.

574 Murakami 2015, 275.

575 Millon and Drewitt 1961; Millon *et al.* 1965; Sugiyama *et al.* 2013.

576 Manzanilla 2005, 283.

577 Batres 1906; Cabrera and Serrano 1999; Sugiyama *et al.* 2013.

578 Sugiyama 1991; Sugiyama 1998.

579 Gómez and Gazzola 2015a; Gómez and Gazzola 2015b; Rubín de la Borbolla 1947; Sugiyama 1991; Sugiyama 1998; Sugiyama 2005, 89.

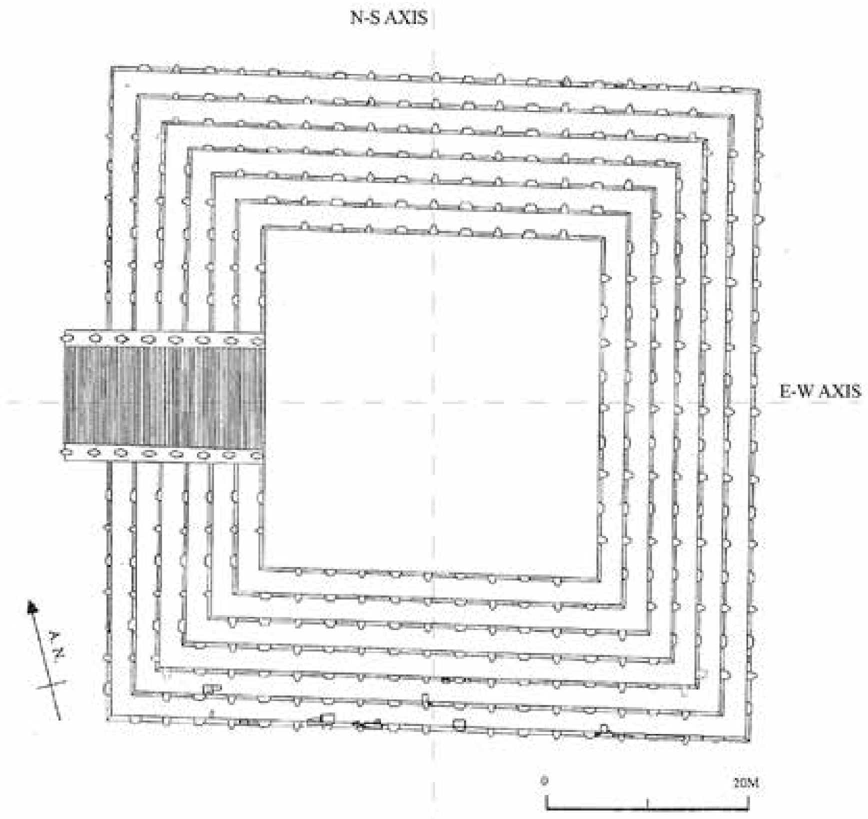

Figure 10.5. Plan of the Feathered Serpent Pyramid (modified after Sugiyama 2005, 23).

They found walls, floors, and a human sacrifice (Burial 15) that did not belong to the erection process of the pyramid, and thus conjectured that they belonged to a previous construction stage. [580] The latest discoveries in the Ciudadela complex have revealed the existence of large sculpted stones with serpent motifs that may have formed part of an earlier public building.[581] In short, the available archaeological data does not prove the existence of a pre-temple. Yet, the architectural remains do support the hypothesis of a possible public pre-pyramid structure with serpent iconography, as well as a ritual human sacrifice with evidence for the extraction of the heart (Burial 15).[582]

Another relevant architectural feature built during these early phases, 0-200 C.E., was the artificial tunnel under the Feathered Serpent Pyramid.[583] This subterranean conduit is one of the most pristine remains excavated in Teotihuacan, and dates to the Tzacualli and Miccaotli phases (Table 10.1). Within this 102.45 m-long cavity, a team led by Gómez found more than 60,000 artefacts of varying local and imported materials, together with botanical remains. Moreover, they established an intensive

580 Cabrera *et al.* 1991; Sugiyama 1991; Sugiyama 1998.
581 Gómez and Gazzola 2015a; Gómez and Gazzola 2015b.
582 Gómez and Gazzola 2015a; Gómez and Gazzola 2015b; Sugiyama 1998.
583 Gómez *et al.* 2017; Gómez and Gazzola 2015a; Gómez and Gazzola 2015b.

Figure 10.6. Main façade of the Feathered Serpent Pyramid (photograph by Maria Torras Freixa).

sequence of events characterized by separate ritual closures, similar to the closure of the tunnel situated under the Sun Pyramid (see above). According to these scholars the tunnel was related to the pre-pyramid structures of the Feathered Serpent Pyramid and for a short time with the pyramid itself, creating a first sanctuary complex in the area of the Ciudadela.[584]

Normally, the building of the Feathered Serpent Pyramid is dated between 200 and 250 C.E. based on ceramic assemblages and a few radiocarbon analyses.[585] The Temple of Quetzalcoatl Project has offered more accurate information on the pyramid's construction process and the caches found inside it.[586] The building was erected in a single episode as a square pyramidal platform measuring around 65 m at its base and 20.30 m in height (Figure 10.5). Its main feature was the introduction of the *talud-tablero* (a combination of sloping wall and vertical panel), and feathered serpent stone sculptures on its façades (Figure 10.6). The fill matrix is very different from the Moon and the Sun Pyramids, as it is homogenous and consists of stone walls and cells filled with stones and mud.[587] Also, the building's orientation shows a minor deviation from the Teotihuacan standard. The east-west axis of the Feathered Serpent Pyramid is aligned between 16°50' and 17° south of astronomical east.[588]

The most important discovery, however, was a set of complex ritual dedication caches with more than 200 female and male adult human sacrifices. Most of these had their hands behind their backs and were found together with high-quality artefacts. Analyses of oxygen-isotope ratios in the skeletal phosphate from 41 victims showed

584 Archaeologists have explored a ballcourt, elite residential complexes, and some platforms in the Ciudadela, see Gazzola 2009; Gazzola 2017; Gómez and Gazzola 2015a; Gómez and Gazzola 2015b.
585 For the ^{14}C results see Sugiyama 1998.
586 Cabrera and Cabrera 1991; Cabrera *et al.* 1989; Cabrera *et al.* 1991; López *et al.* 1991; Sugiyama 1991; Sugiyama 1998; Sugiyama 2005.
587 Cabrera 1991.
588 Cowgill 2005.

that some of these individuals were of foreign origin or had moved geographically during their lifetimes.[589] The associated objects were obsidian artefacts, shells, slate, greenstone objects, and necklaces with real or imitation human maxillae. Some individuals were identified as soldiers due to their age, sex, the presence of projectile points, slate disks, and maxillae, as well as the absence of ceramic offerings.[590] The skeletal remains make up numerical groups symbolising significant calendrical meanings and the beginning of time. Thus, scholars argue that these elements reflect an organised worldview with strong central rulership and mass human sacrifice.[591]

10.3 Monumentality in Teotihuacan's urban growth

The construction sequences of the large-scale buildings reveal structures that predate the monumental pyramids. Modifications observed throughout these construction sequences can provide valuable information on Teotihuacan's history and socio-political development. Overall, the period comprising 0-250 C.E. can be divided into two separate stages.

Here I would argue that the first stage spans the Tzacualli and Miccaotli phases (0-200 C.E.). In this initial period, the ancient city of Teotihuacan evolved gradually and established a shared identity among its people. For example, the Teotihuacan worldview started to develop during this first phase, such as the standard Teotihuacan orientation. The cavities and the caches found in the Pre-Sun Pyramid remains, in the pits of the Moon Plaza, and in the tunnel under the Feathered Serpent Pyramid show the materialization of an early common symbolism, partly linked to concepts of fertility and the underworld.

At the same time, the urban settlement was taking shape, resulting in a civil-ceremonial core where the underworld held a prominent position. During this period, public structures were very modest in size and had few dedicatory caches. The pre-structures of the monumental pyramids of this first period comprise Buildings 1 to 3 of the Moon Pyramid, the Pre-Sun Pyramid constructions, and the Pre-Feathered Serpent Pyramid structure. Furthermore, all these architectural units are linked to subterranean cavities: the tunnel under the Sun Pyramid, that under the Feathered Serpent Pyramid, the Moon Plaza's pits, and a conjectured tunnel from the plaza to the Moon Pyramid.

Aside from the visible importance of the underworld as a common motif in the city's growth, the location of the pre-monumental structures within the settlement is also one of the most important features at this initial stage. Hence, the civic-ceremonial position of the buildings within the grid plan does not change, and they remain in the same place throughout the entire history of Teotihuacan. This has two possible explanations. On one hand, the first location may have been chosen spontaneously by separate groups who, through time, unified the sacred places with urban arteries like the Street of the Dead. On the other hand, the static position may indicate the existence of a previously worked-out urban plan, designed by some kind of individual or authoritative group with a singular vision of the settlement's layout. However, it is ex-

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589 White *et al.* 2002.

590 Cabrera and Serrano 1999; Serrano *et al.* 1991; Spence *et al.* 2004; Sugiyama 1991; Sugiyama 2005.

591 Cabrera *et al.* 1991; Cabrera and Serrano 1999; Sugiyama 1989; Sugiyama 2005, 120, 226, 229, 242; Taube 1992 .

tremely difficult to establish what type of creation process – top-down or bottom-up – was involved. Rather than one or the other, it seems likely that both processes were intrinsically linked in the city's formation. As Smith writes in relation to the creation of neighbourhoods and districts: 'the forces that generate change in social zones can be divided into two categories: bottom-up processes – the actions of individuals and households – and top-down processes – the actions of civic authorities'.[592] In my view, this perspective can be applied to the location of the pre-monumental structures in the ancient city of Teotihuacan.

Another outstanding feature is the standardization of Teotihuacan's orientation, seen in Buildings 2 and 3 of the Moon Pyramid, and in Structure 1 of the Sun Pyramid. This may be linked to a reconfiguration of the urban layout in this earlier phase and the establishing of a common construction pattern – the standard Teotihuacan orientation – relating to a shared symbolic knowledge. Thereafter, the top-down implementation of this alignment may point to a gradual increase of centralised power.

The second period, belonging to the Early Tlamimilolpa phase (200-250 C.E.), could be seen as the outcome of processes taking place up to that time. These include the consolidation of the civic-ceremonial core (*i.e.* the implementation of the standard Teotihuacan orientation), that began a new chronological period and the growth of top-down control of the city. The explosion of monumental constructions, with their sudden growth in number, size, and complexity of caches is one of the most visible outcomes of this new epoch. During this period, the civic-ceremonial centre of Teotihuacan was dominated by Building 4 of the Moon Pyramid, the Sun Pyramid, and the Feathered Serpent Pyramid. As Sugiyama[593] has pointed out, these large-scale building projects were carried out in correlation with each other during a very short period of time. The socio-economic and political decision-making necessary to build these large-scale projects in so brief a time suggests the existence of a powerful ruler. Based on this evidence we can conjecture that this political authority increased its power at local (the Teotihuacan Valley) and regional (the Basin of Mexico) levels. At the same time this power achieved increased commercial contacts, or some kind of control, in the wider area of ancient Central Mexico. As Blanton[594] argued, political strategies can be represented in the ideology of a society/ruler, and this may in turn be reflected by monumental buildings.

Likewise, following on from the development of the symbolic thought-world of the previous chronological stage, this new period of Teotihuacan reveals a common worldview. This was manifested in the material culture of the dedicatory caches with their burials and offerings. However, human sacrifice, ritual militarism, the feathered serpent, and calendar meanings show the emergence of a new symbolic discourse. In addition, the terrestrial level expressed by the monumental buildings became more important than the underworld, given that some ritual closures took place inside the tunnels.

It is likely that Teotihuacan developed its main architectural features during the Early Tlamimilolpa phase, 200-250 C.E., and not before. In this phase, the character-

592 Smith 2010, 150.
593 Sugiyama 2013; Sugiyama 2017; Sugiyama *et al.* 2013; Sugiyama *et al.* 2014.
594 Blanton *et al.* 1996.

istic monumentality of the city was established and a common worldview was embodied in the grid layout and the pyramid caches. Furthermore, some scholars suggest that the monumentalisation process is proof of an increase in the complexity of the state and a political centralization, which was able to mobilize the labour power necessary for these huge public works.[595]

10.4 Rethinking large-scale buildings in the Early Tlamimilolpa phase

As Sugiyama pointed out,[596] the three pyramidal buildings were erected between 200 and 250 C.E., thus offering a specific time range. Despite the fact that these monuments were contemporaneous, they show some differences that are discussed in this section. The variations between the structures raise a great number of questions that require further discussion. On the basis of the material study of these large-scale projects we can explore interpretative frameworks to yield a holistic vision of the city's development. In other words, proxies such as location, dimensions, orientation, construction materials, building techniques, dedicatory caches, labour investment, and ceramic sherds can be used to explore Teotihuacan's society, politics and economy during the Early Tlamimilolpa phase.

The monumental pyramids of Teotihuacan were built in sacred places with a long civic-ceremonial history. The presence of small substructures and cavities linked to them shows inner spaces that were important for the society of Teotihuacan. The builders of the large-scale pyramids had the earlier traditions of these sites in mind when they planned and erected the monumental architectural units. Thus, the pyramids contributed to developing a common shared identity and a worldview that shifted from the underworld to the terrestrial world. Furthermore, respect for the previous locations of the public buildings reflects the consolidation of a broader city plan. This epicentre of monumental buildings characterizes the layout of Teotihuacan, thus revealing a possible master plan that was maintained with few variations throughout the city's history.

Equally importantly, the existence of a preestablished and purposefully designed city plan can be deduced from the pyramids' dimensions. Sugiyama studied the size of Building 4 and the Sun Pyramid using his Teotihuacan Measurement Unit of 83 cm.[597] He proved that they shared calendrical meanings and that the distances between the pyramids conform to a pattern of 260 units. Likewise, he adds that 'the entire city layout existing around 200 C.E. integrated careful calculations of minimally the following calendrical cycles: the 260-day ritual calendar, the 365-day solar cycle, the 584-day Venus cycle'.[598]

Another relevant feature of these large-scale projects is their orientation, as explained above. The implementation of a common architectural and urban orientation began in the Tzacualli and Miccaotli phases, 0-200 C.E. Their progressive adaptation can be seen in the substructures of the Moon Pyramid up to Building 4. During the

595 Murakami 2010; Murakami 2016; Sugiyama and Cabrera 2007.
596 Sugiyama 2013; Sugiyama 2017; Sugiyama *et al.* 2013; Sugiyama *et al.* 2014.
597 Sugiyama 1993; Sugiyama 2013.
598 Sugiyama 2013, 6.

Early Tlamimilolpa phase, the standardization of the canonical Teotihuacan orientation was evident, and in later phases, it was also used when building apartment compounds. This may show a shared symbolic identity and a possible increase in the power of the rulers. During the Tzacualli and Miccaotli phases, buildings followed several different orientations, although Structure 1 of the Pre-Sun Pyramid had already been built according to the standard orientation. This feature reveals the importance of the area of the Sun Pyramid during the first third of Teotihuacan's history, 0-250 C.E. Also, the Feathered Serpent Pyramid's shift from the standard Teotihuacan orientation to the east-west axis (between 16°50' and 17° south of astronomical east) is relevant. This may indicate that this area had acquired a special meaning and was intended to be differentiated from the other two pyramids. Furthermore, this new variation in astronomical orientation was shared by the East-West Avenue and some east-west streets.

The question remains whether this master urban plan was intentionally created from the Tzacualli phase onward, or if it developed over the years until the emergence of the city's monumentalisation. The main public sites were established during the Tzacualli phase, though they did not share orientations or distinct spatial relationships at this time. Nevertheless, the city's monumentalisation reflects the strengthening of the civic-ceremonial location as well as the establishment of a symbolic city plan that was emphatically embodied by the alignment of the buildings and their interrelationships.[599] Thereafter, these massive constructions gave visibility and durability to this new symbolic layout.

This symbolic urban plan may express a common worldview that can also be seen in the dedicatory caches. The Sun Pyramid offerings have some elements in common with Burial 2 of the Moon Pyramid, such as greenstone items, Tlaloc vessels, obsidian goods, and puma, wolf, and eagle bones. In addition, Burial 2 also features human sacrifices, like the Feathered Serpent Pyramid, where local and foreign individuals, some of them with their hands tied behind their back, were adorned with greenstone ornaments, shell necklaces with imitations of human maxillae, and obsidian artefacts. This may reflect a construction sequence of the large-scale building projects starting with the Sun Pyramid and ending with the Feathered Serpent Pyramid. However, it may also be explained by the different purposes and meanings represented by each building. Despite these variations, the grave contexts show a common worldview with the marked presence of a focus on warfare and fertility.[600] From the Tzacualli phase onwards, ideas of fertility formed part of Teotihuacan's ideology, but during the Early Tlamimilolpa phase a profusion of military and calendrical meanings were added to the symbolic discourse.

Alongside these similarities, the monumental pyramids also exhibit some differences. They were built with diverse materials, construction techniques, and architectural styles. Building 4 of the Moon Pyramid and the Sun Pyramid have stepped *talud* façades, while the Feathered Serpent Pyramid has *talud-tablero* façades. Equally, the buildings' fills differ: the Moon and Sun Pyramids are built mainly with earth, and the Feathered Serpent Pyramid with stones and mud in a cell system. This is a very interesting feature and raises several issues of interpretation. The chronological order of the monuments' erection may explain their differences in construction. The use of *talud-tablero* appears in

599 Sugiyama 2013.
600 Sugiyama 2013, 6.

the subsequent construction stages of the Moon Pyramid at Building 5 and the *Adosada* Platform,[601] and also in the *Adosada* Platform of the Sun Pyramid. Thus, Building 4 of the Moon Pyramid and the Sun Pyramid may be slightly earlier than the Feathered Serpent Pyramid. Furthermore, in later periods, the use of stones and mud in a cell system was common in Teotihuacan architecture.

Using both micromorphology and botanical (pollen and phytolith) analysis, scholars have found that some soils used in the pyramid construction processes had an agricultural origin. This indicates that the farm soils were intentionally destroyed for urban purposes.[602] How the city's inhabitants maintained their food supply is still unclear. However, this basic question suggests that a new food supply system was successful, since the city continued to grow until 550 C.E. This line of research requires further investigation as it has major implications for the city's government and how its rulers interacted with the surrounding region.

One evident question is whether it was actually possible to build Teotihuacan's large-scale constructions in such a brief period. Murakami,[603] in his replicative experiments and published measurements, has estimated labour costs in terms of the energy needed for building the pyramids. Through total labour costs (composite person-days) and per capita labour costs (days per person), he established the duration of construction of various buildings at Teotihuacan, including the three monumental pyramids. Murakami relies on Teotihuacan Valley population estimates by Cowgill, Millon, and Sanders:[604] 120,000 inhabitants in the Miccaotli phase and 150,000 inhabitants in the Tlamimilolpa phase. However, as I remarked above, Murakami places the Early Tlamimilolpa phase 50 years later than in Rattray's chronology (see Table 10.1). Thus, he uses the Miccaotli phase population to calculate the labour force for Building 4 of the Moon Pyramid and the Sun Pyramid. He assumes that one person from every household of five participated in building the central core. Also, following Abrams,[605] he posits a five-hour workday for procurement and transportation, and an eight-hour day for manufacture and assembly. Moreover, he uses 30, 60, and 100 days as the number of days per year devoted to construction. Based on these three scenarios for workdays per year, Murakami[606] concluded that each monumental pyramid took less than 10 years to be built. Thus, energetic calculations support the chronological view that the three monuments were erected at the same time or slightly after each other.

The final issue that remains to be addressed is that of the discrepancy between the ^{14}C results and quantities of the ceramic sherds found in the buildings' fills. The Sun Pyramid and Building 4 of the Moon Pyramid are still seen by many publications as belonging to the early stages, 0-200 C.E. This perspective is based on their fill matrix, which present high percentages of ceramic sherds from the Patlachique and Tzacualli phases.[607] However,

601 The platform was later built over the main façade.
602 McClung 2012; Rivera *et al.* 2007.
603 Murakami 2010; Murakami 2014; Murakami 2015.
604 Cowgill 1974; Cowgill 2000; Cowgill 2008; Millon 1974; Millon 1981; Sanders 1981; Sanders *et al.* 1979.
605 Abrams 1994.
606 See Murakami 2010 for his methodology and all calculations, and Murakami 2015 for a brief summary of replicative construction experiments and energetic data.
607 See Sugiyama and Cabrera 2007 for sherd percentages; Sugiyama *et al.* 2013.

this divergence can be explained, as Sugiyama[608] has suggested, by considering that their fill matrix is composed of previously dumped surface refuse; the radiocarbon dating span can cover an interval longer than the ceramic phases. In addition, if we bear in mind Rattray's[609] hypothesis that the Miccaotli ceramic phase primarily characterizes elite items, then the absence of Miccaotli pottery in the fill matrix makes sense, since it was composed of mixtures of soils and earth. Moreover, Murakami adds that 'the short duration of monumental construction implies that sherds from the most recent phase might not be well represented in the fill'.[610] Therefore, we can combine the idea that the Miccaotli ceramics are an elite assemblage (and are thus underrepresented in construction fills), with the fact that the construction of each building took less than 10 years. Then, the discrepancy between the ^{14}C results and the near absence of ceramic sherds from the Miccaotli and Early Tlamimilolpa phases can be explained.

The evidence of the dedicatory burials/offerings, architectural styles, building orientations, materials, and construction techniques used suggest that the large-scale buildings may have been erected one after the other in consecutive order: the Sun Pyramid, Building 4 of the Moon Pyramid, and then the Feathered Serpent Pyramid. Therefore, this required complex kinds of interaction between all members of the community to organize and manage the processes inherent in such a massive construction programme.

10.5 Conclusion

To conclude, large-scale buildings do not appear in Teotihuacan's earliest phases. An urban master plan probably was initiated in the Tzacualli phase (0-150 C.E.), reconfigured in the Miccaotli (150-200 C.E.), and monumentalised in the Early Tlamimilolpa (200-250 C.E.). This monumentality was latent during the early phases and subsequently realised over a brief period. Synchronically, the undertaking of these monumental projects, the changes in their orientation, and the introduction of human sacrifice demonstrate an increase in authority that is coupled with the emergence of new symbolic discourses. In addition, this evidence suggests the existence of a powerful central authority capable of implementing or manifesting a common worldview, structuring a grid plan for the city, managing labour investment, and ensuring a supply network stable enough to extend the urban settlement at the expense of farmland. The current archaeological record is not clear enough to establish exactly what type of government this was, exclusionary or corporate. Nonetheless, a strong authority was necessary to satisfactorily address all the issues involved with the large-scale buildings.

Thus, the first phases of the ancient city of Teotihuacan need to be redefined. Likewise, the results of the chronological analysis of the architectural remains, which show that monumentalisation did not start during the city's first years, oblige us to rewrite the history of the city's formation and configuration. In this context, we have the opportunity to continue developing fruitful and exciting research lines that can enable us to explain Teotihuacan's history more fully, which can offer a more global view of its social and political evolution.

608 Sugiyama *et al.* 2013.
609 Rattay 1991.
610 Murakami 2015, 277.

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11

Economic choice in Roman construction: case studies from Ostia

Janet DeLaine

In memory of Hanna Stöger

11.1 Introduction

A fundamental constraint on the construction of monumental buildings is the cost, which, in the absence of documentary evidence for actual monetary outlay, is best expressed by the expenditure of natural and in particular human resources. In complex societies, as was the case in the Roman heartland, construction is not limited to immediately available resources and simple technologies. It should therefore be possible to use architectural energetics not only to gain some idea of the scale of expenditure on specific resources, but also of the economic choices being made from a range of those available. Furthermore, it should be possible to assess the level of anti-economic, or even counter-economic, choices being made as deliberate expressions of conspicuous consumption and the power to command.[611]

Ostia, the port city of ancient Rome at the mouth of the Tiber some 20 km from the capital, provides a fertile testing ground for investigating such questions of economic choice in Roman construction. As was the case for Rome itself, Ostia was a city built of remarkably permanent materials and on a grand scale and has been extensively excavated as a continuous urban fabric. By the second century C.E. the city had expanded to cover upwards of 100 hectares and with a population which may have approached 60-70,000 (Figure 11.1), while many of the individual buildings, especially of the early second century, can be quite closely dated to within five years. Although Ostia had nothing on the scale of the great imperial building projects of the city of Rome, it was well-provided with monumental public buildings, from temples and basilicas to numerous bath buildings, while large commercial and high density residential buildings, some up to five stories high, comprised the bulk of the urban fabric.

611 See the discussion in DeLaine 2006, 244-246.

In: Brysbaert, A., V. Klinkenberg, A. Gutiérrez Garcia-M. & I. Vikatou (eds) 2018. *Constructing monuments, perceiving monumentality and the economics of building: Theoretical and methodological approaches to the built environment*. Leiden: Sidestone Press, pp. 243-270.

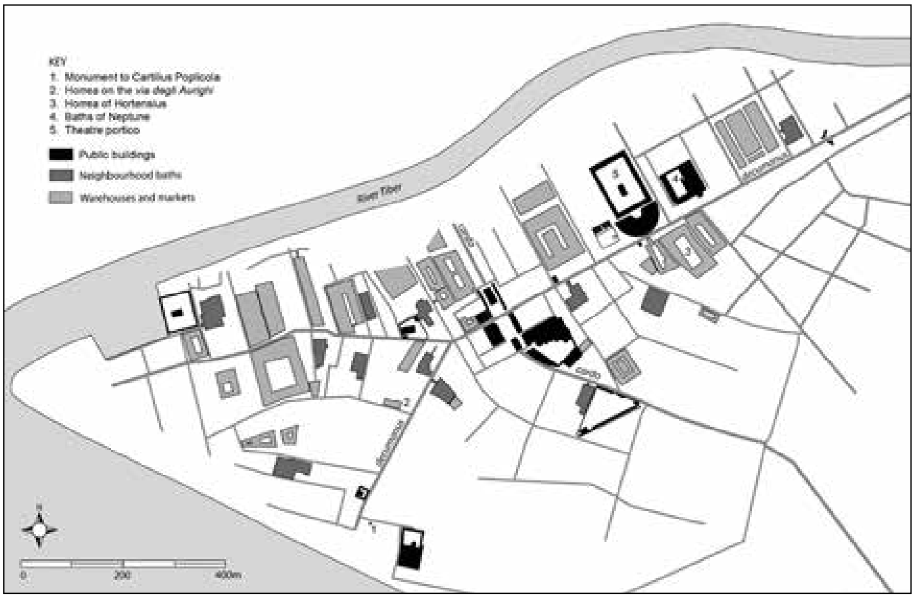

Figure 11.1: Schematic plan of Ostia, second century C.E. (Janet DeLaine).

Although in the earlier Republican period buildings were often made of mud-brick or the soft local stone (*tufo*), from the first century B.C.E. strong mortared rubble faced with small pieces of stone began to be employed. This was used for the city walls and prestige monuments such as temples, with stone ashlar being reserved for points of major significance and/or where structural reinforcement was needed. By the start of the second century C.E., brick began to take over from *tufo* as the main facing material, while solid stone was very largely limited to the columnar orders.[612]

Public buildings, and some earlier high-status domestic buildings, were rich in columns. These had a symbolic value derived ultimately from their use in temples and other high-status architecture, but they were also applied to commercial and high-density residential structures. In short, this was a monumental city, where even the utilitarian and middle-range domestic buildings were large and well-built in permanent materials, of a quality comparable to the grand monuments of the imperial capital. At the same time, however, Ostia did not have the resources that the imperial pocket brought to Rome. Although there is evidence for the financing of a small number of buildings at Ostia by the emperors or members of their families and close allies,[613] on the whole Ostia appears to have relied for funding building projects on the city's own resources, on benefactions from individuals with local connections, very few of whom were even of the senatorial order, or from members of the mercantile class whose origins were often elsewhere.

Ostia, therefore, provides an exceptional opportunity to examine the exercise of economic choice in construction. In order to do this, we have to rely almost entirely on

612 For the materials and techniques used at Ostia see Gismondi 1953, and the summary in DeLaine 2001a.
613 See Pensabene 1996; DeLaine 2016, 424.

Table 11.1: Historic rates for bricklaying in London. a: Langley 1749, 83; b: Dobson 1850, 31; c: Hurst 1865, 214; d: Rea 1902, 72.

Number of bricks laid in a day			
Year	**Rough**	**In face**	**Fine**
1749[a]	1,500	1,000	500
1850[b]	average 900		
1865[c]	1,300	500 - 700	
1902[d]	1,500	1,000	500

the calculation of manpower requirements,[614] based on the quantities of materials and close observation of construction techniques. Perhaps surprisingly, the Roman period is hardly any better off than prehistory for providing the data which gives us actual costs of construction, although we do have some amounts paid for finished buildings mainly from building inscriptions. Unfortunately, we almost never know exactly what these amounts covered, or even whether they represent the total cost, an estimate, or merely the sum supplied by an individual benefactor representing only part of it. The approach used here for estimating manpower requirements for construction in the Roman period is very similar to that outlined by Daniel Turner in his contribution to this volume, which also highlights many of the problems involved. For the Roman period, we rely heavily on 19th century practical manuals designed for estimating quantities of materials and manpower in construction as well as costs. For Roman Italy, the exceptionally detailed treatise developed by Giovanni Pegoretti in the 1840s, and further elaborated over the next 20 years or so,[615] both provides an internally consistent set of figures for construction methods similar to many of those used in Roman construction and treats materials such as the volcanic stones from central Italy and marbles similar (and occasionally identical) to those used in Rome and Ostia.[616]

The fact that we can use this with some confidence also depends on the general conservatism in building tools and general practices in the western world from the Roman period into the Middle Ages and well beyond. This is demonstrated by strong similarities between surviving tools and illustrations of construction scenes right through into the 19th century, including but not restricted to the builder's trowel still in use and much beloved of archaeologists. These similarities in tools and practices are reflected also across recorded historical manpower figures, for laying bricks for example (Table 11.1). It is notable that the rates from published British sources do not change much from the 18th to the early 20th century for the same kind of work. So, provided we can match the ancient actions to the modern and use consistent sources such as Pegoretti, we should be able to make sensible estimations which at least give us the right order of magnitude.

There are, of course, still numerous problems facing those engaged in the quantitative analysis of manpower for construction, one of which is incorporating elements that are difficult to break down into individual actions, including the lifting and placing of stone or timber elements which cannot be handled by a single person; another

614 Since all the admittedly few representations of Roman builders at work only depict men, and the 19th century quantity surveying manuals equally appear to assume that the manpower is male (including boys who assist the masons), the following analysis assumes manpower.

615 Pegoretti 1863-1864.

616 For a summary of the arguments and further bibliography see DeLaine 2017.

is transport. Partly in order to address these problematic areas, this paper looks at the relative resource expenditure for specific comparable elements, selected to give insight into the nature of the choices being made, rather than what we might call the 'full economic costing' of any one entire building. By focusing on the differential use of materials and construction techniques either within single buildings or between similar elements in different buildings, the possible role of economic factors can be assessed. Three case studies are examined (Figure 11.1). These are:

1. the Mausoleum of Cartilius Poplicola, a small, but in its day significant, cenotaph erected around 20 B.C.E. on what was then the seaward edge of the city;
2. the Horrea in *via degli Aurighi* (III.ii.6), a small warehouse and auction room of the early second century C.E. built on an important street leading to the mouth of the river Tiber; and
3. the colonnaded porticoes of three monuments of different types, the mid-first century C.E. (or possibly B.C.E.) Horrea of Hortensius, the mid-first century C.E. phase of the *porticus post scaenam* of the theatre, and the palaestra of one of the larger sets of public baths, the Baths of Neptune, dated to the 130s C.E.

11.2 The Cenotaph/Tomb of Cartilius Poplicola (III.IV.ix.2) (Figure 11.2a, Figure 11.2b)

Gaius Cartilius Poplicola, eight times *duumvir* at Ostia and three times *quinquennalis*, was one of the most important political figures in the city between the death of Caesar and the early years of Augustus. According to the inscription on his monument, it was set up to him as a public memorial for his benefits to the city, which seem to have included a naval battle of some kind to judge from the narrative frieze which crowns the podium of the monument.[617] The memorial once faced an open space just outside the city gate (the so-called Porta Marina) in the late Republican walls nearest the sea, a prestigious position very likely on public land.[618]

The surviving monument consists of a square three-step base, all in squared blocks of travertine from near Tivoli northeast of Rome, and a tall podium, crowned with a low entablature including a figured frieze in Luna marble from Carrara in northern Italy. The monument originally had at least a third tier, but nothing now remains of it. The body of the podium provides an interesting example of the selective use of materials, something recognised already in its first publication: Luna marble ashlar for the façade facing the open space; travertine ashlar for the sides; *tufo* ashlar for the back; and mortared rubble for the core. The use of Luna marble is particularly interesting as it is one of the earliest examples at Ostia of the use of this material, which only started to appear in Rome about the middle of the first century B.C.E. Although the monument is in a ruined state with considerable restoration in the marble façade, a hypothetical reconstruction of the base and podium can be easily accomplished in analogy with

617 Gismondi 1958 and Floriani Squarciapino 1958 for the monument; Pensabene 2004, 103-104 for the use of marble.

618 Stevens 2017, 207-210 for the significance of the location and context.

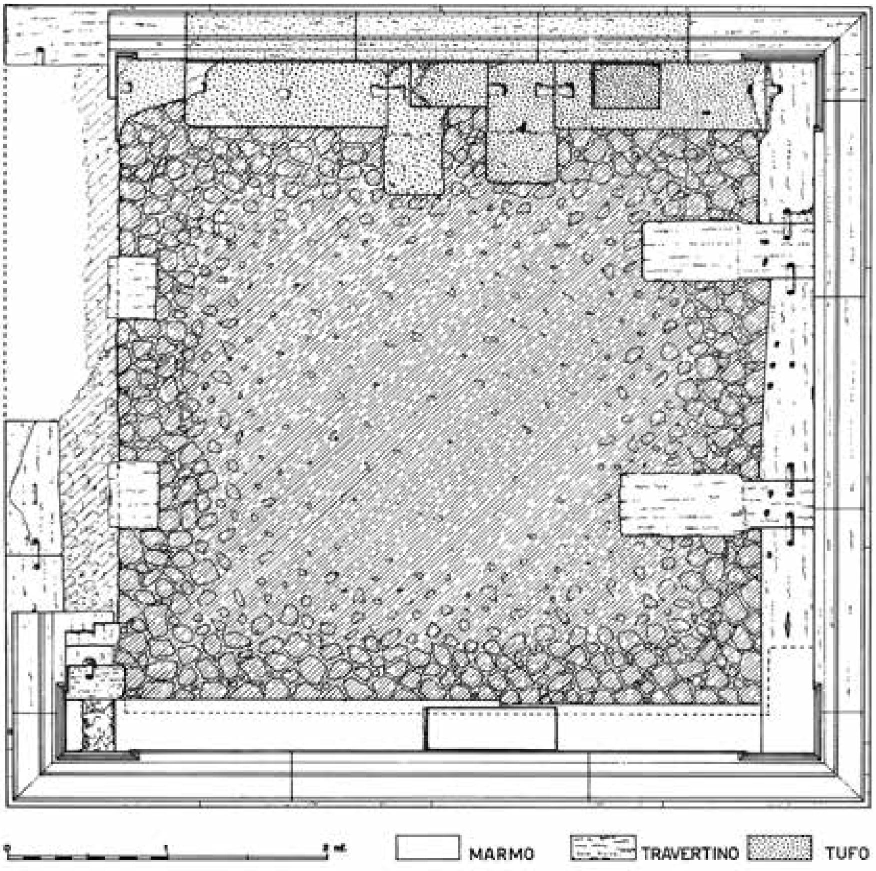

Figure 11.2a: Monument to Cartilius Poplicola. Plan, (after Gismondi 1958, Figures 70, 71).

the surviving material.[619] It is, therefore, a very useful example with which to start this analysis. At the same time, it involves dealing with ashlar masonry, one of the materials for which it is most difficult to break down costs in terms of manpower alone. The analysis presented here does not attempt any sort of absolute cost, but looks at the relative resource implications of the three materials used for the ashlar component, and the hypothetical effects of building the monument entirely out of each of them. The comparisons are made in terms of the transport of materials (often a significant element in the cost of construction), the work required to shape and finish the blocks, and that required to put them in place.

619 The first two courses of the base remain intact, and most of the third course. The south side survives to the top of the fourth course of the podium, and the badly-preserved north side can be reconstructed on analogy with this. The heights of nearly all the course of the marble façade are preserved, together with that of the frieze and frieze cornice, and the width of several blocks including the capitals. The volume calculations are therefore likely to be accurate to one decimal place at least, although the precise lengths of individual blocks, and sometimes the number of blocks in a course, are frequently estimates.

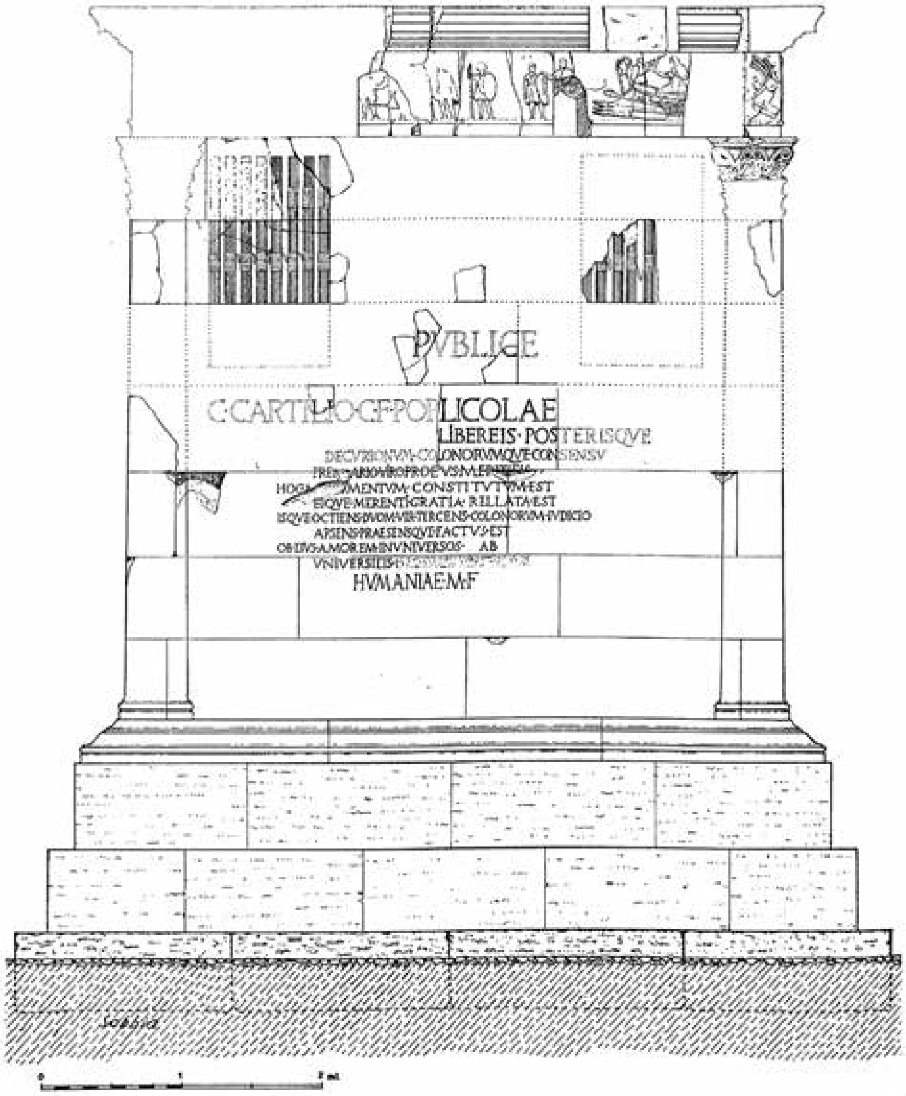

Figure 11.2b: Monument to Cartilius Poplicola. Reconstructed façade, (after Gismondi 1958, Figures 70, 71).

The main variables affecting the cost of transport for any given volume of material are its unit weight and the distance and mode of travel. The general location of the travertine quarries below Tivoli and the marble quarries at Carrara above the Roman colony of Luna in the Apuan Alps are well-known. Since both were also worked from the Renaissance onwards, historical documents give us a good idea of the most efficient transport routes: along the Anio river to the Tiber and hence downstream to Ostia for travertine; and overland to the Tyrrhenian sea at Luna, then by coastal shipping to Ostia for marble.[620] The *tufo* is of the type generically associated with

620 See Russell 2013, 57-59 and 110-112 for Luna; DeLaine 1995 for travertine and *tufo*.

Material	Volume used	Unit weight	Total weight	Distance sea	Distance river	Distance road	Equivalent distance by road	Total needed	Relative 'cost' of transport
	m^3	tonnes/m^3	tonnes	km	km	km	km	Road km tonnes	
Anio *tufo*	9.3	1.7	15.8	-	67.9[a]		8.5	134	1
Travertine	41.9	2.25	94.3	-	85.5[b]		10.7	1,010	7.6
Luna marble	8.3	2.72	22.4	385[c]	-	14.8[d]	24	538	4
Total	**59.5**		**132.5**				**43.2**	**1,680**	

Table 11.2: Relative cost of transport for the base and podium of the cenotaph of Cartilius Poplicola, by material. Given the degrees of uncertainty inherent in these kinds of estimates, all figures in the tables have been rounded up to three significant figures to avoid any appearance of spurious accuracy. Since the calculations behind them are done with the raw figures, the total amounts do not always agree with the numbers obtained by multiplying the figures in the tables. a: Estimated from GoogleEarth; b: Estimated from GoogleEarth; c: Taken from Orbis (http://orbis.stanford.edu/, last accessed 12/09/2017), Luna to Ostia/Portus in summer, using the cheapest route; d: Estimated from GoogleEarth. The figure for marble is an under-estimate as the extra work/cost required for trans-shipment between ox-cart and boat has been omitted.

the deposits around Rome from the Alban volcanoes, and here it is assumed to come from the quarries still visible along the Anio, which took advantage of the river for transport. Other closer sources, for example on the nearest outcrop to Ostia at Acilia, are possible, but in those cases, transport would have been by road or road plus river, and it is not clear that the relative cost would have been any less. The only evidence for relative transport costs in the Roman world come from the early fourth century C.E. Prices Edict of Maximum Prices of the emperor Diocletian, there are many difficulties in using this.[621] It is, however, generally accepted that a ratio for sea:river (downstream):road (by ox-cart) of 1:8:42 is valid.[622] By reducing all transport to the equivalent in km by road, and multiplying this by the required weight of the materials for ashlar in tonnes (giving road km tonnes), the relative impact of transport can be assessed. The results are given in Table 11.2, where relative 'cost' of transport is calculated in relation to the transport requirements for *tufo*, as this is the lightest material and its source was closest to Ostia.

The calculation of manpower for working the ashlar blocks has benefitted from the recent assessment by Barker and Russell, based on an analysis of a variety of Italian and French estimating manuals, where the work is divided into three ba-

621 Giacchero 1974. For recent analyses of the Prices Edict in relation to labour costs see Domingo 2013, and Groen-Vallinga and Tacoma 2016. On the problems of using the Prices Edict, including questions about its nature, geographical area of application, degree of internal consistency in the prices given, and, in some instances, even what the text means, see the useful discussion in Arnaud 2007. To overcome the problems of combining the costs given in the Prices Edict for specific items with quantities of labour, all money values can be converted into equivalent quantities of grain according to the ratios given in the Edict (cf. DeLaine 1997, 207-211). They can also be expressed as the equivalent of a day's labour for an unskilled workman; in the Edict a workman is paid 25 *denarii* plus food, equivalent to 0.25 *kastrenses modii* (KM) of wheat plus 0.11 KM for food at the level of the Roman corn dole.

622 Russell 2013, 95-140 for a recent discussion of the evidence and problems for sea transport in relation to building materials, and DeLaine 1997, 210-211 for an overview.

Material	Volume used	Total surface area of blocks	Rough work rate	Area of hidden/ joining surfaces	Joining faces work rate	Area of visible face	Visible face work rate	Total work needed	Relative 'cost' of basic labour
	m^3	m^2	Man-hours/ m^2	m^2	Man-hours/ m^2	m^2	Man-hours/ m^2	Man-hours	
Anio *tufo*	9.3	75	4.6	38	7.5	17	8.8	774	1
travertine	41.9	360	7.4	188	12.8	80	14.8	6,260	8.1
Luna marble	8.3	118	8.7	57	15	29	17.5	2,380	3.1
Total	**59.5**	**553**		**283**		**126**		**9,410**	

Table 11.3: Relative cost of working ashlar blocks for project by material.

sic stages: quarrying or sawing; roughing-out or shaping; and finishing.[623] For the purposes of this exercise the first stage, which takes place at the quarry, has been omitted, and only the shaping from the rough block and finishing which would have been done on site are included. The frieze and upper cornice have also been omitted, as we do not know how far the marble decoration extended, and for the lower cornice and capitals only the general shaping is included and not the finished details of the mouldings. Likewise work for the low relief decoration and the inscription on the façade has been omitted. Thus, the calculations focus on the ordinary ashlar blocks, which simplifies the process and reduces the degree of guess-work while increasing comparability.

For the work required to shape and finish the blocks, this simple schema has been applied using the schedules given by Pegoretti.[624] They can be applied precisely to the materials used at Ostia, as Pegoretti specifically identifies the material type for Luna marble,[625] and for the travertines and volcanic tuffs of Rome, using the lower figures of the range he gives for these.[626] It has been assumed that all blocks were subject first to shaping (*apparecchio/taglio rustico*), in the version Pegoretti gives for one visible face and the rest touching (Item 6c in his schedules). Then, where relevant, each face is assumed to have been further worked, either *cesellatura* on faces which touch another block (Item 9 in his schedules), or double *martellinatura* (rough and fine, Items 14a and 15a) on outer faces of the blocks. It has been assumed that all other faces were left in the roughly-shaped form. The results are shown in Table 11.3. The man-hours of labour in this case are all for skilled stone workers, and the relative 'cost' of shaping the blocks is again calculated in relation to Anio *tufo*, which is the easiest material to work.

The final element that may have been affected by the choice of materials and construction technique is the labour required to lift and position the blocks in place. Here the determining element is the weight of the individual blocks and the height to which they need to be raised. For putting ashlar blocks in place, Pegoretti distinguishes between the different types of apparatus needed to raise blocks within specific ranges of sizes:[627]

623 Barker and Russell 2012, esp. pp. 87.
624 Pegoretti 1863, 355-359, and his Tables 6 and 10.
625 Pegoretti 1863, Table 6, *Marmi salini o sacceroidi, a grani mezzani*, and note pp. 402.
626 Pegoretti 1863, Table 10, *Travertini, Tufi vulcanici e Tufi calcarei*, and note pp. 438.
627 Pegoretti 1864, 217-218 supplemented by pp. 14-15 for different types of machines.

1. pieces under 80 kg require no special equipment;
2. blocks effectively under 0.3 tonnes, which need only an A-frame and simple hoist, can be raised by one workman at a rate of one metre per minute, and with a stone mason, a stonecutter and a further workman to assist in putting in place;
3. blocks over 0.3 tonnes but under 0.6 tonnes are treated the same but need two workmen;
4. and large blocks which require more complex systems of pulleys, winches, and hoists, depending on the overall weight and shape of the object.

Pegoretti gives a general figure for the motive force for raising in this latter system as one workman for every 0.625 tonnes at a rate of 0.25 hour per metre raised, but also indicates that raising these larger blocks requires extra men beyond this.[628] The precise number of workmen needed overall is difficult to determine given that Pegoretti's figures are rather general (they vary according to height but without indicating at what heights), but seems to be five to eight skilled workers, one to two workmen depending on the height to which the blocks are lifted, and a supervisor.[629] Very large blocks need multiple machines and larger ropes and pulleys, but, as all such systems lose efficiency with any increase in the number of pulleys, levers or capstans employed, they also need proportionately more manpower and/or an increase in time. Clearly there is a considerable difference in the manpower requirements for using a simple A-frame compared with a more complex winch and pulley system, without considering the cost of the machines themselves and the time required to install them.

There is good evidence that similar machines were used in antiquity. The A-frame operated by one or two men with levers described by Pegoretti is very similar to that described by Vitruvius (*de arch.* 10.2), and features in several ancient depictions of the late first century B.C.E. to first century C.E. of construction in ashlar blocks.[630] Machines using more complex pulley systems, which would fit Pegoretti's discussion of machines for larger blocks, are also described by Vitriuvius, including the *trispastos* or three-pulley system.[631] The replacement of winches/capstans by treadmills for providing the motive force, illustrated in several other Roman reliefs, was presumably not needed for the fairly modest blocks used for this monument and will not be taken into consideration here.

The use of one or the other system was most likely linked to the weight of the blocks involved. Excluding the missing blocks where the sizes have been deduced from analogy, only a couple are below 0.3 tonnes, and these weigh 0.27 tonnes and 0.28 tonnes, so that an A-frame operated by only one man would not have served. An A-frame operated by two men could have been used for all but one of the Anio *tufo* blocks, about a third of the travertine blocks, and just under a quarter of the marble blocks, or they could have been lifted by the motive power of one man using a winch

628 Pegoretti 1864, 14-15.

629 Pegoretti 1864, 15.

630 See the illustrations and discussion in Adam 1984, 44-48, Figures 87-90, and the useful illustrated commentary on these passages in Rowland and Howe 1999.

631 I know of no ancient illustrations to suggest that the use of the single-upright *polyspastos* described by Vitruvius (*de arch*. I 10.8-10) was in common use. For a later parallel almost certainly known to Pegoretti, see Zabaglia *et al.* 1743, Tav. 7.

and pulley system, but more slowly. The remaining blocks would most likely have required the heavier-duty crane, with all but one of the larger marble blocks, and about two-fifths of the larger travertine blocks at 1.25 tonnes or less, requiring two men on the hoists at Pegoretti's rates.[632] The 22 largest travertine blocks of over 1.25 tonnes, are, however, all in the lowest two courses of the base, as are the eight blocks weighing just under 1.25 tonnes. These would not have required lifting devices at all as they could have been manoeuvred into place using levers and ramps, especially given that the lowest course was partly below the final ground level. A winch with a three-pulley system and the power of one or two workmen as required could, therefore, have moved all but one of the surviving blocks into place. For the courses above the top level of the base, where these survive, there are always more of the smaller blocks requiring the motive force of a single workman, rather than the larger blocks which require twice that. Few of these blocks have the same dimensions even where the overall volume is the same, and these are blocks of different materials, which might suggest an awareness of the unit weight of the materials (however conceived by Roman builders), and possibly of the inherent limits of manpower in these systems.

In order to compare the effects of the different materials in the actual putting in place of the blocks, I have assumed here that the same, more complex system was used for all irrespective of size, although it might have been possible to use the simple A-frame and lever system at the rear for raising the blocks of Anio *tufo*. In addition to the motive power, I have used the simplified formula given by Pegoretti which includes the time taken for preparing the blocks for lifting (0.2 hours/tonne) and for finalising the position of the blocks in the wall (0.1 hours/tonne). I have, however, omitted the manpower for moving the blocks on site, as well as supervision, as there are too many unknowns to calculate it.[633] The results are shown in Table 11.4. Man-hours here include both unskilled manual labourers and skilled workers of various kinds, and the 'cost' is once more calculated as relative to Anio *tufo*. It is notable that it would have been possible to construct the podium using only blocks of 0.6 tonnes or under, and there was certainly no structural need for the very large block of Luna marble (0.62 × 0.33 × 2.49 m) weighing 1.35 tonnes in the centre of the third level of the podium façade. This suggests that conspicuous consumption, especially in this new material, was as much of a concern as minimising cost.

If we consider these three elements together in relation to the volume of each material used (Table 11.5), and in relation to the 'cost' involved for Anio *tufo*, the relative economics of the choices of materials becomes clearer. Simple work in ashlar travertine and Luna marble are similar, requiring almost twice as much labour as *tufo* per unit volume, although the figure for marble would be higher if the work for the relief sculpture and inscription were added. The relative cost of transport and the labour for raising per unit volume are, however, considerably higher for marble than for travertine.

Another way of looking at the economic impact of the different materials is to compare the 'costs' of using only Anio *tufo*, only travertine or only Luna marble for the monument compared with the monument as reconstructed (Table 11.6). While there is no way of telling whether the same sized blocks would have been used in these cases,

632 See Ducret 2017 on the importance of heavy machinery like this in late Republican building.

633 Pegoretti 1864, 217-218.

Material	Volume used	Total weight	Preparing for lifting (0.2 hrs/ tonne)	Raising (0.625/tonne/ metre)	Placing	Total	No men/ hour[a]	Total work needed	Relative 'cost' of raising and placing
	m³	tonnes	Hours	hours	hours	hours		Man-hours	
Anio *tufo*	9.3	15.7	3.1	11.6	1.6	16.3	5.06	82.5	1
travertine	44.1	101	19.9[b]	37.4	10.1	67.5	6.09	411	5
Luna marble	15.3	41.3	8.2	40.4	4.1	52.7	6.04	318	3.9
Total	**68.6**	**158**	**31.5**	**89.2**	**15.8**	**137**		**812**	

Table 11.4: Manpower requirements for raising and placing ashlar blocks for project by material. a: i.e. 2 masons + 1 stonecutter + 1 workman + the average no. workmen needed for raising power. The number varies depending on the proportion by weight of blocks under 0.63 tonnes, between 0.63 tonnes and 1.24 tonnes, and over 1.24 tonnes in each material; b: omits preparation of 18 tonnes of travertine in the first course, assuming these were not lifted.

Material	Volume used	Relative Volume of material	Relative 'Cost' of transport per unit volume	Relative 'Cost' of transport	Relative Labour for working per unit volume	Relative 'Cost' of basic labour	Relative Labour for raising per unit volume	Relative 'Cost' of raising and placing
	m³							
Anio *tufo*	9.3	1	1	1	1	1	1	1
Travertine	44.1	4.7	1.6	7.8	1.7	8.1	1.1	5
Luna marble	15.3	1.7	2.5	4	1.9	3.1	2.4	3.9

Table 11.5: Summary of volume of material, 'costs' of transport, working and placing in relation to Anio tufo.

Material	Volume used	Total needed	Relative 'cost' of transport	Total work needed working	Relative 'cost' of basic labour	Total work needed raising	Relative 'cost' of raising and placing
	m³	Road km tonnes		Man-hours		Man-hours	
As built	68.6	1,680	1	9,410	1	812	1
All Anio *tufo*	68.6	858	0.51	5,770	0.6	539	0.7
All travertine	68.6	1,460	0.87	9,580	1	804	1
Luna marble	68.6	3,850	2.3	11,300	1.2	928	1.1

Table 11.6: Estimates of transport, working and raising 'costs' for building the monument entirely in Anio tufo, travertine and Luna marble, relative to the 'cost' of the monument as constructed.

for the sake of simplicity it has been assumed to be so.[634] Given that travertine accounts for over two-thirds of the monument as built, it is not surprising that it would not have made a significant difference if the whole had been of travertine as well. By building the entire monument in *tufo*, however, between half to one third of the 'cost' would have been saved on all these elements, while building it all in marble would have more than doubled the transport costs, but not have made a very significant difference in the other elements considered here. Because the cost of the material at the quarry has been omitted in these calculations, it is likely, but unprovable, that this would have increased

634 Among the surviving blocks, there are few large *tufo* blocks, the more numerous travertine blocks cover the whole range, while the marble blocks include both quite small and very large blocks.

the cost differential considerably, especially given that at this point the Luna marble quarries had only just begun to be exploited on any scale.

Overall it is clear that the use of Luna marble would not have been intrinsically much more costly than travertine if transport were not taken into account, or any specific extras involved in the quarrying. This is less surprising than might be imagined, given that Luna marble is well-known for its ease of working compared with other marbles and decorative stones. Access to the material at a point where large-scale extraction was only beginning may, therefore, have been the limiting factor for the use of Luna marble. The real saving in expenditure would come from using all Anio *tufo*, but that material clearly did not have the status that this monument demanded.

11.3 The Trajanic Horrea on the *Via degli Aurighi* (III.ii.6) (Figures 11.3a-d)

The choice of ashlar construction in prestige materials was highly suited to the honorific and commemorative functions of the monument of Cartilius Poplicola. Most of imperial Ostia, however, was built of faced mortared rubble, particularly the commercial and residential properties which formed the bulk of the urban fabric. The Trajanic Horrea on the *via degli Aurighi* provides a useful case study for this type of structure. This small warehouse was erected in the early years of the second century C.E. and is sufficiently self-contained as a structure to make it a suitable subject for analysis. It is interesting because, while being built entirely in faced mortared rubble, it uses an unusual combination of facing techniques which are in many ways peculiar to buildings of this date and in this part of the city.[635]

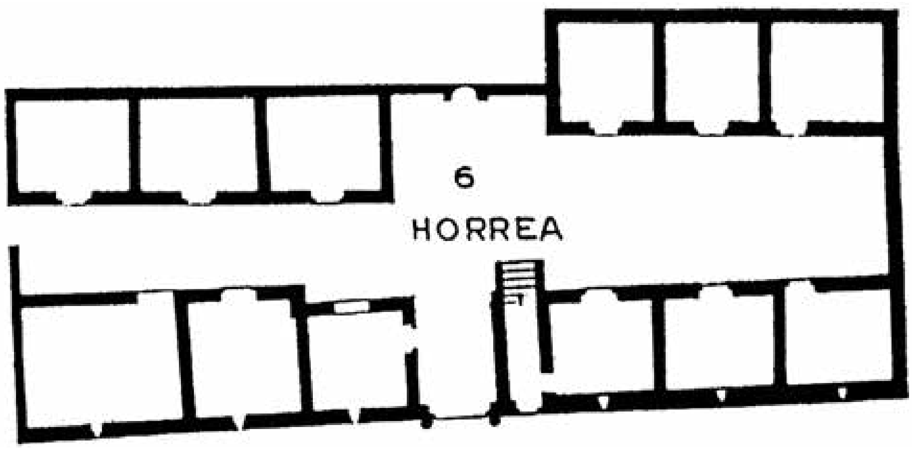

Figure 11.3a: Horrea, via degli Aurighi (III.ii.6). Plan (after Calza 1953, Pianta generale).

635 Short descriptions: Calza 1953, 125; Rickman 1971, 54-58. Building techniques: Gismondi 1953, 199; DeLaine 2002, 45. Very similar techniques are found in neighbouring structures (III.ii.7-10, xii and xiii).

Figure 11.3b: Horrea, via degli Aurighi (III.ii.6). Fine reticulate of façade (photo: Janet DeLaine).

Figure 11.3c: Horrea, via degli Aurighi (III.ii.6). Coarse reticulate of interior face (photo: Janet DeLaine).

Figure 11.3d: Horrea, via degli Aurighi (III.ii.6). Rubble facing of dividing walls (photo: Janet DeLaine).

These techniques are not used at random, but are distributed in specific parts of the structure (Figures 11.3b to 11.3d). The external faces of the boundary walls are all in *opus reticulatum*, a facing composed of neat regular square blocks, c. 8 cm each side but cut roughly into a point behind, in Monteverde *tufo* from the hills by the right bank of the Tiber south of the Aurelianic Walls. The main entrance has jambs in fine brickwork, which is also used for the columns and pediment framing the door, but this is not used elsewhere apart from a single band at the level of the internal floor, and will not be included here.[636] The interior faces of the boundary wall, and the faces of the internal walls which give onto the central court and corridor, are also in a form of *opus reticulatum*, but the pieces are much less uniform in size and colour and are set much less carefully, producing overall a rather irregular effect. The dividing walls of the interior rooms are in another technique again, using larger and very irregular pieces of the same mixed *tufo* as the poorer reticulate walls. The relative uniformity of the *tufo* used for the outer face suggests that this was newly quarried material from a single source or came from a single source of reused ashlars at Ostia, while the mixed colours and textures of the stone in the poorer reticulate and the irregular facing suggest that this is reused material, from a variety of demolished ashlar walls or arguably from earlier reticulate buildings.

The differential resource expenditure for walls built with these different types of facing can be worked out in detail covering most stages of production, transport and construction, and is expressed in the equivalent of man-days of a labourer.[637] These are based on detailed calculations, published in an earlier study, of other buildings in Ostia which have close parallels with those used for the *horrea* on the *via degli Aurighi* and are very close in date, but with some recalibration to bring them in line with the parameters of construction of this particular building.[638] Two versions of the reticulate facing have been included, one which uses newly quarried material for the reticulate blocks, the other which makes new blocks from ashlars available at Ostia, substantially reducing the transport element. To these is added a figure for reused reticulate pieces in the facing. Pegoretti give figures of 1.5 hours of a mason plus a labourer for the demolition of a cubic metre of brick wall, plus 1.6 hours for cleaning and sorting the usable material.[639] These figures can replace those for the production of the reticulate pieces in the original formulae, to which should be added transport within Ostia as for reticulate made from reused ashlar blocks already at Ostia.[640] Since the facing blocks are set more irregularly and in more copious mortar, adjustments have also been made

636 The point of the exercise is to compare the bulk cost of construction. The brick formed a very minor element by volume of the overall construction in the original phase, as did *tufo* ashlar, restricted to the jambs and quoins of the small central court.

637 The labour equivalents are established using the relation between the actual costs in *denarii* of unskilled labour and transport in Diocletian's Prices Edict, cf. note 15, and for the methodology see DeLaine 2001b, 232-234.

638 DeLaine 2001b. The reticulate from the *horrea* is the same size and neatness as that from the *Casa dei Dipinti* used in the study (pp. 250-253), and the rubble facing is similar to that of the nearby *Casette Tipo*, which share the same construction regime as the *horrea* (pp. 249-250), but with larger pieces and less carefully laid, which reduces the construction time.

639 Pegoretti 1864, 163. Obviously, he does not give a figure for reticulate, so this is necessarily a case of choosing the next best fit.

640 DeLaine 2001b, 254.

	Production	Transport	Construction	Total	Relative 'cost'
Type of facing (assumes uniform core in all examples)	Man-days labourer equivalent/m³	Man-days labourer equivalent/m³	Man-days labourer equivalent/m³	Man-days labourer equivalent/m³	Man-days labourer equivalent/m³
Fine reticulate, new *tufo* for face, reused for core	12.9	3.6	3.6	19	3.2
Fine reticulate, new blocks and core from reused *tufo* ashlar	9.4	2.8	3.6	16	2.7
Coarse reticulate reused *tufo* blocks	2.2	2.8	3.3	8	1.3
Coarse rubble, reused *tufo* for face and core	1.3	1.6	3.2	6	1
Tufo ashlar	12	6	22	40	6.7

Table 11.7: Manpower equivalents for a cubic metre of wall, as used in the horrea on the via degli Aurighi.

to the quantity of mortar and to the rate of construction. The figures for a cubic metre of a standard wall built with two faces in each of the four techniques are given in Table 11.7. As these calculations involve a number of assumptions (the rate for making and laying reticulate involve the most), the figures have been expressed to one decimal place for each element, and the total given only in round figures. For comparison, the production, transport and construction 'costs' for a cubic metre of walling of the same size in solid ashlar of Monteverde *tufo* has been included in the table.[641]

While the figures give only a general idea of the costs involved of each type of walling, they do provide a sense of the economic choices made in this building. Once again, one way of appreciating the economic implications of using this combination of facing techniques for mortared rubble construction is to see what the changes in manpower equivalents would have been if a single technique had been used for the whole structure.[642] If all had been done to the standard of the outer face of the external walls, where freshly quarried *tufo* was used, the overall cost would have increased by about 80%, while if all had been done only to the level of the internal dividing walls, the cost would have decreased by roughly 40%. This needs to be put further into perspective by considering what the cost equivalent would have been if the whole structure had been made in large squared stone blocks (ashlar) in the same *tufo* as was used for the external face. This would have had to be quarried freshly, giving a unit cost per metre cubed of wall of the equivalent of 40 man-days of labour, twice that of the fine reticulate of the outer face of the wall, so that building the warehouse in ashlar would have cost roughly four times as much.

Altogether this case study strongly suggests that Roman builders (or their patrons) were aware of cost differentials in construction and were to some extent making rational economic choices. However, given that the construction of the internal dividing walls appears to have been as adequate in terms of structural requirements as that of the outer facing, some of the choices being made were presumably related to aesthetics or, more probably, to self-presentation and prestige. The most expensive and refined technique was

641 DeLaine 2001b, 257-259.

642 Assuming that the building had only two floors, and a total height of 6 m, the overall volume of the walls is approximately 444 m³, of which the fine reticulate accounts for 125 m³, the coarse reticulate for 205 m³, and the rubble for 114 m³, giving a total of man-days of a labourer equivalent of 4,330 days if the fine reticulate is made from reused ashlars, and 4,710 if new material is used.

used for the parts of the structure most visible to the external viewer, and the only one at all likely to have been left exposed in the finished structure, as internal walls were routinely plastered. Interestingly, since this *tufo* is not very tenacious and tends to weather quite badly, it is most likely that the façade was also protected from the elements by a coat of plaster or whitewash. This raises the possibility that the external face was only visible during construction and shortly afterwards, which would emphasise the importance of the process of construction, as well as the finished building, for self-presentation. The addition of a colonnaded porch and pediment in brick to the main entrance adds weight to the idea that even in this relatively modest building status mattered.

11.4 Colonnades: the Horrea of Hortensius, the porticus behind the theatre, and the Baths of Neptune (Figure 11.1)

In the Roman world, columnar orders were the prime elements of conspicuous display, as well being the most expensive items, whether in temples or for the decoration of theatre *scaenarum frontes* and similar columnar screens. The importance of variations in cost arising from the use of different materials increases in structures which use large

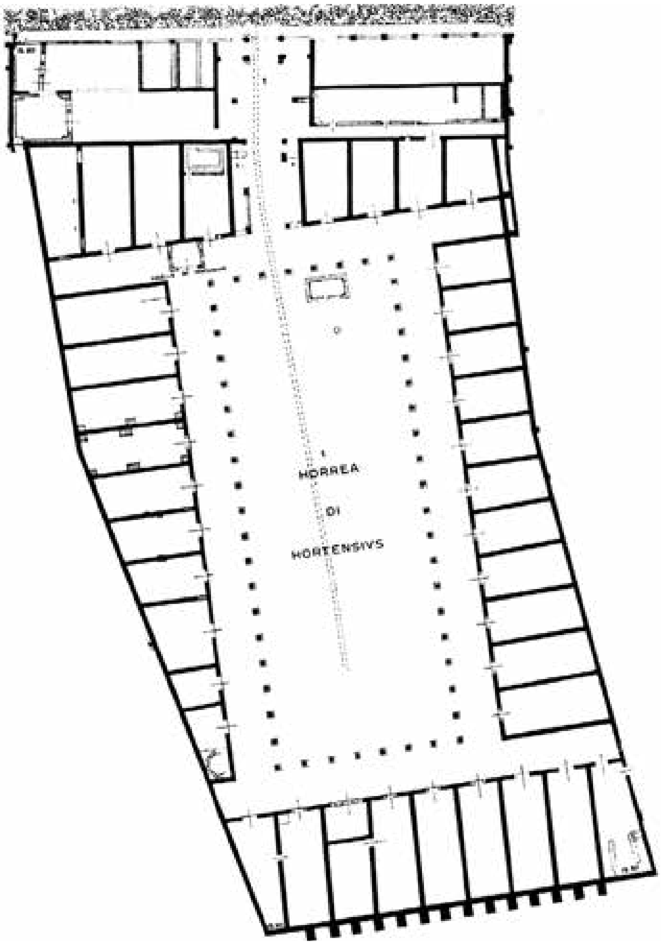

Figure 11.4a: Horrea of Hortensius (V.xii.1). Plan (after Calza 1953, Pianta generale).

Figure 11.4b: Horrea of Hortensius (V.xii.1). View, columns in Anio tufo and travertine (photo: Cristina Pappalardo).

numbers of columns, mainly those with large open areas with colonnades on all or most sides. The three examples under consideration in this exercise are:

1. the Horrea of Hortensius (V.xii.1, Figures 11.4a to 11.4b), a commercial structure variously dated between the mid-first century B.C.E. and the mid-first century C.E., with columns made of separate drums of Anio *tufo* and travertine;[643]
2. the porticus behind the theatre (II.vii.4, Figures 11.5a to 11.5c), with a double colonnade of brick and mortar finished in high-quality stucco, the first erected in the mid-first century C.E., the second in the 120s C.E.;[644] and
3. the palaestra of the Baths of Neptune (II.iv.2, Figures 11.6a to 11.6b), completed by c. 140 C.E., with marble columns, the shafts from the island of Chios in the eastern empire and the Corinthian capitals and bases in Luna marble.[645]

These are among the buildings with the highest number of columns known from imperial Ostia, together with the forum, the basilica, the so-called Forum of the Porta Marina, the precinct of the Magna Mater, and two other large civic baths, the Forum Baths and the Baths of the Porta Marina.

As with the monument of Cartilius Poplicola, some of the following analysis is based on reconstruction. A number of the individual marble elements from the Baths of Neptune palaestra are well-preserved, and the order can be reconstructed, the monolithic shafts giving the height of the order. Several of the *tufo* and travertine columns of the Horrea of Hortensius survived where they fell and have been reconstructed on site. Since not all the columns drums are of the same height, an average has been used to

643 Calza 1953, 117-118; Rickman 1971, 64-69.
644 Calza 1953, 116-117; Pohl 1978.
645 Romano 2005; Pensabene 2007, 240-241.

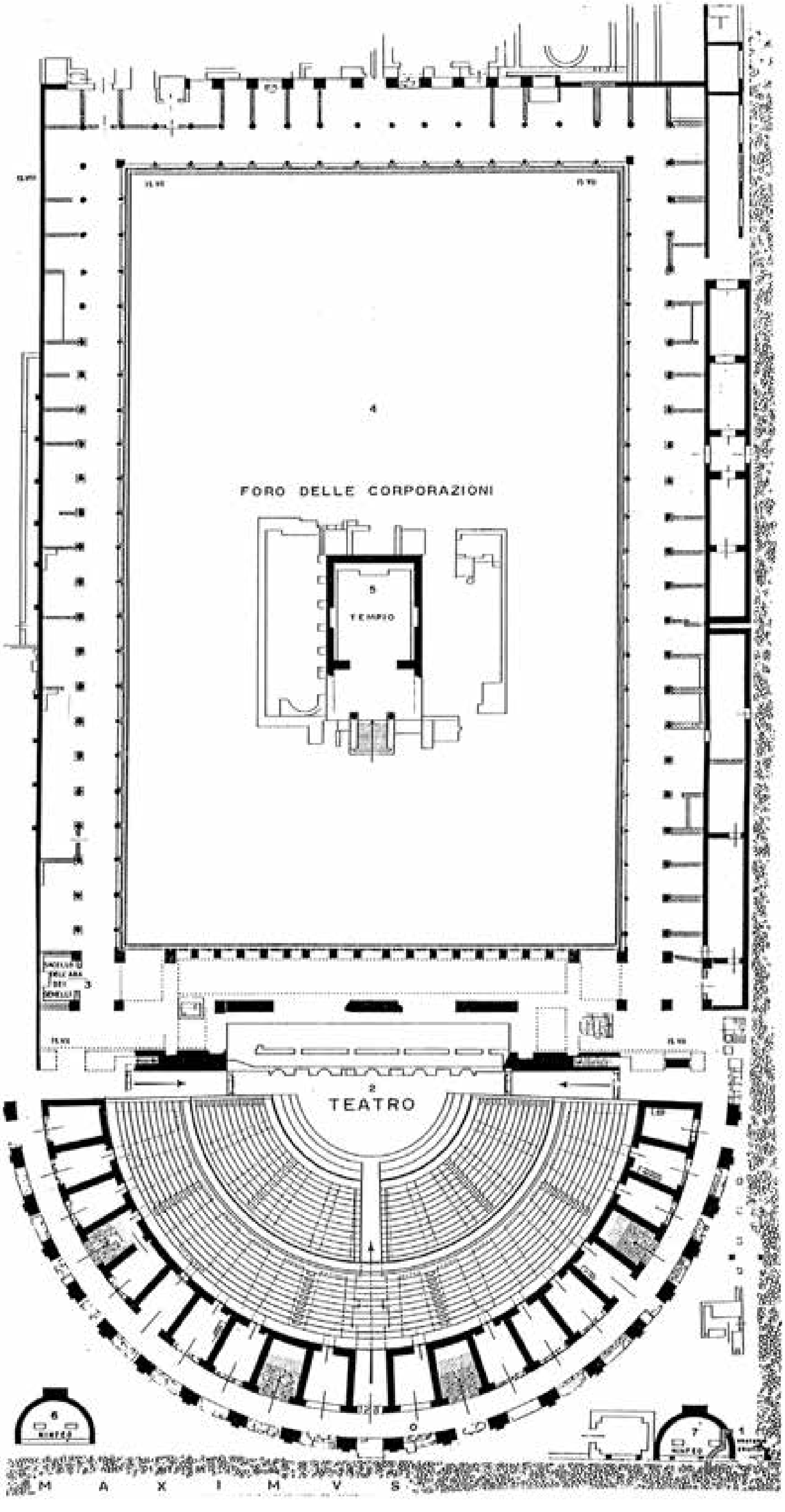

Figure 11.5a: Porticus behind the theatre (II.vii.4). Plan (after Calza 1953, Pianta generale).

Figure 11.5b: Porticus behind the theatre (II.vii.4). View, inner (mid-first century C.E.) and outer (early second century C.E.) brick columns (photo: Janet DeLaine).

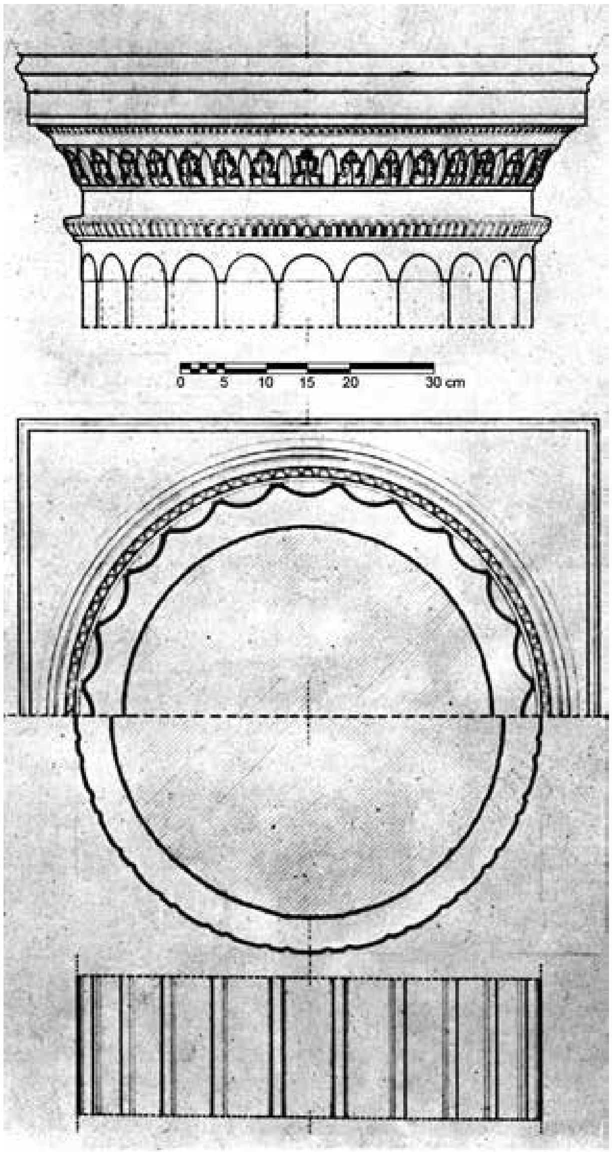

Figure 11.5c: Porticus behind the theatre (II.vii.4). Reconstruction of stucco decoration of original inner columns (after Pohl 1978, figure 2).

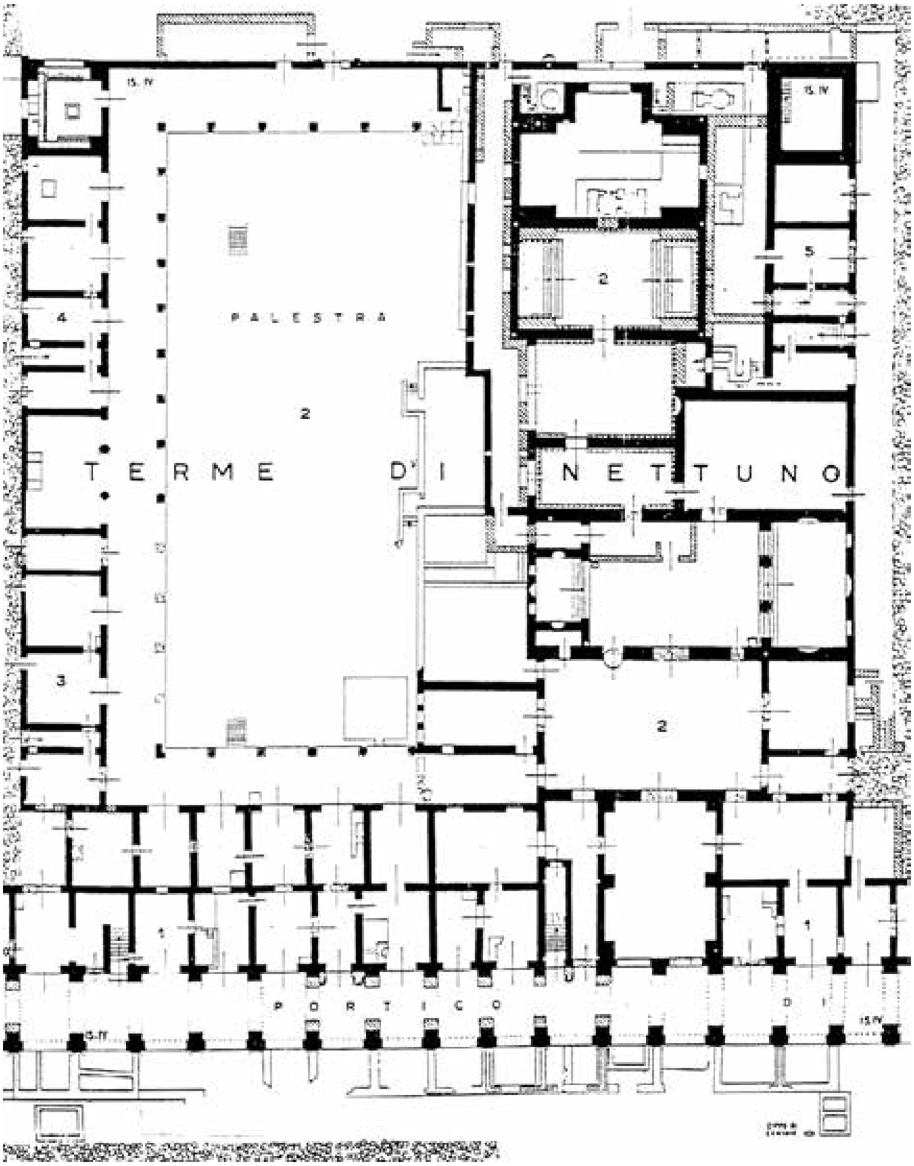

Figure 11.6a: Baths of Neptune, palaestra (II.iv.2). Plan (after Calza 1953, Pianta generale).

simplify calculation.[646] There is no indication that the columns were finished in stucco (although this is certainly possible for the *tufo* columns), but it has been assumed that they were not. More difficult are the brick and mortar columns of the porticus behind the theatre, because only the stumps of the columns remain *in situ*. While nothing remains to indicate the order being used for the outer row, excavations in the 1970s produced fragments of stucco from Doric-Tuscan capitals and fluting belonging to the original decoration of the inner row of columns, which has allowed this to be recon-

646 Pensabene 2007, 160, note 567 for the diameters of some drums.

Figure 11.6b: Baths of Neptune, palaestra (II.iv.2). View (photo: Janet DeLaine).

structed (Figure 11.5c).[647] The following analysis, therefore, only looks at the original columns, but even here the height has had to be estimated based on the diameter of the columns and the nature of the order, at nine times the lower diameter.

The calculations for the columns follow the same principles and include many of the same elements, as the previous two case studies, so only the main points of difference need to be addressed. Here, unlike in the first case study, a nominal figure has been included for quarrying the stone elements as this allows for a better comparison between the stone and the mortared brick columns, since the bulk of the manpower requirements in the latter are in the production of materials. There are also differences in the lifting devices used. In the case of the Horrea of Hortensius, where all the columns were composed of drums (seven of the heavier travertine in the four corner columns, and five of the lighter Anio *tufo* for the rest), the average weight of each drum, irrespective of material, was 0.36-0.37 tonnes and the capital blocks (which include part of the shaft) weighed less than 0.3 tonnes. Since these are all less than 0.625 tonnes, the erection of the columns could have been achieved using the simple A-frame and lever system without the need for the larger machines which have been assumed for the monument of Cartilius Poplicola. For these simple machines Pegoretti gives a rate of one metre per minute which has been used here. The heavier monolithic column shafts for the Baths of Neptune, at just over half a tonne, have been calculated for the other type of machine. No machines would have been needed for the brick columns of the theatre porticus. The resource requirements for individual columns in each of the examples are given in Table 11.8.

647 Pohl 1978, 335-336.

Building	Material	No cols	Ht m	Vol m³ per column	Materials (man-hrs unsk + sk)[a]	Move Road (Km tonnes)[b]	Shape and finish (man-hrs unsk + sk)	Raise (man-hrs unsk + sk)	Man-hrs unsk	Man- hrs sk
Horrea of Hortensius	Annio *tufo*	48	4.9	1.10	0 + 75.5	15.9	0 + 198	1.3 + 1.1	1.3	275
	travertine	4	4.9	1.10	0 + 128	27.1	0 + 361	1.7 + 1.3	1.7	490
Baths of Neptune	Marble (Chios + Luna)	22	4.27	0.54 + 0.05 + 0.14	0 + 125	88.6[c]	0 + 965	2.2 + 2.1	2.2	1,092
Theatre portico, inner	Brick and mortar	60	6.3	2.42	114 + 21.4[d]	50.3	13.5 + 17.5[e]	na	128	39

Table 11.8: Manpower and transport requirements for individual columns in the selected colonnades. a: Unsk = unskilled, sk = skilled; b: Figures in this column cannot be added to man-hours and need to be considered separately from other values in the table; c: For the shafts in Chian marble, the sea transport has been calculated at 2.195 km, from Orbis (http://orbis.stanford.edu/, last accessed 12/09/2017) for Chios to Ostia/Portus; d: Materials production for brick and mortar as in DeLaine 2001b, 254-256, except that the river transport distance used is 133 km, from Orbis (http://orbis.stanford.edu/, last accessed 12/09/2017) for Ocriculum to Ostia/Portus; e: Pegoretti 1863, 151-152 for making brick columns; 1863, 486 and 1864, 223-224 with 243-244 for stuccoing.

Building	Material	Ht	Move	Produce	Total per column	Relative 'cost' per column	Per m of ht	Relative 'cost' per m height	No cols	Total for colonnade	Relative 'cost' of colonnade
		m	mdle	mdle	mdle		mdle			mdle	
Horrea of Hortensius	Annio *tufo*	4.9	1.5	46.6	48.1	2	9.8	2.5	48	2,650	1.8
	travertine	4.9	2.6	83	85.6	3.5	17.5	4.5	4		
Baths of Neptune	Marble (Chios + Luna)	4.3	8.6	185	193	8	45.3	11.6	22	4,250	2.9
Theatre portico, inner	Brick and mortar	6.3	4.9	19.4	24.3	1	3.9	1	60	1,460	1

Table 11.9: Relative 'cost' in man-days of a labourer equivalent (mdle) for selected colonnades.

Even a quick glance at these figures shows that, as would be expected, the marble columns had the highest resource implications while the stuccoed brick ones had the lowest. Less predictable is the detail. One striking feature is the very great difference in the amount of skilled versus unskilled labour required between ashlar and mortared brick. Pegoretti's figures for stone working, however, tend not to include any subsidiary labour for assistance to the skilled stone workers, for example in clearing away the debris, nor do they include easily usable figures for the skilled and unskilled workers required to maintain the stone-working tools. Including these elements would thus increase even further the resource differentials between the stone colonnades and the stuccoed-brick one.

We can take this analysis further by expressing the resource costs of all elements (including transport) in terms of man-days of work for an unskilled labourer, using the relationships which can be established through the Prices Edict of Diocletian, thus allowing us again to express the relative cost of each type of column (Table 11.9).[648] Since each of the colonnades had columns of different heights, it also allows us to indi-

648 See note 38. Skilled labour is calculated at 1.69 times unskilled labour to include an element for food which was part of the daily rate in the Prices Edict (DeLaine 2001b, 233-234).

cate a 'cost' per metre of height, although this does not take into account the fact that taller columns invariably also were of greater diameter, so these figures underestimate the increases in 'cost' for taller columns. [649] Finally, we can gain an idea of total outlay for each project, again in relative terms.

In the Horrea of Hortensius, the decision to build the corner columns in the stronger travertine was presumably taken for structural reasons, but where possible the cheaper *tufo* was preferred; it would have required about two-thirds more resources to make all the columns of travertine. Each *tufo* column, however, required twice as many resources as the larger brick columns of the inner portico of the theatre, even assuming that the *horrea* columns were not stuccoed. If the columns of the Horrea of Hortensius had been the same height as those of the theatre portico, they would have needed over two-thirds more resources than the columns actually used, and three and a half times what the columns of the theatre portico required. The most marked differences come, however, with the marble columns of the Baths of Neptune. Even though these are somewhat smaller than those of the Horrea of Hortensius, each requires about four times the resources for the *tufo* columns, and eight times those for the much larger brick ones of the theatre portico. Marble columns the same height as those of the Horrea of Hortensius would have required about a third more expenditure of resources than the ones used. Marble columns the height of those of the theatre portico would have 'cost' over half as much again as the ones used, and 12 times the brick ones of the theatre portico.

The comparisons presented here show the greatest 'cost' differentials, and they underline just how much more expensive marble was, without even taking into consideration any quarry costs other than simple extraction and very rough shaping, or any trans-shipments. While it cannot be proven that this building was a benefaction by the emperor,[650] the resources required to use imported marble for the palaestra colonnade of the baths must have been considerable. If, however, we consider the total 'costs' of supplying columns for the three projects, rather than the 'cost' per column, the differences, while still there, are much reduced because of the numbers of columns employed, which increases as the 'cost' decreases. This is of course the wrong way around: the project must have come first and the materials used for the columns are more likely to be related to the number needed for the space in question. While we do not know who paid for the Horrea of Hortensius (the state, the city, or private individuals), the theatre portico was most likely the responsibility of the town council.[651]

Overall, the results of this analysis suggest some correlation between the choice of material and the number and size of the required elements, chosen from within the parameters of current construction practices and materials to fit the available resources. This impression is reinforced by some of the other large porticoes at Ostia. The other colonnaded warehouse, the so-called *Grandi Horrea*, which should be roughly contemporary with the Horrea of Hortensius, had 64 columns in Anio *tufo* with travertine capitals and bases, slightly smaller than those of the Horrea of Hortensius, making the overall 'costs'

649 Generally, the fixed relationships between lower diameter and total height of Roman columns were roughly 1:10 for the Corinthian order, or 1:8 to 1:9 for the Tuscan.

650 On this see Meiggs 1960, 409, and the doubts expressed in DeLaine 2016, 424.

651 Cf. DeLaine 2016, 426.

for the two colonnades very similar.[652] Both the 'Foro di Porta Marina', which may have been a religious precinct, and the sacred area of the Magna Mater, had respectively 30 and 27 brick columns of small dimensions (c. 0.40 – 0.44 m). Marble columns were reserved for the two other large civic bath buildings, but of similar numbers and size to those of the Baths of Neptune; notably, the portico of the Forum Baths has the cheaper Ionic capitals which might have reduced the overall cost by up to a third. Only the basilica, one of the most prestigious buildings in the city, had a considerably higher number of larger marble columns with Corinthian capitals: 45 with plain shafts c. 0.6 m in diameter, and eight larger fluted ones c. 0.64 m in diameter, the fluting of which might add some 40-50 further man-days of a labourer equivalent per column, even without accounting for the likely second storey of columns on the inside.[653] This type of analysis therefore adds further weight to other studies of architectural patronage at Ostia.[654]

11.5 Conclusions

This exercise has thrown some interesting light on the question of economic choice in construction at Ostia. While it is possible from a simple subjective and qualitative analysis to create a hierarchy of materials and techniques in each case, the quantitative assessments presented here enable us to gauge the scale of difference in resource expenditure required by different materials and techniques used for very similar purposes, and in the first two case studies in the same monument.

One constant theme to emerge is the apparent tension between strategies for minimising construction expenses and the requirements of the patron's self-presentation. Even with the two commercial buildings, the horrea on the *via degli Aurighi* and the Horrea of Hortensius, it is clear that the patrons have not gone purely for complete cost minimization. Economies of material make sense in the *horrea* on the via degli Aurighi, as it was a small commercial building presumably of limited value in establishing or displaying personal prestige; nevertheless, it was not made throughout of the cheapest form of construction. If the Horrea of Hortensius should in fact be dated to the mid-first century C.E., the cost of building the colonnade could have been much reduced by opting for brick and mortar construction as used in the near contemporary theatre portico. Instead the choice was made for stone columns, and costs were kept down by preferring the cheaper *tufo* over travertine except where structural strength came into play.[655] Marble, predictably, only appears in the colonnade of the most prestigious building, the Baths of Neptune, the only one where there is the possibility of direct imperial funding. Even so, quite small columns were used (under 15 Roman feet) and in lower numbers, as was the case with the other two civic baths. This can be put in perspective by comparing the columns of the two internal palaestrae of the Baths of Caracalla in Rome, a major imperial benefaction. Each had 30 Corinthian columns, 24 Roman feet high, with grey granite shafts and white marble capitals and bases, needing c. 880 man-days of a labourer

652 Pensabene 2007, 169-170. The columns had five drums plus the capital and base, and a lower diameter of c. 0.6 m.

653 Pensabene 2007, 214-216.

654 Cf. especially Pensabene 1996 and 2007.

655 This might have also been the case if the building were dated to the mid-first century B.C.E., as columns of brick and mortar firmly dated to before 76 B.C.E. were used in the basilica of Pompeii.

to produce, compared with c. 185 days for the columns of the Baths of Neptune.[656] The use of marble gave the impression of putting the baths at Ostia in the same league as the imperial thermae in Rome, but at an expenditure perhaps no more than three times that of the simple stuccoed brick of the theatre portico.

None of the case studies analysed here provide complete figures for all elements of the buildings concerned, and the focus has instead fallen on comparative analysis of the relative resource implications. This has the inestimable advantage of speeding up the process of analysis, while still making a contribution to understanding the socio-economic impact of building projects, in terms of the parameters of human choice, which is the ultimate aim of most quantitative analyses.

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656 DeLaine 1997, 178-179, Tables 17 and 19, for 20 foot granite shafts (i.e. 24 foot column), and 261-262.

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12

Large-scale building in early imperial Tarraco (Tarragona, Spain) and the dynamics behind the creation of a Roman provincial capital landscape

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12.1 Topography and brief overview of the main public buildings in Early Imperial Tarraco

In Early Roman times, Tarraco (modern Tarragona, Spain) became the capital town of the largest Roman province in the Western Mediterranean. This change of status involved an intense period of building activity that completely modified its urban and architectural landscape. This paper focuses on the two of the main public building projects that shaped Tarraco's landscape: the Provincial Forum, which comprised most of the upper part of the town, and the Colonial Forum, located in the lower part. Due to their scale, their chronology, and their direct link with the town's dual political entity, they are ideal case studies to address the dynamics involved in large-scale building in the Roman West.

The town's layout was strongly influenced by the particular topography of its location. The area occupied by the town spread across a highly strategic and scenic hill standing about 80 m above sea level, is called the 'upper part'. A flat area extending to the coast and including the alluvial plain of the Francolí river, is called the 'lower part' (Figure 12.1). This particular landscape had a clear impact on settlement since the first Roman contact with this territory. The lower part was already occupied by an Iberian settlement since the sixth century B.C.E.,[657] and Gnaeus Scipio established a *praesidium* on Tarraco's upper hill during the Second Punic War (218 B.C.E.). These two distinct parts of its urban layout continued to be present at least until the second century B.C.E. At this time, the process of consolidation

657 There is evidence of an Iberian settlement, although it has not been clearly identified yet (for details on this issue: Miró 1994; Adeserias *et al.* 1993; Asensio *et al.* 2000).

In: Brysbaert, A., V. Klinkenberg, A. Gutiérrez Garcia-M. & I. Vikatou (eds) 2018. *Constructing monuments, perceiving monumentality and the economics of building: Theoretical and methodological approaches to the built environment*. Leiden: Sidestone Press, pp. 271-271.

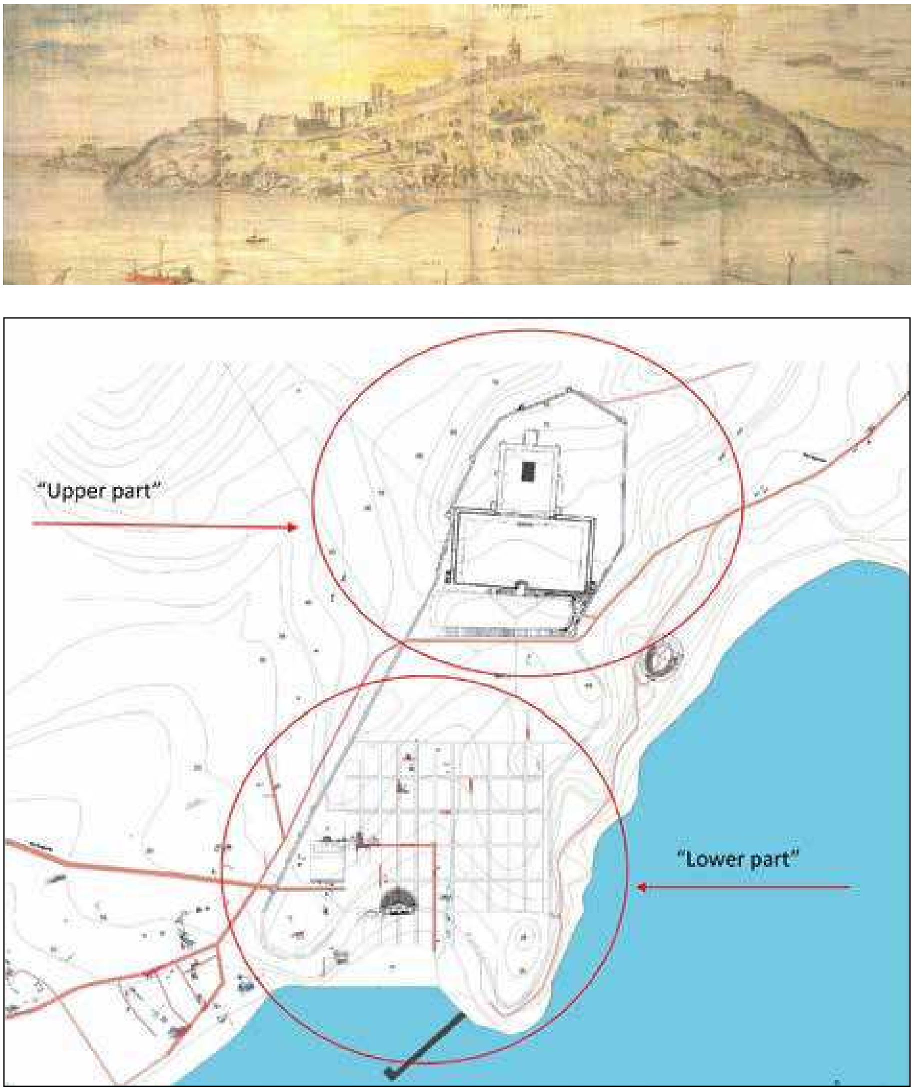

Figure 12.1: The topography of Tarraco: view of Tarragona from the sea (by A. van Wyngaerde, 1761) and plan of Tarraco between the first and second century C.E. with indication of the upper and lower parts (from Macias et al. 2007, 29, fig. 19, with modifications by the authors).

and affirmation of Roman power in the Iberian Peninsula led to an important transformation of the town.[658]

Little is known about Tarraco's building activity during the Early Republican period,[659] whereas Late Republican phases are better attested. A first phase of the

658 For an up-to-date summary of its evolution and an overview of the current state of the research, see Macias and Rodà 2015.

659 There are traces of works to flatten the bedrock at the upper area of the hill, but it is not possible at present to advance any hypothesis on the shape or plan of the town.

town wall, for which only a *terminus ante quem* is known,[660] has been identified as surrounding only the military *praesidium*. Between 150 and 125 B.C.E. (the second building phase),[661] the wall was enlarged to enclose the lower part. Other contemporary building activities occurred: a new urban town plan based on *insulae* measuring 1 × 2 *actus*, the construction of the first sewer system running from the hill slope to the town harbour, and the construction of the complex known as the Colonial Forum.[662]Augustus divided the Iberian Peninsula into new administrative units and upgraded Tarraco to become the opulent capital of the largest Western Roman province. From this period onwards, a new urban plan was established. Extensive modifications took place on the existing Republican forum, located in the lower part of the town, and the area next to the seafront.[663] This impressive transformation also included the construction of the theatre.[664] At the same time, the road network and other infrastructure in the territory[665] were extensively reorganized.

Unfortunately, the urban and architectural evolution of the upper part during this period is not as well known. Nevertheless, literary sources report that Augustus himself lived in Tarraco between 26 and 25 B.C.E.,[666] which made Tarraco the *de facto* official capital of the province.[667] This political context suggests the possible existence of at least an early construction project to give a monumental image to the already meaningful and scenic natural site that is Tarraco's hill.[668] Aside from the theories suggesting the erection of an altar dedicated to Augustus when he was still alive,[669] the only archaeological evidence from the Augustan period (in the upper part) comes from two branches of the Gaià aqueduct.[670] The evidence of a water system strongly points to the existence of a wider project to monumentalise this area as a symbol of its new status as capital of *Hispania Citerior*. In any case, in the Early Imperial period this part of Tarraco was most certainly involved in an intensive building activity. The erection of the so-called Provincial Forum completely modified the urban and architectural outlook of the town. It consisted of three enormous terraced spaces on the upper part of the town,

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660 The wall's first building phase could be contemporary with the Second Punic War or Cato's military campaigns in 195 B.C.E.: see Mar *et al.* 2012, 51-52; Menchón 2009, 48-49. It is dated by pottery remains associated to the following phase.

661 For the constructive phases of the town wall see Hauschild 1975, 246-262; Hauschild 1983; Hauschild 2006, 153-172.

662 Aquilué 2004, 42-46; Mar *et al.* 2010, 39-70.

663 Adserias *et al.* 2000; Pociña and Remolà 2001.

664 It was erected where there had once been warehouses related to the harbour activities, see Mar *et al.* 2012, 286-322 with previous bibliography. The remains of two thermal complexes were discovered close to the theatre and next to the south side of the forum. Their morphological characteristics cannot be defined, but they date to the Early Imperial age: Díaz *et al.* 2005, 68-69.

665 Gurt and Rodà 2005.

666 Quint. *Inst.*, VI, 3, 77.

667 It was probably in 27 B.C.E., when Augustus officially moved the seat of the *legatus Augusti propraetore Hispania Citerioris*, (i.e. the governor of the province of Hispania Citerior), to Tarraco: Arrayás Morales 2004, 295-296.

668 Vinci and Ottati in press.

669 Mar *et al.* 2012, 345-348. The existence of this altar is only known from its depiction on the town's coins issued under Tiberius (RPC, vol. 1, n. 218.), and from the anecdote recorded by Quintilian (Quint., *Inst.*, VI, 3, 77).

670 Mesas 2015, 249. Both branches belong to one of the two aqueducts existing in Tarraco. Its Augustan date is confirmed by the inscription A[QV]AM [AVGVS]TA[M]: López and Gorostidi 2015, 253.

beginning with the circus in the lowest terrace. The intermediate terrace (the so-called Representation Square), formed a wide area for the political and administrative functions for whole province. At the top of the hill was the Worship Area, which contained the temple of Augustus; the temple was surrounded by a portico, which acted as its *temenos*. As part of an Empire-wide program to restore administrative and ideological establishments,[671] Hadrian significantly restored the porticoes of the intermediate terrace and the temple.[672] Also in the second century C.E., the amphitheatre was built directly outside the city's eastern gate: it was the last large public building constructed in Tarraco.[673]

12.2 Tarraco's monumental landscape: the two *fora*

Many disciplines and research teams have been involved in the study of the two *fora* of Tarraco over the years. Yet, the corpus of archaeological evidence for both these specific areas, and the for the town's wider territory has significantly increased in recent years. These new data will be the focus of this paper. The first monumental complex of the town was the Colonial Forum, where a large Capitoline prostyle temple *sine postico* with three *cellae* stood on a podium.[674] Its construction in the Late Republican period marked the lower part of the city as the centre for the civic and political activities of the *municipium*. Between 50 and 25 B.C.E., this forum underwent substantial refurbishments, which were probably linked with the granting of the new status of *colonia* by Julius Caesar in 49 B.C.E.[675] Changes were made to both the square and the temple. The latter was erected on a high *opus quadratum* podium of Italic tradition and became a monumental peripteral temple with six columns on the front.[676] During the Augustan period, the Colonial Forum continued to be the main focus of the town's monumental landscape. It gained impressive new buildings, such as a basilica, and a new square built next to the Republican one (Figure 12.2). It was also then that a *Chalcidicum* (or Square of Statues) was created. Here, epigraphs and statues for the imperial cult were displayed as a portrait gallery dedicated to the imperial family. Under Tiberius' reign, the architectural decoration of the basilica was renovated and the Capitolium was reconstructed. Yet, the last important building activity in this area was under Hadrian, when the temple was rebuilt once again probably because of a fire or some structural problems. Even though only the foundations of this Hadrianic temple have been discovered, they indicate that it was probably an octastyle, prostyle, and pseudoperipteral temple with three *cellae*.[677]

As for the Provincial Forum in the upper part of the city, three main phases can be identified. However, the exact chronology of this building sequence remains debated, given the lack of clear stratigraphic data linked to individual structures. The Julio-Claudian period witnessed a

671 On this subject see Ottati 2016, 239-253.

672 Hadrian stayed in Tarraco in the winter of 122 C.E., during which he supposedly ordered the renovation of the *Aedes Augusti* (*SHA*, Ael. Spart, *Vit. Hadr.* 12). For the architectural decoration related to this restoration, see Pensabene 1993, cat. 1-2, 33-35; Macias *et al.* 2012a, 30, cat. 1.2.10 e 1.2.11.

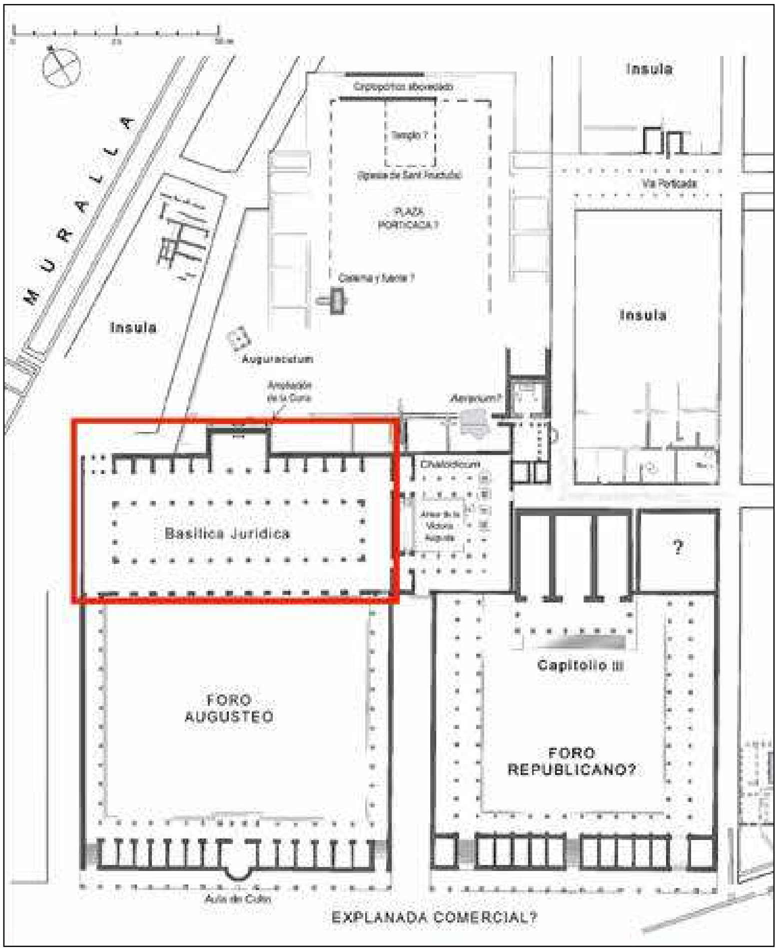
673 TED'A 1990.

674 Mar *et al.* 2014, 40-46.

675 Rodà 2016, 248.

676 Mar *et al.* 2014, 40-46.

677 Mar *et al.* 2014, 45-47.



a

b

Figure 12.2: Plan of the Colonial Forum under Augustus (Mar et al. 2014, 63, fig. 22) and image of the Basilica remains (photo: M.S. Vinci).

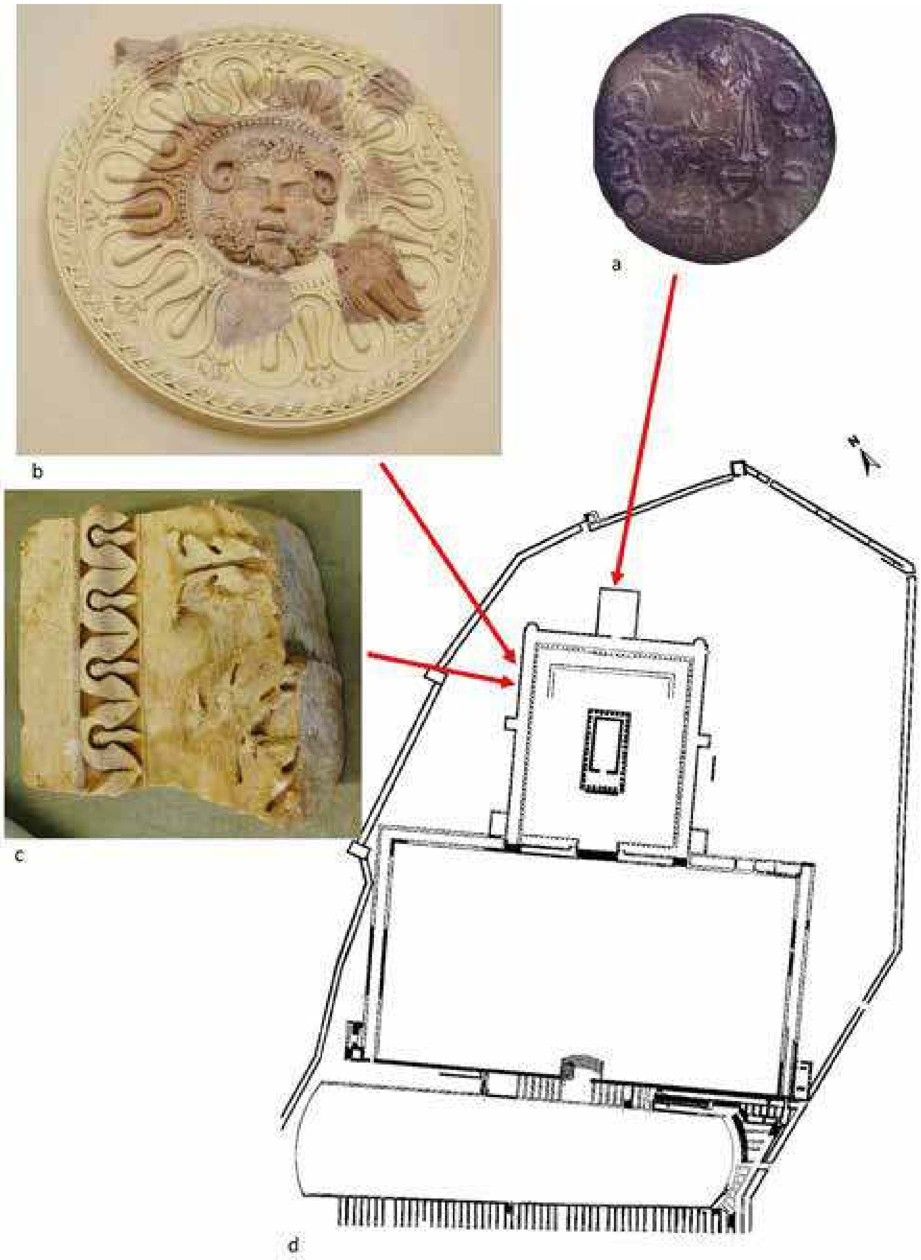


Figure 12.3: Plan of the Provincial Forum under the Flavians (re-elaborated version by M.S. Vinci from Macias et al. 2007, 32, fig. 22). Detail of a Juppiter-Ammon clipeus and a candelabra relief in Luni-Carrara marble, and representation of Emperor Augustus on a Tiberius coin (photo: M.S. Vinci).

distinct change of activities in the upper part. The existence of the first Julio-Claudian temple is confirmed by the written sources and some Tiberian coins minted in Tarraco.[678] Additional evidence for this date comes from the style of execution of the acanthus frieze, and the Corinthian capitals[679] uncovered in the upper part. All of these elements are made of Carrara marble from Italy.[680] The size of these architectural decorations confirms that this temple was of such dimensions that it can be described as 'gigantic'.[681] Therefore, it seems clear that this whole area became the symbol of sacredness of the imperial power. The second phase took place under Nero's reign. The *figlina* or potter's workshop[682] that existed in the area later occupied by the circus, was abandoned. The foundations of a first t*emenos* were filled up and were subsequently broadened, perhaps to surround the first temple.[683] Under the Flavians,[684] a vast project covering more than 12 ha and inspired by the Forum Pacis in Rome was created. As part of this Flavian project, the administrative area was enlarged; an axial hall on the north side of the Worship Area probably contained the statue of the Emperor Augustus.[685] Also during this phase, the columned portico of the upper terrace was decorated by exquisite Jupiter-Ammon *clipei* separated by *candelabra* reliefs; both of these elements were carved from the renowned Carrara marble. The final stage of this massive transformation involved the construction of the circus.[686] This phase dates to the period of Domitian according to the epigraphic evidence (Figure 12.3).

12.3 Economics of large-scale building in Tarraco

Since these building activities took place over long periods of time, economic factors and the dynamics of the construction process were strongly at play in Tarraco. Large-scale construction projects involved a massive amount of materials and money,[687] as well as the necessity to feed, house, and – when needed – pay for human resources. Many of these resources (materials, funds, and labour) could be found close to the building sites, and were provided by the town itself, or came from its immediate territory. However, the construction of these large public complexes also put into motion an extensive network that linked Tarraco with the rest of the province and beyond to more distant territories.

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678 Tac., *Ann*., I, 78 mentions the request for permission to erect this temple; the cult statue of Augustus was represented on the obverse of the Tiberian coins with the temple depicted on the reverse: Beltrán 1953, 39-66; Villaronga 1979, 273-274. For a new interpretation of Tacitus' statements see Castillo Ramírez 2015, 176-180.

679 Pensabene and Mar 2004, 73-88; Pensabene and Mar 2010, 258-259.

680 Known in Roman times as *marmor Lunense* or *lapis Lunensis*, since it was quarried near the town of *Luna* (modern Luni).

681 Domingo 2015.

682 López and Piñol 2008.

683 Sánchez Real 1969, 281.

684 The epigraphic data from the Worship Area and Representation Square confirms that this complex was in use at this time: Alföldy 1973.

685 This statue has been documented by the discovery of a single fragment of a marble toe: Macias *et al.* 2012b, cat. n. 1.3.1, 34.

686 Due to the construction of the circus, important changes were needed to maintain the accessibility of the intermediate terrace: Vinci *et al.* 2014.

687 See, for example, the ground-breaking work on the Baths of Caracalla: DeLaine 1997.

Figure 12.4: View of the central area of El Mèdol quarry (photo: A. Gutiérrez Garcia-M.).

12.4 Procurement of building materials

Building materials are the basis of any construction project. For it to be completed, large quantities of raw materials need to be located, selected, extracted, transformed, and transported from the source or production site to the building site. To do so on the scale required for the construction of the two *fora* at Tarraco, the degree of planning, optimization of the logistics, and coordination of these different steps was indeed complex. Unfortunately, very few of these materials have survived in the archaeological record and we can thus only speculate about the procurement of timber, metals, and mortar. Yet, this is not the case for the stones. Indeed, most of the preserved evidence of these two architectural projects is made of stone: it was ubiquitously used, and its natural properties (*e.g.* strength and resistance to weathering) ensured its preservation.[688]

12.4.1 Building stone

Since a wide variety of stones can be suitable for building purposes, the specific kind that is chosen, and how it is used is usually determined by the resources available in the immediate, or sometimes the neighbouring environment.[689] In the case of Tarraco, the outcrop of Miocenic stone north from the town provided a large quantity of good quality and easy-to-cut stone. This was the main source of building material for all sorts of edifices and infrastructure projects that equipped the town with water sources, roads, and other needed assets. Indeed, several ancient quarries had been located there, providing El Mèdol or soldó stone (two varieties of the same stone type),[690] or a much

688 Although inevitable, part of the stones are now lost as already-cut stone was very much reused in subsequent periods due to these same reasons. Examples of such reuse are numerous; for Hispania and the case of Tarraco in particular, see Domingo 2011, Utrero and Sastre 2012, Menchón and Pastor 2015.

689 Illustrative examples in the Western provinces are Emerita Augusta (modern Mérida, Spain) and Nemausus (modern Nîmes, France). The first one is an example of how the different igneous rocks (granites, diorites, etc.) of the local bedrock were used differently in the construction of public buildings such as the theatre. There is also evidence for the degree of contribution and organization of each quarry or quarrying district: Pizzo *et al.* 2018; Pizzo 2011. At Nemausus, studies on the stone resources show that the stone used in its building came from across the entire region: Bessac 1987; Bessac 1988, 59-60.

690 They basically differ in the bioclastic content and can usually be found in one and the same quarry: Gutiérrez Garcia-M. 2009, 106-108, 112; Gutiérrez Garcia-M. 2011, 325.

finer and sandy stone.[691] Both El Mèdol and soldó stone were extensively used to create and subsequently repair the Colonial and Provincial *Fora* of Tarraco.

El Mèdol stone is named after the quarry of El Mèdol, a deep, open-cast quarry that was the largest one in the territory of Tarraco. This quarry has been the subject of awe and interest for local scholars for centuries, due to its dimensions and configuration.[692] It consists of three sectors:

1. A central sector, known as Clot del Mèdol, is a huge pit-type quarry with two wide quarrying areas, one to the northwest and one on the southeast, connected by a narrow corridor; a 20 m high pinnacle of rock in the middle of the southeastern area is one of the most distinctive features of El Mèdol (Figure 12.4).
2. Two other sectors, located to the east and to the west of the Clot, which have resulted from quarrying in terraces and in trenches.

This large quarry landscape has only recently been the object of an in-depth study, thanks to new evidence uncovered due to a fire in 2010,[693] and to a comprehensive rehabilitation project carried out in 2013. The latter included the field survey of its surroundings, the detailed recording of the fronts, debris heaps, and other quarrying-related features, as well as some targeted archaeological excavations.[694] The results of all this work significantly increased our knowledge of the quarry, which subsequently provided more specific information regarding the building phases of Tarraco. Besides a comprehensive, detailed plan of all the quarry fronts, a new small area of ancient extraction and large debris heaps were discovered.[695] But even more importantly, these excavations confirmed that the volume of stone extraction at this site was far larger than was previously thought. The known volume of stone removed from the central extraction pit could be increased from 66,000 m^3 to about 150,000 m^3 (*i.e.* 350,000 tons). It seems clear, thus, that El Mèdol was the first and foremost supplier of stone for the Colonial and Provincial *Fora*.[696] Moreover, the archaeological excavations provided solid evidence to date the beginning of the main period of extraction to around the early first millennium C.E.; previous research had dated this initial phase to the

691 This second type of stone came from quarries at Coves del Llorito and Coves de la Pedrera. It was used for some stretches of the city's walls and to construct or repair the second aqueduct of Tarraco, which collected water from the Francolí river: Gutiérrez Garcia-M. 2009, 185-197.

692 The quarry was first mentioned in 1461 C.E. in the chronicle by J. Blanch, and subsequently well-attested in several documents. It was officially declared a Monumento Artístico-Histórico (1934), Bien de Interés Cultural (1985), Bien Cultural de Interés Nacional, and a World Heritage site by UNESCO (2000). For a summary of the quarry's history, see Gutiérrez Garcia-M. 2009, 146-149.

693 Gutiérrez Garcia-M. *et al.* 2015.

694 These consisted of eight test pits: two were opened in the eastern sector of the quarry and six were located in the Clot: López Vilar and Gutiérrez Garcia-M. 2016.

695 Gutiérrez Garcia-M. and López Vilar in press.

696 As well as for other buildings and uses in Tarraco. El Mèdol stone was also employed for a wide variety of products such as sarcophagi, epigraphs, sculptures, and even sculpted portraits that were usually plastered with stucco to finishing since El Mèdol stone is quite porous and rough. Such plastering of stone has also been observed in columns, capitals and other architectural decoration as well as some *cupae*: Gutiérrez Garcia-M. 2009, 150-151.

a

b

c

d

Figure 12.5: Some blocks discovered next to El Mèdol quarry with: engraved marks (a-b), red painted marks (c) and marks written in charcoal (d) (photos: M.S. Vinci).

Flavian period.[697] As the southeastern area of the Clot already reached its maximum depth (20 m) by the change of the first millennium C.E., it indicates that the quarry was already in full production when the Late Republican and Augustan phases of the Colonial Forum occurred. It was also functioning during the first works on the upper part of Tarraco.

697 Evidence comes from a Roman *denarius* found in stratigraphic context and minted under Tiberius (RIC I, 30, dated to 36/37 C.E.). A charred piece of wood uncovered at the base of the central pinnacle during archaeological excavations in 2013 underwent ^{14}C analysis, providing a date ranging between 27 B.C.E. to 19 C.E.: Roig Pérez *et al.* 2011, 403; López Vilar and Gutiérrez Garcia-M. 2016, 185, 191.

Other important discoveries in the quarry excavations were that of a control point next to the ramp leading to the lower part of the main extraction pit, and the remains of a possible Roman shrine. Also identified was a workshop area where the blocks were first roughly-hewn, checked, and stored before being loaded for transport to the town. This workshop area is located just in front of the quarry entrance, where a large accumulation of discarded blocks existed until very recently.[698] This consisted of about 6,000 piled-up blocks and while little archaeological material was found among these,[699] a total of 77 quarry marks or inscriptions were found on the blocks.[700] This assemblage is outstanding because of the nature of these marks, which are very rarely preserved on non-imperial marble quarries.[701] They consist of engraved marks (58) and signs or letters painted in red paint or written in charcoal (19)[702] (Figure 12.5). Despite the predominance of both alphabetic and numerical characters, the typology of the engraved marks is very diverse.

At the current state of research, it is possible to make an initial distinction between simple marks composed of a single letter (*e.g.* M, A, V, C, D, H), and complex abbreviations, composed of several letters (*e.g.* LE, TIR, CLONI, BVCOLI). These last ones undoubtedly reflect the use of an abbreviated terminology easily understood by the workers or staff inside the quarry. According to J.C. Fant,[703] the short abbreviations composed of a few letters were in fact useful to the quarry's administrative staff; the abbreviations pertaining to the management operations of the material once it leaves the quarry (*e.g.* in storage or distribution areas), belong to a second group. In our case, we cannot rule out that these marks refer to teams of labourers in charge of one of the activities carried out at the quarry, or to their leader.[704] As for the painted and charcoal marks, they are much more articulated and complex than the engraved ones, which seem to suggest a different function or type of recipient. In two examples, the inscription continues onto a second line and could even contain the name of the person in charge of the management or administration stages.

It remains difficult to accurately interpret the evolution of the quarrying activity at El Mèdol,[705] and to clarify the function of the aforementioned marks. Nevertheless,

698 It was confined between the two main modern roads, the AP-7 and the A-7 motorways, and was not far from the N-150 road which follows the route of the ancient Via Augusta. A series of archaeological excavations were carried out on the heap of blocks between 2007 and 2009: Roig Pérez *et al.* 2011.

699 Namely, some African red slip ware and a coin from Tiberian times: Roig and Pérez *et al.* 2011, 403.

700 These marks are currently being studied as part of the project 'The economy of construction processes from the quarry to the monument. Skilled specialists and construction technology in the Provincia Hispania Citerior (1st century B.C.E./1st century C.E.)' in AUSONIUS. This project collaborates with the I+D project '*Officinae Lapidariae* Tarraconenses. Canteras, talleres y producciones artísticas en piedra de la provincia tarraconensis (HAR2015-65319-P) of the ICAC'.

701 Notable examples of these sort of marks are found in the marble quarries of Docimium, Asia Minor, and Carrara, Italy: Fant 1989, Paribeni and Segenni 2015. In Spain, the only examples of blocks bearing marks have been found *in situ* in the building they were intended for. This is the case of the Roman dam at Muel, where most of the marks have been interpreted as indicating the *loci* within the quarry from which they came: Navarro Caballero *et al.* 2014.

702 For preliminary considerations, see Vinci in press a.

703 Fant 1993a, 145-170; Fant 1993b, 71-96.

704 This hypothesis is based on the three-letter signs used to identify teams found at the quarry of Mathieu (France); these distinguish between the production of each team in a specific part of the quarry: Bessac 1996, 297-299.

705 As most of the site still remains unexcavated.

we can propose a link between the quarry and the creation of the Provincial Forum of Tarraco. In fact, the peak of its exploitation certainly takes place in the Early Imperial period, when the building investments of the town were focused on the realization of the triple-terraced Provincial Forum. Furthermore, some inscribed marks on blocks in the walls of one sector of the Provincial Forum were found to match some of those documented in the quarry.[706] This connection between quarry and site highlights unique aspects of the extractive/constructive phases within the same building programme.

12.4.2 Marbles and other ornamental stones

The use of marbles and other decorative stones was also a very important part of the building programmes in the Early Roman period. As symbols of prestige and power, they were widely employed in public monumental architecture as a means of displaying the ultimate supremacy of Rome. This idea is revealed by the well-known boastful proclamation attributed to Augustus by Suetonius: 'I found Rome as a city of bricks and left it as a city of marble'.[707] But its use spread rapidly also in the conquered territories and newly established provinces. Previous architectural models and the use of materials in their decoration, were soon reproduced in the process known as *imitatio urbis*. Thus, the use of marbles and decorative stones became a projection of the political authority, economic strength, and social prominence, and as such they played a key role in strengthening the self-image of the provincial elites.[708]

In Tarraco, these materials were used in large quantities mostly in the highly symbolic Provincial Forum. Indeed, even disregarding sculptures or inscriptions and only considering architectural elements and revetments, marbles and other coloured stones from both local and exotic origin are numerous. The vast majority of them were reused in post-Roman buildings, but their Early Roman origin is undeniable. The most remarkable case is the numerous column shafts in Troad granite (Figure 12.6). This stone comes from Asia Minor, but was widely disseminated across the Mediterranean. It was commonly used for architectural elements, often in association with Corinthian capitals in Proconnesian marble. More than 40 shafts of Troad granite have been identified at present in Tarragona,[709] or outside the town, due to later transport.[710] Most of them have very similar features indicating that they likely belonged to a single building complex. The size required to accommodate at least the known number of columns leaves little choice for speculation: we can assume that they were indeed brought to Tarraco for the porticoes of the Provincial Forum.

These columns are not the only remains of the decorative elements of the different buildings forming this complex. As mentioned above, the use of marble from Carrara is well attested in the city's architectural decoration since Julio-Claudian times.[711]

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706 Hauschild 2016; Vinci in press b.

707 Suet. *Aug*. 29.

708 See Pensabene 2004 for a summary on the specific case of Hispania.

709 These columns were found out of context, lying underwater just next to the Punta del Miracle promontory: Pérez 2007. They were also found during the excavations at the amphitheatre, where they were probably reused in the sixth century Visigothic basilica: TED'A 1990; Rodà *et al.* 2012.

710 Especially in the 16th century, like the columns reused in the church of Sant Pere in Reus (in 1563 C.E.), or the ones placed in the façade of the Palau de la Generalitat in Barcelona (in 1598 C.E.): Rodà *et al.* 2012, 210.

711 Pensabene 1993; Pensabene and Mar 2004.

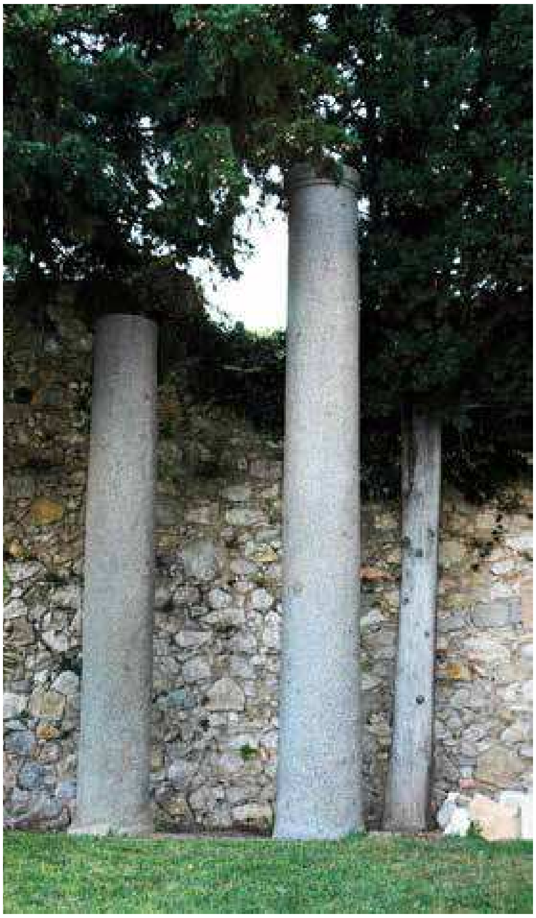

Figure 12.6: Two Troad granite column shafts currently at the Archaeological promenade of Tarragona (photo: M.S. Vinci).

Together with other finds,[712] they confirm that with this architectural project, Tarraco saw the massive arrival of Carrara marble for the first time; this material was especially intended for the most sacred part of the complex. The complex was much larger than the rest of the town buildings, and extensively used Carrara marble[713] in contrast to the previously ubiquitous local stone. Its position on the top of the hill was as a sort of an acropolis presided over by the temple of Augustus, ensuring that the Provincial Forum had the most outstanding place within Tarraco's urban landscape.[714] Furthermore, large quantities of coloured marbles and other stones have been uncovered within or near the Provincial Forum. These stones include a wide range of materials of foreign, regional, and local origin. The scattered location of these finds and the lack of detailed quantification studies render it difficult to have an overall estimation of the use of each

712 Fragments of massive columns in Carrara marble and large rectangular floor slabs in white marble, probably also from Carrara.

713 Pensabene 1993; Gutiérrez Garcia-M. and Rodà 2012; about 4,000 m^3 are estimated to be employed only for the temple of Augustus and the upper terrace: Mar and Pensabene 2010, 528-531.

714 Domingo 2015.

kind of marble,[715] and to identify with which building or phase of the complex they belonged. Nevertheless, after Carrara marble, the following marbles were all dominant in the ornamental programme: giallo antico (*marmor Numidicum*), pavonnazzetto (*marmor Docimium*), Africano (*marmor luculleum*) and cipollino (*marmor Carystium*).[716] Other non-Spanish *marmora*[717] are much less frequently present. Most of the marble from imperially owned quarries were used for wall and floor revetments, but there were also some mouldings and column shaft fragments in pavonazzetto, giallo antico and portasanta. Yet next to these imported marbles, ornamental stones available in the surrounding territory were also sought. Next to the colourful broccatello from Dertosa (modern Tortosa),[718] nearby quarries were opened and promoted to supply Santa Tecla stone, Tarraco's ornamental stone par excellence.[719] This diversity of polychrome marbles showcase an intention to underline the importance and wealth of the complex. Additionally, it emulates Rome's decorative programmes, especially that of the Forum of Augustus with its central temple of Mars Ultor.

12.5 Transport, logistics, and infrastructure

Tarraco's excellent location in terms of maritime access was decisive in the arrival of these stone resources from all over the Roman world, as well as from its more immediate catchment territory. Water transport was crucial to cut down costs and was thus essential. Transport had a very high impact on the total price of materials, regardless of the medium (sea, river, land), climate, or distance, and could sometimes increasing the cost by 50% or more.[720]

The extensive Roman commercial network, with major redistribution ports such as Portus and Ostia, meant that all sorts of shipping agents and contractors were mobilized to bring all these different marbles to Tarraco. Yet the marble from Carrara and numerous Troad granite columns might have arrived through more direct channels.[721] A large project like the Provincial Forum needed to avoid intermediaries and possible market fluctuations as much as possible to ensure a constant supply. Marbles would have arrived at Tarraco's harbour and warehouses as any other luxury goods. However, those intended for the Provincial Forum most likely had a specific arrival point on the nearby El Miracle

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715 Most of them were not found *in situ* and were assembled to be reused/re-cut in workshops, either related to the Hadrianic reform or to later phases: Àlvarez *et al.* 2012; Arola *et al.* 2012; Gutiérrez Garcia-M. and López Vilar 2012.

716 From Simmithus (modern Chemtou, in Tunisia), Docimium or Docimeium (modern Iscehisar, Turkey), Teos (near modern Sigacik, Turkey), and Carystus or Karystos (on the Greek island of Euboea), respectively. All of these marbles came from imperially owned quarries.

717 They are marbles from: Greece (portasanta/*marmor Chium*, rosso antico/*marmor Taenarium*, porfido verde/*lapis Lacedemonius*, verde antico/*marmor Thessalicum* and breccia di Settebasi/*marmor Skyrum*); Asia Minor (breccia corallina/*marmor Sagarium* and occhio di Pavone/*marmor Triponticum* -as recently identified by L. Lazzarini 2004, 90-91); and North Africa (Egyptian porfido rosso/*lapis Porphyrites* and grecco scritto).

718 About 90 km south from Tarraco and on a bank of the navigable Ebro river, which ends not far from its mouth.

719 The importance and degree of use of this stone has been discussed elsewhere: Àlvarez *et al.* 2009; Àlvarez *et al.* 2010.

720 DeLaine 1997, 216-217 for the Baths of Caracalla; for an overview of stone transport: Russell 2013.

721 Keay 2012, 12; Rodà *et al.* 2012, 210; Domingo 2015; Gutiérrez Garcia-M. in press.

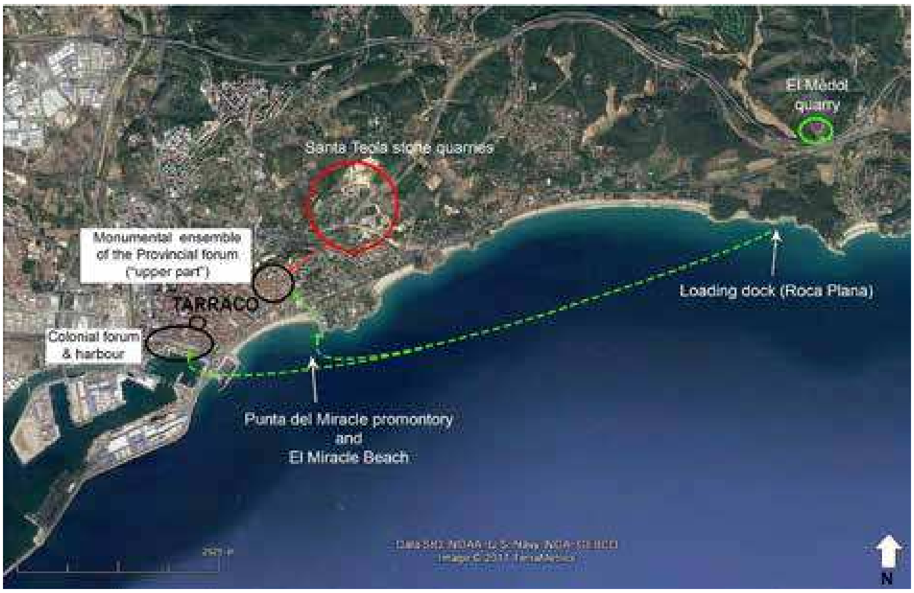

Figure 12.7: Location of the quarries of Santa Tecla stone and of El Mèdol, with the nearby loading dock and the most likely arrival point at El Miracle beach (map: GoogleEarth, with modifications by A. Gutiérrez Garcia-M.).

beach, right below the upper part of Tarraco (Figure 12.7). Not only it is closer to the final destination, but mooring there would avoid disrupting the harbour and the town's traffic.[722] There is some archaeological evidence to support this idea. As mentioned above, an assemblage of granite columns was discovered underwater next to the promontory of Punta del Miracle. Also, several human-made cuts were identified on this promontory bedrock just on the coastline. Together, these finds seem to indicate that an ancillary wooden dock existed here in the past. Despite the lack of stratigraphic context or other archaeological elements to date these vestiges, they strongly suggest that this location was where the loading/unloading of boats could have taken place.[723]

The need to cut down costs and to ensure a continued supply determined the organization and logistics of building stone procurement. The El Mèdol quarry probably became the main supplier because of the extent and quality of the outcrop as well as its location near the coast. The discovery of a loading dock of about 40 m long and 11 m wide carved out of the natural rock on a nearby beach is most interesting in this regard. The sea level has risen here since the Roman period, but there are square post-holes present near the carved out loading dock. Together with the location of this dock in relation to the sea currents, these aspects strongly suggest that this was the place from which the blocks were sent to the town by coastal shipping.[724] The effort of creating this loading dock means that it was to be intensively used. A small Roman site[725] was

722 Which was indeed a main problem: Pensabene and Domingo Magaña 2017.
723 Mar and Pensabene 2010, 507; Gutiérrez Garcia-M. *et al.* in press.
724 López Vilar and Gutiérrez Garcia-M. 2017; Gutiérrez Garcia-M. and López Vilar in press.
725 Still unexcavated.

discovered only 150 m from the loading dock, containing pottery of the second third of the first century C.E., suggesting that it was in use when the Provincial Forum was under construction. From there, the blocks probably arrived to the above-mentioned El Miracle beach when intended for the Provincial Forum, and to the main harbour (or nearby), when intended for the Colonial Forum (Figure 12.7).

Santa Tecla stone was the exception to this local shipping pattern since the quarries lie only a few kilometres northeast from the town. In addition to its use in decorating the Provincial Forum, large quantities of this stone were also employed within the *caementicium*, most likely as extraction waste. Indeed, other likely uses of this debris were the production of lime and the fitting of non-permanent infrastructures, such as on-site platforms or ramps required to haul these materials to the construction site on the upper part of the hill. Since the town wall was already present and the lower part of Tarraco was heavily urbanised, the easiest route from the coastal arrival point at El Miracle to this upper area was through the small entrances, which faced the steepest slopes of the hill (Figure 12.7). Although no evidence of such platforms and ramps were preserved, they could have been similar to those proposed by Korres for the Parthenon,[726] and dismantled or reused for *rudus* when the architectural project reached its end.

12.6 Labour, building costs and funding

The scale of these activities and the wide range of tasks to be performed clearly needed to be perfectly planned, coordinated, and managed. Of first importance was the *architectus*[727] who, together with the promoter, was in charge of designing, organizing, and managing the whole construction site. For a public works project (*opera publica*), all activities were usually entrusted by auction to the *redemptores*,[728] who were awarded the construction, maintenance, or restoration works.[729] In the case of large-scale projects, several *redemptores* could be involved. Many teams had to work simultaneously at many different locations, yet these would have been closely coordinated to ensure the completion of each step of the building process, and most likely with defined deadlines. For all this work, the *redemptores* needed to hire skilled labour.[730] Well-documented examples from other Roman towns show that the entire workforce on such project did not consist of slaves or unskilled workers. On the contrary, a large proportion of the workers were specialized in certain kinds of labour, particularly to carry out complex techniques such as the *opus quadratum* or the final cutting and positioning of blocks,[731] as well as the stone extraction process at the quarry.[732] Indeed, many of the specialists and craftsmen were probably freedmen, and even highly qualified sculptors were summoned from Rome to Tarraco to undertake the sculptural work of the decorative

726 Korres 1995, 48.
727 A primary source about this professional figure is Vitruvius (Vitr. 1.1-2, 1.3.2). For the architect's social status see Gros 1983.
728 The *redemptores* were contractors undertaking several tasks within the building project.
729 Rodríguez 2009, 188.
730 Barresi 2003, 83.
731 See the case of Epidaurus where some inscriptions highlight the need for skilled labour also in the lifting and manoeuvring of the heavy blocks: Burford 1969, 184-189.
732 Bessac 1996.

architectural elements in Carrara marble.[733] Similarly, there is evidence of an *officina marmoraria* working at Tarraco in the Flavian period,[734] which seems to be linked with the last building phase of the Provincial Forum.

The amount and quality of the material and labour directly indicate the cost of the project. A commendable attempt was made to estimate the cost of the Provincial Forum.[735] However, the resulting figures should be regarded with caution due to the amount of missing information, and the extreme difficulty in estimating the costs of the unpreserved parts of buildings and different working stages. Still, such figures do give an idea of the high economic investment required. In terms of the funding, it is possible to propose a clear difference between the two *fora*. Concerning the Colonial one, the municipal investment was likely substantial, especially at the beginning, as it was the civic, political, and administrative centre of the *colonia*. All the Colonial buildings had the same architectural decoration: made in local limestone and, up until Julio-Claudian times, with an archaic style already out of fashion in Rome. Only from Tiberian times onwards, did the new styles from Rome arrive. This is reflected in the renovation of the architectural decoration of the basilica, which shows influences from that of the Mars Ultor temple in the Forum of Augustus in Rome. It is thus probable that the sculptors working on Tarraco's basilica were inspired by those coming from Italy, and that the same sculptors worked contemporaneously on the temple of Augustus in Tarraco.[736] On the other hand, the Provincial Forum was very likely planned and funded by the municipal, provincial, and imperial administrations, after receiving the permission from the *ordo decurionum* and the emperor. The participation of the municipal and provincial elites was a means of increasing their social status, stating their political power, and reaffirming their loyalty to the imperial authority.[737]

12.7 Epilogue

To conclude, these two case studies help to better understand the organisation of the public building industry of Tarraco. It also highlights the links and impact that the construction projects had on the overall economy of Tarraco, while contextualizing it within its wider geographical, social, and political environment. These two large-scale projects created the two main landmarks on Tarraco's landscape, with strong political and symbolic implications. But besides their size, their splendour was also determined by their geographical prominence and the luxury of the materials employed, which matched their political dignity. The completion of these two monumental complexes entailed the development of a very well-organised industry and was almost all inclusive of the aforementioned aspects. The resulting buildings not only shaped the town's landscape in Early Roman times, but continued to do so throughout the centuries, until today.

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733 Domingo 2015, 191.

734 They consist of imperial marble revetments and of debris left by re-cutting fluted marble columns, which were uncovered in the southern limit of the Provincial Forum: Gutiérrez Garcia-M. and López Vilar 2012.

735 Mar and Pensabene 2010.

736 Mar *et al.* 2012, 261. This temple was located in the upper part of the town.

737 As Domingo 2015 has argued in the case of the *Caecina* family in Tarraco.

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13

Building materials, construction processes and labour

The Temple of Isis in Pompeii

Cathalin Recko

13.1 Introduction

The method of estimating labour costs for the construction of ancient buildings based on pre-industrial engineering handbooks is now well established. Since Janet DeLaine introduced the method to the field of Classical Archaeology with her study on the Baths of Caracalla, many studies of buildings from different times and cultures followed.[738] The focus of most studies lies on interpreting the total amount of building materials and required labour, as well as their economic implications. By contrast, the underlying mathematical principles and methods of calculating form, size and amount of each material is usually not emphasized in these architectural studies. In response, this paper aims to shed light on the practical parts and processes of architectural studies and labour calculations. Furthermore, different options and levels of precision regarding the mathematical methods are presented, keeping in mind different perspectives and research questions. Still, the demonstration of exemplary calculations of the amount of only a few building materials cannot provide a complete picture of the possible methods, principles, and difficulties. Considerations of actual labour costs will also be limited to a few remarks about the connection between material data and labour.

13.2 The Temple of Isis

Located in the Theatre District, the sanctuary covers an area of about 720 m², including the temple itself, which is surrounded by a *porticus* and several adjoining rooms (Figure 13.1). Some of the structures can be associated to cult practices like the small crypt in the eastern corner of the courtyard that provides access to an underground

738 DeLaine 1997 and further DeLaine 2015. A small selection of other studies without any claim to completeness: Barker 2012; Courault 2015; Devolder 2013; Pakkanen 2013; Pensabene *et al.* 2012.

In: Brysbaert, A., V. Klinkenberg, A. Gutiérrez Garcia-M. & I. Vikatou (eds) 2018. *Constructing monuments, perceiving monumentality and the economics of building: Theoretical and methodological approaches to the built environment*. Leiden: Sidestone Press, pp. 295-308.

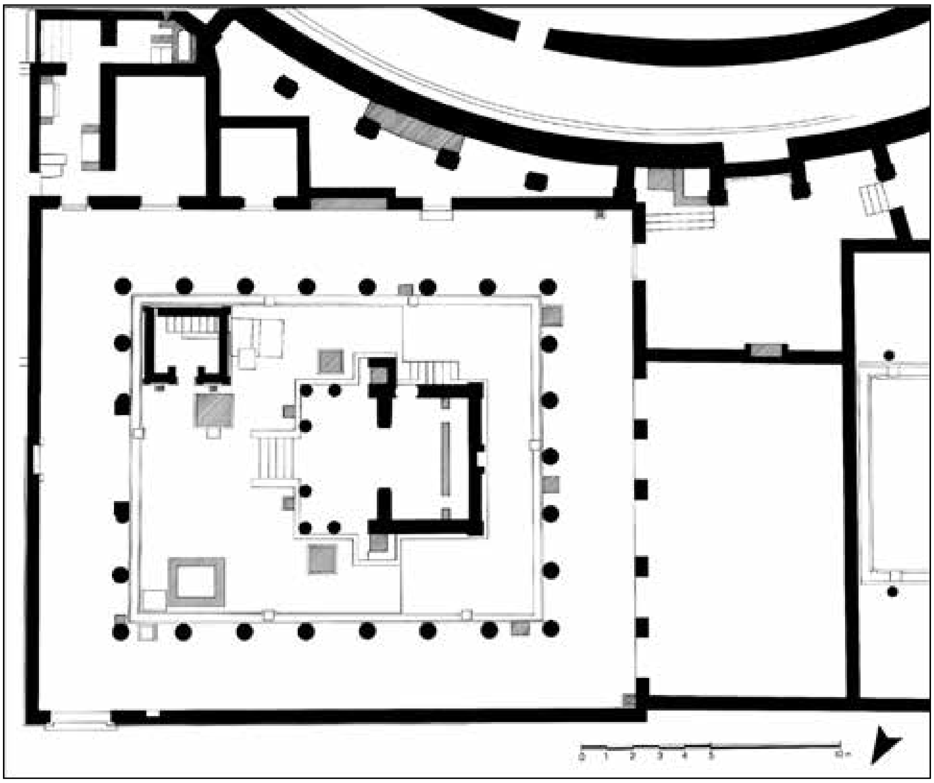


Figure 13.1: Plan of the Temenos (after De Caro 1992, tav. I).

water reservoir, or the number of altars surrounding the temple. The chronology of the building is not entirely clear. According to an inscription, the temple itself was rebuilt 'from the foundation up' after the earthquake in 62 C.E. The former temple is believed to have been constructed in the second century B.C.E. However, the temple shows some structural characteristics that would usually suggest a longer life span. Therefore, the current state of the temple might also be a later building phase of an Augustan temple, as is probably also the case for the surrounding rooms.[739] In this paper, the temple will be studied in the form as it appears today, because the focus lies on methods of quantification applied to the current material record.

The Temple of Isis is extraordinarily well preserved, even within the generally high degree of preservation in Pompeii. Further, due to the large excavation area, almost all building types and a variety of building techniques and structures are represented at Pompeii. Especially when considered *in toto*, this is an exceptional situation that is extremely valuable for studies of construction. Furthermore, the sheer number of standing structures enables us to draw a rather clear picture of local building traditions and developments in the span from the second century B.C.E. to 79 C.E. On the other hand, the surroundings of Pompeii including its street network, the ancient coastline

739 For a discussion of the interpretation of the inscription and the chronology see Blanc *et al.* 2000, 301-304 and in response to that Gasparini 2011.

Figure 13.2: Temple of Isis in Pompeii.

and the quarry sites for different building materials, are insufficiently known due to the area's dense population in modern times.[740]

While the public buildings of Pompeii do not offer the chance to study large-scale or monumental construction, they nonetheless offer excellent case study material for more 'ordinary' building projects, which could be realized without special transportation arrangements or extraordinary use of the city's infrastructure.

The present study focuses only on the temple building and excludes the surrounding structures. The temple is one of the few public buildings in Pompeii built entirely of brick. It stands on a podium with comparatively narrow front stairs, and two niches flank the *cella*, which gives the temple its distinct ground plan (Figure 13.2). The partially crumbled plaster reveals that even the pilasters, which form the outer corners

740 For more information on Pompeii's topography, ancient landscape, and building materials see the publications of the SALVE project, e.g. Seiler *et al.* 2016.

of the *cella* back wall, and the entire entablature, including the cornice, were made of brick. The only stone parts of the building are the two sets of stairs, the pedestal of the podium, the stylobate stones, and the capitals as well as the *pronaos* columns.[741] Needless to say, the roof was also not made of brick, but unfortunately none of its structure is preserved. However, the original height of the temple is preserved to the level where the pediment would have sat.

13.3 Calculating Building Materials

The first step of all studies on construction is to determine the amount, size, and nature of each building material. There is a range of possibilities to do so, especially with help of photogrammetry, 3D modelling, or other digital techniques. However, in some cases such methods are not required and could even be more time consuming, such as when a lot of data from several buildings must be collected. Therefore, an alternative method is used and shown here.

One of the reasons for the complexity of material calculations is the differing data required for each part of the building or building material. For example, numbers of required bricks are calculated from the surface of the wall facing. The aggregates of the wall's cores, on the other hand, are counted as volume and must be subtracted from the volume of the core. To further illustrate this, these two examples are elaborated on in the following parts and the results are summarized in Table 13.3 below.

13.3.1 Ceramic Building Materials: categorizing 'wall types'

Given the fact that the temple was constructed mostly of bricks, this paper likewise focuses on that body of material. Pompeiian bricks generally do not have uniform dimensions; they typically vary in height and in length. For the purpose of calculating the overall number of bricks, however, it is necessary to define an average-size brick. The simplest way to do so, is to take a sample of a wall, for example 1 m^2 in size, and count the bricks (Figure 13.3). The sample should of course be as representative as possible. In the case of Pompeii, that can be challenging because the sample has to be freely accessible and, of course, should be free of any modern repairs or restorations. With the Temple of Isis, the excellent state of preservation presents another obstacle: the parts of the walls that are not covered by plaster rarely display sufficiently large areas with which to make brick counts. Furthermore, it seems that extensive rejointing was part of restoration procedures.

The sample square under consideration is located on the corner of the podium beneath the southern niche. The fact that one side of the square includes a wall corner is not an ideal situation, but as Figure 13.3 shows, the corner bricks do not noticeably differ in size from the regular bricks. Together with the fact that, with any choice of sample square, some of the bricks are always cut at random positions, this makes the location of this particular square little problematic. Table 13.1 sums up the results we can gain from the sample measurement and shows how to further calculate the dimen-

741 Curiously, the capitals are plastered over and thus receive another shape and size. For a discussion on that see Blanc *et al.* 2000, 246-247.

Figure 13.3: Sample of one square metre with bricks highlighted.

Measured		**Calculated**			**Estimated**	
Number of bricks (*B*)	66	Bricks per row	$b = B / R$	3.77	Shape of bricks	Triangular
Number of rows (*R*)	17.5	Average length of bricks	$L = (1 - T_v) / b$	0.26 m	Width of bricks	0. 15 m
Thickness of vertical joint (t_v) Total thickness of joints per row (T_v)	0.01 m 0.03 m	Average height of bricks	$H = (1 - T_h) / R$	0.042 m		
Thickness of horizontal joint (t_h) Total thickness of joints per row (T_h)	0.015 m 0.27 m					

Table 13.1: Information and further calculation that can be retrieved from the sample of the brick wall.

sions of the average brick. The characteristics presented there define the 'wall type', with which we will continue to work.

A few remarks about the reliability of these figures are in order. It cannot be emphasized enough that we are not aiming for exact numbers. As mentioned before, the size of the bricks as well as the thickness of the mortar joints are simply too irregular to determine any exact amount. Even if technological aids (e.g., photogrammetry, 3D modelling) are used to analyse all visible parts, there will always remain large areas that have to be manually reconstructed, for example, the missing sections above the level of preservation, internal fill of walls, or simply wall sections that are still covered with plaster. Thus, all quantities and sizes of building materials have to be considered as estimations, rather than exact calculations. That we are talking of ranges rather than exact numbers, however, does not make the interpretation and economic implications less valuable since even ranges of labour provide a whole new dimension to questions of efficiency and economic value.

After defining one wall type through a specific size of brick, and through the brick-to-mortar ratio (e.g., the one shown in Table 13.1), this type can be applied to any wall of the building, whose materials seem to fit the defined characteristics. To avoid carelessly assigning this specific type to every wall though, a close observation of each wall is necessary in order to account for differing features – whether in shape and size of materials or in technical execution – that may require the definition of further wall types. In the case of the Temple of Isis, it is noticeable that the horizontal mortar joints are thicker (2 cm thick, rather than the mentioned 1.5 cm) in the outer, back wall of the *cella*. Furthermore, random individual measurements[742] of bricks from the *cella* revealed that their length tends to be slightly less than the defined standard length (22 to 23 instead of 26 cm), which derived from a sample of the podium. However, concluding that generally a different kind of brick was used in the *cella* would be hasty. A close observation of the bricks both of the podium and of the *cella* walls shows that notably longer bricks appear more frequently in the podium than in the *cella* walls. In the sample square, five of those bricks with a length of around 40 to 45 cm were observed. This difference was enough to raise the length of the average brick by a few centimetres, which means that the sizes of the other bricks actually match well with those of the bricks of the *cella* walls. Table 13.2 shows the effect that an alternative standard brick for the *cella* walls and the thicker mortar joints in the back wall would have on the overall counts. The total amount of required bricks is calculated from the overall surface of the facings from the outside as well as the inside of the *cella* walls together with the outside facing of the podium. In order to generate these numbers, the same principles as used in Table 13.1 were followed. By comparing the overall numbers of bricks and their total volume, it becomes clear that variation in brick sizes as well as brick-to-mortar ratios do have a reasonable impact on material and thus, labour calculation. This is another demonstration of the inevitable uncertainties which accompany this kind of studies.

Regarding the different wall types, it is the responsibility of the researcher to evaluate the range of variation from the standards that should lead to the definition of another wall type. The *cella* back wall should probably not be accounted as a separate wall type, because pictures of the temple from the 1960s show that the relevant areas were still plastered at that time. Thus, it is very well possible that the bricks with their unusually thick mortar joints are modern restoration works.

So far, the information on the used bricks was obtained from the visible, outer parts of the wall. What is yet missing is the width of the bricks, respectively of the wall's facing, and of course the core itself. As was the case with plastered wall surfaces, large sections of the interior of the wall must be reconstructed using reasoned estimates. In the fortunate case of cut off facings and exposed cores, there is at least some data on which to base a reconstruction. Unfortunately, we do not have any such cores for the Temple of Isis, as all of the wall facings are still intact and modern tiles cover the top of the *cella* walls.[743] However, for the study of building materials and labour costs, a clear

742 Taking a one square meter sample unfortunately is not possible on any of the *cella* walls because of the plaster.

743 In general, it is difficult to have access to exposed cores in Pompeii, because cut off walls are usually sealed by a modern rubble and mortar mixture to prevent moisture to infiltrate the walls. Thus, exposed cores are mostly found in holes in the walls or when only one facing of the wall is broken off, and the core as well as the other facing remain standing.

Average brick type	Size (L x W x H)	Bricks in 1 m² facing	Surface of podium	Surface of *cella* excluding back wall	Surface of *cella* back wall (outer facing)
Podium (A)	0.26 × 0.15 × 0.042 m	66	25.73 m²	89.47 m²	16.08 m²
Cella (B)	0.225 × 0.13 × 0.042 m	75	25.73 m²	89.47 m²	16.08 m²
Cella back wall (C)	0.225 × 0.13 × 0.042 m	53	25.73 m²	89.47 m²	16.08 m²

Differentiation of wall types	Total number of bricks	Volume of bricks
Type A for every wall	(25.73 + 89.47 + 16.08) × 66 = 8,664.48	7.1 m³
A for podium, B for every *cella* wall	25.73 × 66 + (89.47 + 16.08) × 75 = 9,614.43	5.9 m³
A for podium, C for *cella* backwall, B for other *cella* walls	25.73 × 66 + 89.47 × 75 + 16.08 × 53 = 9,260.67	5.7 m³

Table 13.2: Demonstration of the impact that different wall types would have on the overall counts of bricks.

understanding of the form, size and composition of the aggregate in the *caementicium* core of the walls is indispensable. Figure 13.4 (on the right-hand side) shows a reconstruction of how the inside of a *cella* wall from the Temple of Isis might have appeared. As is typical for Roman walls, they consist of two facings enclosing a *caementicium* core. The facings consist of roughly triangular bricks that vary in length and shape as well as in the thickness of the mortar joints. The width of the bricks simultaneously defines the width of the wall's facing and thus:

Volume of wall – Volume of both facings in 1 m² wall = Volume of core

The width of the shorter *cella* bricks reconstructed here is 13 cm, based on their average length and, furthermore, that figure is consistent with bricks found at other sites in Pompeii. However, for the longer podium bricks a width of 15 cm appears to be more appropriate. Thus, when 0.45 m is the thickness of the *cella* walls, the volume of the core equals:

$$0.45 - 2 \times 0.13 = 0.19\ m^3$$

The core consists of mortar and different kinds of aggregates. Its reconstruction is also based on personal observations on other buildings and walls of Pompeii, which revealed that inside walls with brick facings, ceramic fragments appear to have been used more often as aggregate (as opposed to the more commonly attested use of rubble). There are two possible reasons for this. The first one is that there was simply an abundance of available brick fragments and discarded pottery in an environment where brick is the main building material and ceramics are used as everyday objects. The second hypothesis is associated with the use of unusually large rubble stones for cores in Pompeii. Instead of the elsewhere common (roughly) fist-sized stones, the rubble in Pompeii is typically twice as large. Stones of that size are much less convenient to fit with the pointed side of the bricks that form the facing, than smaller and thinner ceramic fragments. Based on these considerations, the majority of the aggregate is considered to be ceramic fragments (70%), with smaller parts of limestone (20%) and lava (10%) rubble.

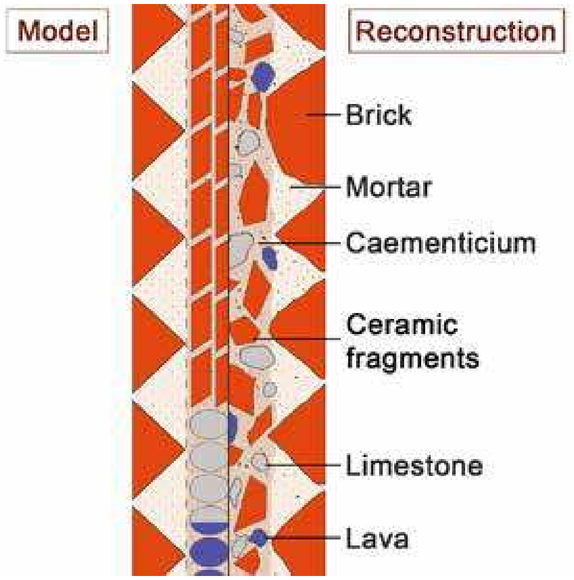


Figure 13.4: Cross-section of a wall, model and reconstruction.

The left-hand side of Figure 13.4 shows how the reconstruction is transferred into a geometric model for calculating these materials. Contrary to the triangular bricks or ashlar blocks, the irregular shape of rubble or ceramic fragments is hard to display as a geometric shape. For the model, rhomboids and ellipses were used instead. For the actual calculation, however, this problem is avoided by estimating the ratio between aggregate and mortar and thus, the total volume of the aggregates.[744] Table 13.3 shows the calculated amount of materials for the core, assuming a ratio of 60:40.[745]

To sum up, to construct 1 m^2 of *opus testaceum* wall from the type used in the *cella* walls of the Temple of Isis, the following material is employed:

- 150 pieces of brick with a total volume of 0.092 m^3
- 0.244 m^3 of mortar[746]
- 0.114 m^3 of aggregates consisting of 0.08 m^3 ceramic fragments, 0.023 m^3 limestone rubble, and 0.011 m^3 of lava rubble.

13.3.2 Building structures apart from walls

Having demonstrated the methods of calculating and estimating the primary building materials used to construct a typical Roman *opus testaceum* wall, the following part will

744 This type of calculation is possible, because of the way of producing this material e.g. with a pickaxe, where surface of individual pieces and so forth is negligible.

745 DeLaine 1997, 123 assumes a ratio of 62.5 to 37.5 on the basis of the increase in volume of rubble over solid stone (in her case *selce*). The proportion of mortar is considered to be slightly higher here, because observations indicate a rather generous use of mortar, especially when smaller fragments are used as aggregates instead of the bigger rubble stones in *opus incertum* walls.

746 The mortar has to be further distinguished into its main components lime, sand/pozzolana and water. At this point, however, this cannot be pursued any further.

Part of wall	Size (L × W × H)	Volume	Aggregate to mortar ratio	Volume of brick / aggregate in 1 m^2 wall	Amount of mortar in 1 m^2 wall
Single brick facing	1.0 × 1.0 × 0.13 m	0.13 m^3	35:65	$Volume_{brick} \times number_{bricks}$ 0.00061 × 75 = 0.046 m^3	$Volume_{facing} - Volume_{bricks}$ 0.13 – 0.046 = 0.084 m^3
Core	1.0 × 1.0 × 0.19 m	0.19 m^3	60:40	60 % of 0.19 = 0.114 m^3	40% of 0.19 = 0.076 m^3

Table 13.3: Calculation of the materials required for building 1 m^2 or 0.45 m^3 of the cella wall. Note that in the first row the ratio is the result of the proportion of brick to mortar, whereas in the second row it is an estimation.

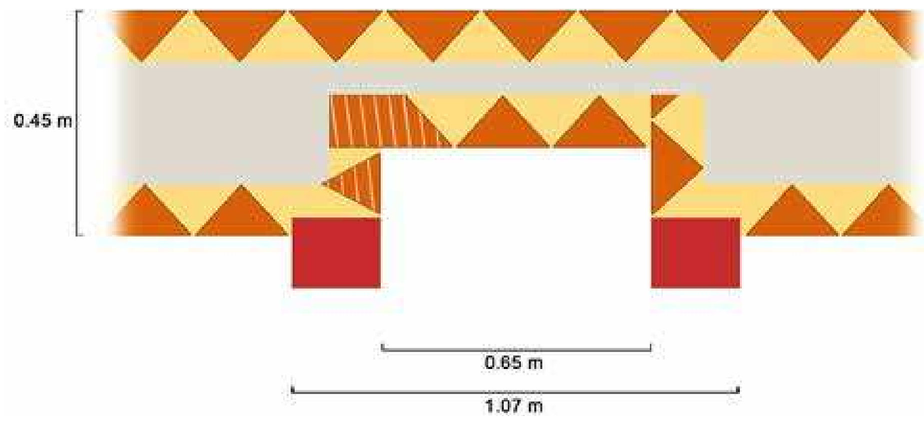
consider extraordinary building structures and will demonstrate how to include (or exclude) those into the overall calculations.

For these purposes, a small niche located on the outer back wall of the *cella* of the Temple of Isis serves as an example (Figure 13.5). The niche is framed by two columns supporting an arch and has, with a total height of *circa* 1.52 m, rather moderate dimensions. Except for a few modern restorations and for the use of stone in the bases and capitals, it is – like the temple itself – completely constructed of brick. From what is visible of the brick structure, it appears that the bricks forming the plinth as well as the bricks forming the tapering pilasters were not broken into shape, but rather they were specially formed. What lies under the plaster around the arch, can only be assumed. Most likely, there was a facing of small radial bricks or tile fragments while the arch itself was made of *opus caementicium,* as seen elsewhere in Pompeii.[747] The side walls as well as the back wall of the niche are assumed to be made of regular bricks. At especially narrow or otherwise difficult positions, the bricks were probably broken to the size and form necessary to fit the specific space. Figure 13.6 shows a model of the cross-section of the niche and the surrounding *cella* wall with the different kinds of bricks. Highlighted in red are the bricks forming the column, which were probably customized. The striped ones form the side walls of the niche and may have been broken into pieces that fit their location best. The differentiation between the standard bricks and the individually processed bricks is, however, of no relevance to the material calculation, as that processing is too uncertain and too abstract to be quantified. As it concerns the labour requirements, there is also no calculable difference between breaking a larger brick into triangles as opposed to other, more specific forms. In fact, this example nicely illustrates the method of modelling with standardized bricks. Note that if the length of a wall or a section thereof does not result in an exact integer multiple of the standard length, it is not advisable to immediately round to a whole number (of bricks). Instead, working with fractional numbers will ultimately lead to more accurate projections, since rounding errors would inevitably be introduced that could then be multiplied into future calculations and eventually resulting in significant biases in the overall calculation. In general, rounding-up or rounding-down should be avoided in between the sets of calculations and it should be limited to statements of final results,[748] and even in the final results, the precise numbers should not be discarded in case further calculations become necessary.

747 For example, in the horizontal arches above the niches in the western magistrate building at the forum.
748 DeLaine 1997, 109. At that point, rounding is quite useful to prevent the assumption of false accuracy.

Figure 13.5 (left): Niche in the outer back wall of the cella.

Figure 13.6 (below): Model of the niche's cross-section with brick distribution.



13.3.3 Stone building materials

To demonstrate another type of calculation, two examples of stone building materials are addressed. Massive blocks of tufa are found amongst others in the base of the podium and in the stylobate of the Isis Temple. The latter have a profiled front face, while the former are simple ashlar blocks. Each block from both the podium base and the stylobate has a unique size, and in order to prevent the calculation from getting too complicated, it is again advisable to work with an average size. The method to gain that standard size differs from the one shown for the bricks, though. Instead of extrapolating a sample, all the stones should be imagined as lying in a straight row, which,

Quantity and dimensions of stylobate stones	Stones in the pronaos area	Stones in the cella area
Number of stylobate stones	13	35
Height	0.255 m	0.255 m
Average length	0.61 m	0.48 m
Average width	0.7 m	0.5 m
'Straight surface' of the profiled front side	0.07 m^2	0.06 m^2

Table 13.4: Relevant characteristics of the tuff stylobate stones. 'Straight surface' means that the rounded parts are not considered individually, but instead, the front is treated as if it was a straight, diagonal surface.

in the case of the base, would be 27.24 m long. Divided by the number of stones used in its construction, this results in a standard length of 0.74 m. It is very likely that the width of the blocks also varied considerably, but as this is completely indeterminable from the outside, a uniform width of 0.5 m is suggested here. This width assures that the bricks forming the facing of the podium could be laid easily on the straight and flat surface of these stones.[749] As opposed to the rubble and ceramic fragments, it is necessary to count individual stone elements because the size of the surface in square meters is an important factor in calculating the labour effort of quarrying as well as forming and finishing the stone. However, the overall surface remains the same, regardless of whether each individual length or the average length is employed.[750]

The same principle is also applicable to the stylobate stones. However, the profiled front needs extra attention. Volume and surface, especially of ornamental decorations such as floral or dental cornices or egg-and-dart, are extremely difficult to measure. Luckily, it would be equally difficult to calculate the labour effort for carving such small details. This is why in most handbooks, for the sake of simplification, the common ornaments and other stone decorations such as Corinthian capitals are measured in running metre or piece.[751] Thus, the necessary information about the stylobate stones can be found in Table 13.4.

13.4 Precision and detail

The outlined approach of calculating building materials is not intended to be understood as a manual demonstrating the single and only method. In fact, this could be considered to be a rather basic, pedestrian approach. As previously mentioned, there are also several ways to digitize this process. In the end, the choice of method depends on many, often practical research factors, for example, the accessibility to the building under study, the research funding available, the type of research questions being posed or simple personal preference. However, the very detailed demonstration of this low-

749 If the saving of stone materials is assumed to be the highest priority, however, a lower width could also be possible.

750 Of course, this does not apply to the reconstructed average width of the stone, but in that case, being more precise is simply not possible.

751 For example, Pegoretti 1863, 397-399.

tech method aimed at making the considerations and mathematical principles behind the calculation of building materials more understandable and transparent.

The choice of either working manually or computationally is not the only decision to make. Depending on the research question as well as the research case, there is a range of options regarding the appropriate level of precision. The majority of published studies deal with large-scale building projects. These usually focus on the sheer magnitude of the building, its materials, and the resulting specialized as well as complex building processes. Working with such dimensions naturally excludes small details and specifics, which only marginally impact the overall calculation. The niche, for example, made from only a cartload of bricks seems to be of little relevance to a large-scale building project. Even for the comparatively small Temple of Isis, the proportions seem to be extreme. The overall construction volume[752] adds up to about 113 m^3, from which the niche covers about 0.5 m^3, and thus only 0.4% of the total volume. Keeping that in mind, differentiating between standard and customized bricks seems to be even more negligible. In fact, their inclusion would not really impact the overall number of bricks and thus the total calculation, because they simply are omitted when the numbers are rounded. However, it can still be useful to consider these characteristics of the material usage. Even if they do not affect the actual calculation, they might be valuable to analyse local building traditions and their socio-economic impact.

13.5 Interpreting choice and processing of building materials

So, what can the Temple of Isis tell us about Pompeii's brick industry? The specific shape and size of the bricks needed for the niche and for other parts of the building[753] strongly suggest that the bricks were custom-made for this building project. The uniformity in colour and the relatively clean edges of the bricks for the regular walls also indicate that newly fabricated bricks were used instead of reused tiles, the latter being often generally assumed to be used in the buildings in Pompeii. However, it is remarkable that buildings entirely made of bricks are an exception until the city's destruction in 79 C.E. Instead, the use of *opus incertum*, which is considered to be a rather inferior building technique, was popular throughout the city's history. It is likewise well known that the choice of building materials is not always or solely based on economic factors, but it is also influenced by ideology as well as the socio-cultural background of the builder and the city itself. In the case of the Temple of Isis, another factor might even be the design of the structure itself. The niche with the columns as well as other parts of the building, such as the annexes or the pilasters on multiple corners, would simply be difficult to erect using walls of *opus incertum* with stone or brick quoins and jambs. Therefore, among a number of other possible reasons, *opus testaceum* offers broader possibilities and freedom in the design and structure of the building. The prestige that comes along with building in a modern technique that is used mostly around the forum in Pompeii also deserves to be mentioned.

752 Taken into account are the whole podium including the stairs, all *cella* walls including the annexes, and the entablature.

753 Extra-ordinary bricks are also used for the pediment of the annexes, for the cornice, and as bases for capitals and other parts of the building.

13.6 Conclusions

This paper illustrated the practical process of calculating the amount, shape, and size of some of the building materials from the Temple of Isis in Pompeii. The chosen examples serve different functions in the building and demand different kinds of calculation methods. It became apparent that bricks – as mass products for wall facings as well as special forms for a specific purpose – are best modelled as simple geometric figures. Furthermore, average sizes should be defined whenever possible. This applies to bricks as well as ashlar blocks. Simplifications become inevitable when shapes are too complex or irregular, for example profiled or ornamented surfaces and rubble stones.

Although these examples demonstrated a range of possible approaches to such calculations, they can by no means represent the whole spectrum of quantification methods. Instead, each material employed in the building process has to be analysed individually. Questions that arise are among others 'how can the material be counted?', 'which parts are visible and how can they be measured?', 'what needs to be reconstructed or estimated and what is the best way to do so?', 'what kinds of data are needed for the labour estimation (surface, volume, number of pieces)?'.

This glimpse into the extensive background work for studies on construction and labour shall help to further open this field of research and make the applied methods and principles more understandable. Furthermore, a transparent exposition of the methods employed can help to unify different approaches, and thus create a common base for comparing different buildings.

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14

The construction process of the Republican city walls of Aquileia (northeastern Italy)

A case study of the quantitative analysis on ancient buildings

Jacopo Bonetto, Caterina Previato[754]

14.1 Introduction

This paper investigates the Republican walls of Aquileia, a Latin colony situated in the northeastern part of the Italian peninsula. The analysis of the construction process of the city's wall is examined by taking a quantitative approach. This can identify the economic impact of the building activity carried out to create the wall, and can determine its cost in terms of 'human energy'. The figures obtained are then used to estimate the number of workers involved in the construction process and the time required by the erection of the wall. The aim of such an analysis is to better understand the historical and economic context in which the walls were constructed, during the Roman conquest of northern Italy. This region comprises a vast geographical area that lies between the southern Italian peninsula and the Alps to the north; the area occupies most of the largest alluvial plain in Europe, the Po river plain. Romans conquered this area between the third and the second centuries B.C.E. with numerous colonies founded as a direct effect of this conquest. Among these is Aquileia, which was founded by the Roman Senate in 181 B.C.E. On this occasion, 3,000 settlers arrived in Aquileia, coming mainly from central Italy.[755] The colony, founded as a strategic military stronghold against the Gauls, soon became one of the most important and richest cities of the Roman Empire. Shortly after its foundation, Aquileia gained infrastructure, public and private buildings, and city walls. The defensive circuit was likely built in the first half

754 J. Bonetto is author of sections 14.1 and 14.6, C. Previato is author of sections 14.2-14.6.
755 Liv. XXXIX, 55, 5-6; XL, 34, 2-3.

In: Brysbaert, A., V. Klinkenberg, A. Gutiérrez Garcia-M. & I. Vikatou (eds) 2018. *Constructing monuments, perceiving monumentality and the economics of building: Theoretical and methodological approaches to the built environment*. Leiden: Sidestone Press, pp. 309-332.

Figure 14.1: The republican defensive wall of Aquileia. Part of the eastern side excavated by Giovanni Brusin in the 20th century (Bonetto et al. 2016).

of the second century B.C.E., although at present we lack precise chronological data coming from stratigraphic excavations.[756]

Until now, different sections of the fortifications have been brought to light by archaeological excavations, which have provided a great amount of data concerning their extent and structural characteristics. Giovanni Brusin first excavated the walls in the 20th century, and he discovered part of the eastern side of the wall, which runs alongside the Natissa river. He also researched part of the western and the southern side, collecting important information about the perimeter of the defensive circuit, and documented its construction features (Figure 14.1).[757] Brusin also excavated some gates and towers along the wall, in particular: the northern gate, straddling the road to the *Noricum*; the western gate, straddling the via Annia; the towers situated at the northeastern and southeastern corner of the wall; and a third tower situated between these two. In the 1960's, Luisa Bertacchi investigated a section of the western side of the circuit, where she found another smaller gate.[758] More recently, new data about the Republican city wall has been collected by excavations carried out by the University of Padova in the Cossar area. Here, part of the southeastern corner of the circuit, already investigated by Brusin in the last century, was unearthed several years ago (Figure 14.2).[759] At this site, only some of the bricks belonging to the upper part of the

756 Regarding the chronology of the walls, see Bonetto 2004, 167-170 and Previato 2015, 507-509.
757 Brusin 1932a; Brusin 1932b; Brusin 1934; Brusin 1937-1938; Brusin 1956; Bertacchi 1965, 8.
758 Bertacchi 1972, 76; Bertacchi 1995, 124.
759 Bonetto 2011; Bonetto and Pajaro 2012.

Figure 14.2: The republican walls of Aquileia. Part of the south-eastern corner excavated by the University of Padua in 2012 in the fondi Cossar area (Bonetto et al. 2016).

structure remained. However, its foundations are well preserved and have revealed important information about the building materials and techniques employed in the wall.

Thanks to the archaeological excavations of the last two centuries, the Republican city walls of Aquileia are well known to modern researchers.[760] They were 3 km long and enclosed a rectangular area of about 42 hectares (Figure 14.3). The wall was 2.4 m thick in the upper part and about 3 m thick at its foundations. As the wall is preserved just for a few decimetres above the ground, its original height is unknown. Yet, we can assume that it was about 6 m tall, when compared to other similar and contemporary defensive walls of northern Italy and France.[761]

Aquilea's wall consisted of a homogeneous structure made almost entirely of fired bricks, both in the foundations and above ground (Figure 14.4). Two different types of fired bricks were employed in the wall: rectangular bricks of 50 × 42 × 8 to 9 cm (type 1), and square bricks of 36 to 37 × 36 to 37 × 7.5 cm (type 2).[762] In both types, the bricks were fixed together by thin lime mortar layers of about 1 cm in thickness.

760 For a synthesis about the walls of Aquileia see Bonetto 2004; Bonetto 2009. For the construction features of the fortifications, see also Previato 2015, 49-54.

761 Indeed, we know that the defensive walls of Aosta reached a height of 7 m, while the city walls of Trieste were about 5.5 m high. The measurements suggested for Aquileia are also confirmed by the height of the walls of different French cities: Bedon *et al.* 1988, I, 87.

762 This unusual module is quite interesting, because it recalls the dimensions of the brick called *pentadoron* by Vitruvius and which, according to him, was used in Greek public buildings. In fact, the available data from published research and studies suggests that this brick module is totally absent in Rome, but was used in some cities in Magna Grecia, like Reggio Calabria and Velia, in the third century B.C.E., see Bonetto 2015.

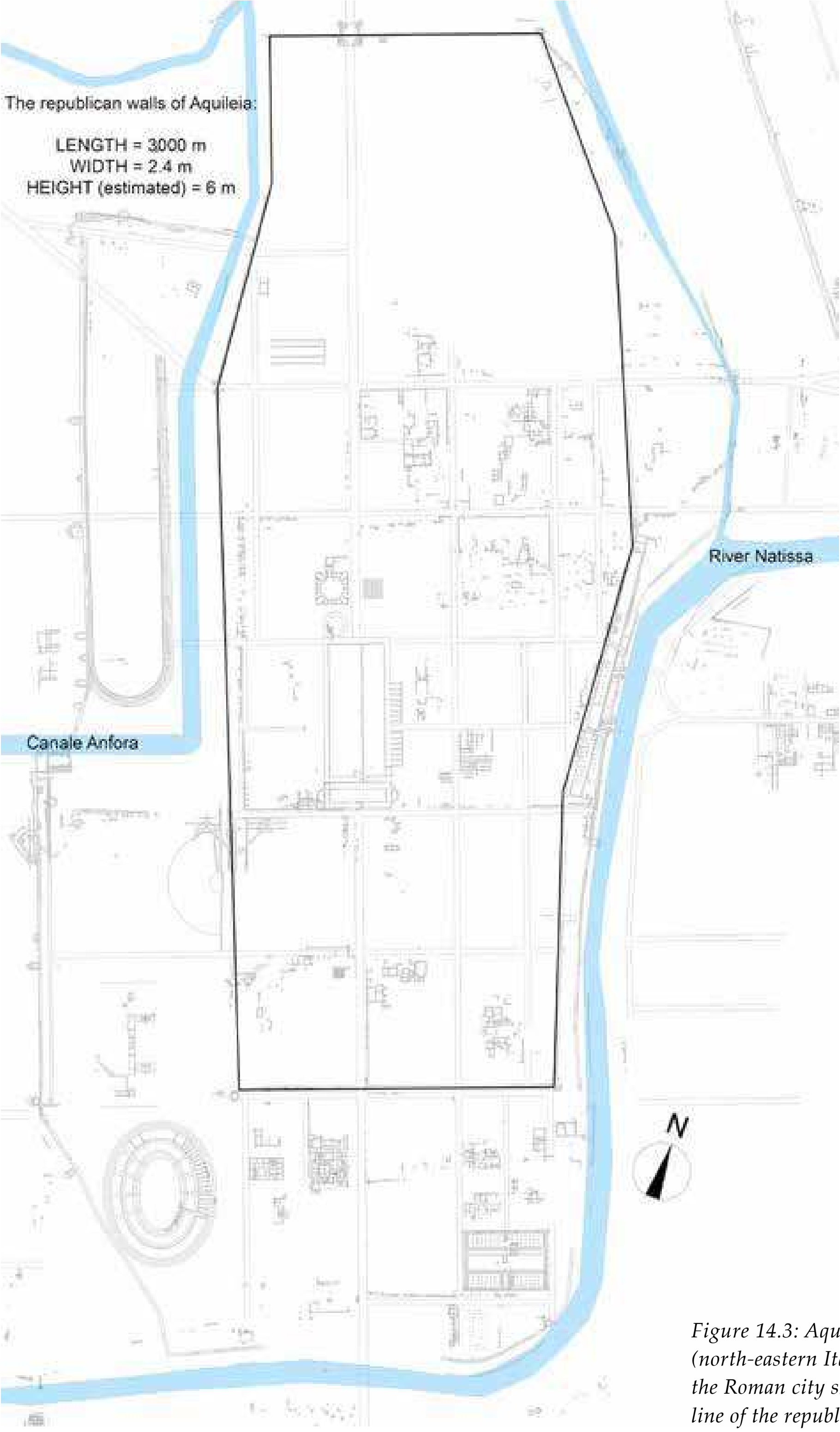

Figure 14.3: Aquileia (north-eastern Italy): map of the Roman city showing the line of the republican walls.

Figure 14.4: The republican fortifications of Aquileia: part of the wall made of fired bricks (Tiussi 2006).

This building technique (*i.e.* a homogeneous structure of fired bricks connected by thin mortar layers) characterizes the entire upper part of the wall, the gates, and the towers. However, the foundations present different construction techniques. Indeed, in almost 300 m of the western side of the circuit the wall of fired bricks was laid on two layers of squared blocks, which had a bossed face made of a particular type of limestone, called 'pietra d'Istria'. This material is characterized by a low absorption capacity (Figure 14.5). The use of this kind of stone in this part of the defensive circuit, which crosses a marshy area, is significant; as the wall crosses a marshy area at this point, it indicates that ancient builders likely knew its properties and its particular resistance to water.[763] In addition, these stone blocks were laid over a layer of stone chips that covered alternating layers of gravel and sand. This 'multi-layered' foundation technique was widely practised in northern Italy in the Roman period to stabilize the ground, to hinder the soil moisture, and to stop rising groundwater levels.[764] Similarly, a layer

763 Strazzulla 1989, 213; Bonetto 2004, 159-160.
764 Previato 2012; Bonetto and Previato 2013.

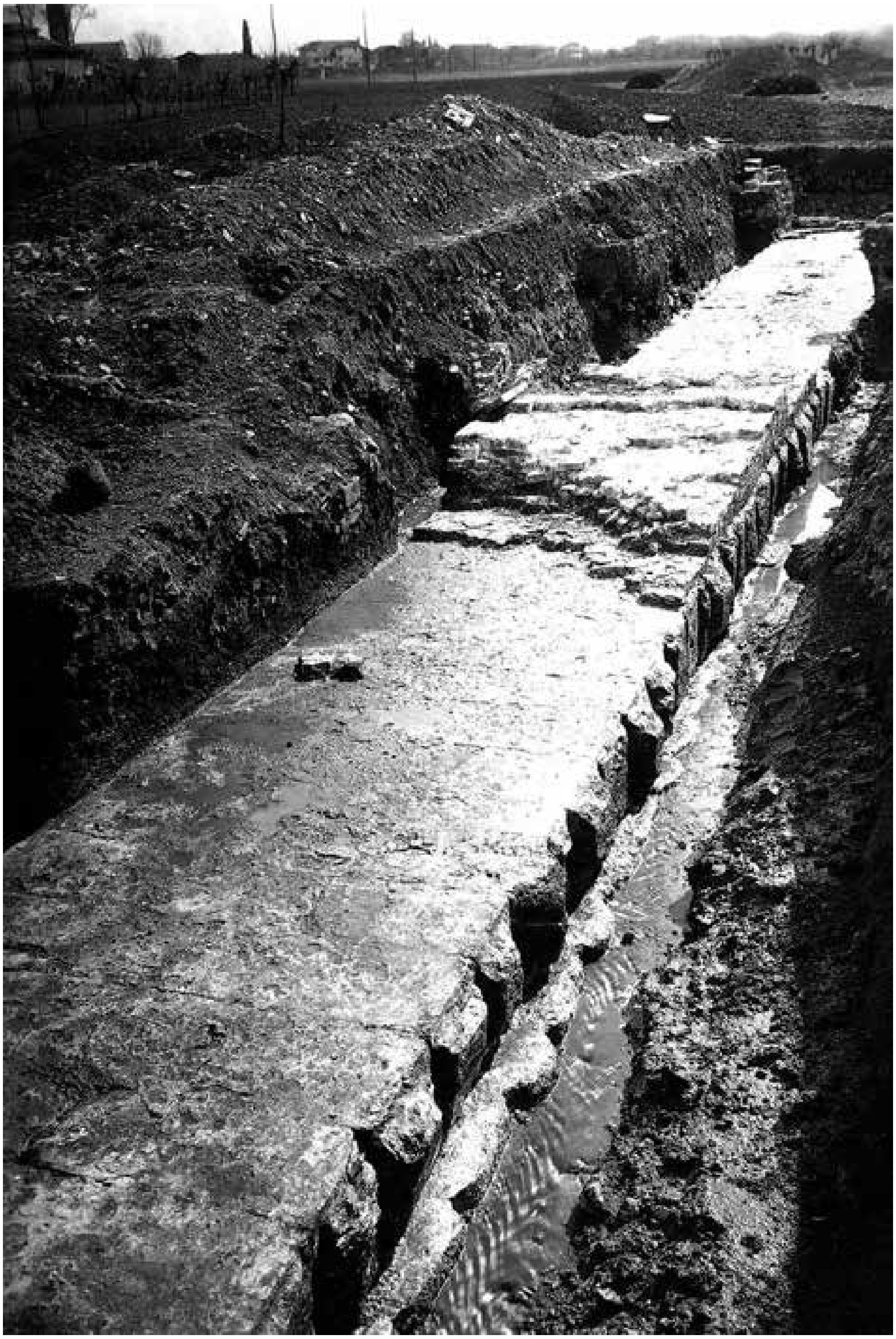

Figure 14.5: The western side of the republican walls of Aquileia. Foundations made of squared blocks of Istrian stone (Strazzulla 1989).

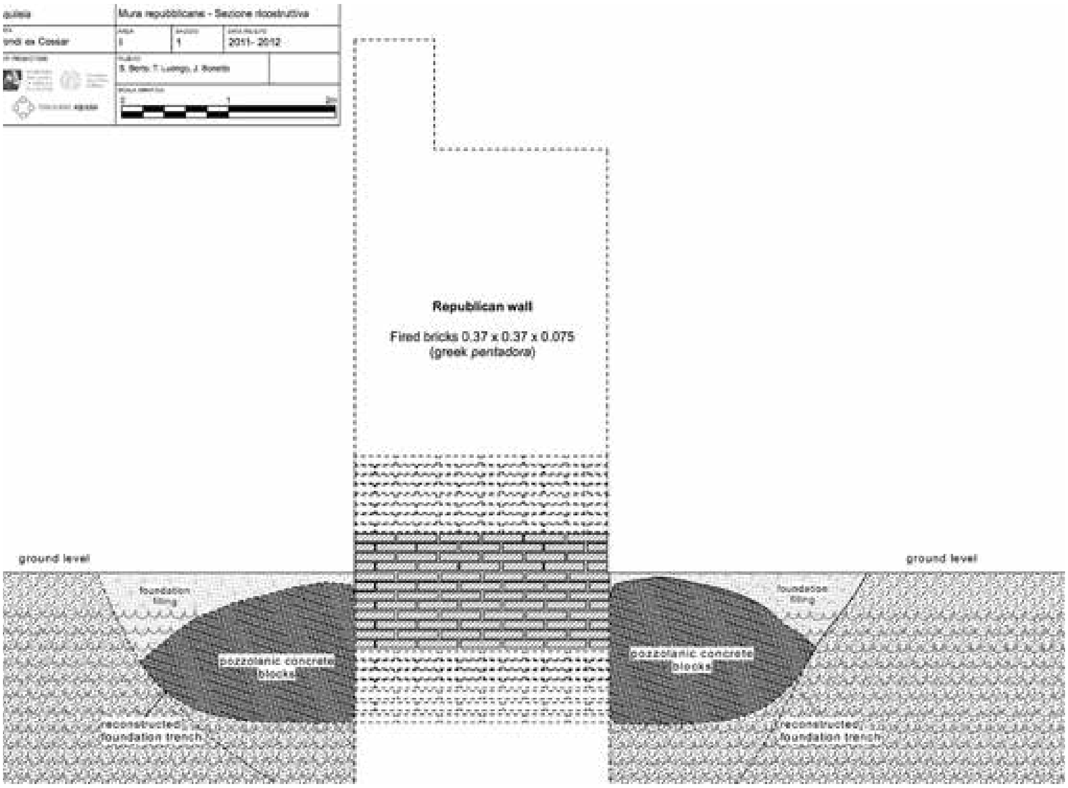

Figure 14.6: Reconstructive section of the republican wall excavated in the Cossar area (Bonetto et al. 2016).

of gravel supported the brick foundations of at least 300 m of the eastern side of the circuit, and the foundations of the northern gate contained stone blocks. In the latter case, the blocks were made of sandstone. Stone blocks with a bossed face were probably employed also in the foundations of the western gate, which opened onto the *via Annia*, visible in some photographs from the last century.[765]

The recent excavation of the southeastern corner of the circuit (in the Cossar area) has revealed another interesting detail about the foundations of the Republican fortifications of Aquileia. The foundation trench and stretches along the internal front of the wall contained some blocks of hydraulic concrete with an exceptional resistance to water (Figure 14.6). These blocks are made of mortar, which contains light-coloured lime and aggregates consisting of small fragments of bricks and gravel. They were used to reinforce the wet soft soil underneath the wall, and to increase the stability of the structure. Recent archaeometric analyses on the concrete,[766] has revealed the hydraulic properties of the mixture. The lime mortar used a volcanic ash similar to the well-

765 See Strazzulla 1989 and Bonetto 2004, 166.

766 Petrographic analyses by polarizing microscope observations, quantitative mineralogical analyses by XRD, and microstructural and microchemical analyses by SEM-EDS.

known ashes of the volcanic districts of central Italy.[767] This material was largely used across the Mediterranean world in the Roman period for the production of hydraulic binders. All these structural elements reveal that the construction of the walls, and especially its foundations, resulted from an accurate building plan. This also took the geomorphological features of the site into account, and was aware of the implications of building in a marshy alluvial plain, characterized by wet and soft soils with a low load-bearing capacity.

Taking into account the available data about its construction features, this contribution takes a quantitative approach to analysing the walls of Aquileia to obtain a more precise understanding of the time and workforce required by the entire construction process.

14.2 Methodology

The quantitative analysis of Aquileia's wall followed the model outlined in the pioneering study of Janet DeLaine on the Baths of Caracalla.[768] This is based on the hypothesis that the construction process is a sequence of human activities, each of which can be quantified in terms of labour-time units (*e.g.* 'man-hours' and 'man-days'). At Aquileia, the available data about the volume of the walls and its structural characteristics have been used to reconstruct the 'cost' of the different construction tasks in terms of time and human energy. This encompasses the supplying and production of building materials to the construction of the wall itself. The cost of each building activity can be quantified on the basis of the labour constants, which come from the well-known manual for estimating architectural works written by Pegoretti in 1843 C.E.[769] In this way, it was possible to estimate the labour effort needed to carry out each construction task in terms of man-hours and man-days, and subsequently to produce a model of the time and workforce required to erect the walls of Aquileia.

It should be stated that in the following calculations the average working year on the construction site has been assumed to consist of eight months (from the beginning of April to the beginning of November), totalling about 220 days.[770] As regards the average working day, it has been assumed to be eight hours, considering both the geographical position and the average hours of daylight in Aquileia. The results of the calculations, which should be seen as an estimate of the minimum workforce required for the construction process, are expressed in man-hours and man-days.

767 The results of the archaeometric analysis carried out on the volcanic ash from the walls of Aquileia show that they were not locally sourced. Yet, they cannot determine whether this material was imported from the Phlaegrean area, from the Alban Hills, or from some other volcanic district (Bonetto *et al.* 2016).

768 DeLaine 1997.

769 Pegoretti 1863.

770 This is the average working year reported by Frontinus in regards to concrete construction (Frontin. aq. 122-123; DeLaine 1997, 105-106). Although the walls of Aquileia contain minimal amounts of concrete (apart from the foundations of the southeastern corner), this time frame was chosen because it seems reasonable considering the geographical position and the climatic conditions of the colony.

14.3 Building materials: quantities and time required for their supply and production

The first step of our analysis consisted of calculating the quantity of materials employed in the walls and the man-power required for their supply or production. The computation of the building materials is based on the volumetric dimensions of the wall (length, width, estimated height), while the estimation of the man-power required to supply or produce them is based on the basic units for building activities provided by Pegoretti's manual.

Firstly, we considered the building materials employed in parts of the foundation. As said above, the western side of the circuit wall utilized a particular foundation system, which consisted of alternating layers of gravel and sand to improve the soil's stability. A layer of gravel was laid also under part of the eastern side of the wall. Totally, we can calculate that at least 315 m^3 of gravel and 157 m^3 of sand were employed in the foundations.[771] Considering that one man can dig 1 m^3 of gravel or sand in about 0.90 h, and that the shovelling of these materials requires respectively 0.75 h/m^3 and 1 h/m^3, [772] we calculate that these operations took about 520 man-hours (= 65 man-days) for the gravel, and 298 man-hours (= 37 man-days) for the sand. Both gravel and sand could be extracted from the nearby Natissa river (see Figure 14.3) and then brought to the construction site by means of carts. By using a two-wheeled cart pulled by two donkeys, each round trip from the river to the construction site took less than 10 minutes, considering that the distance was on average 350 m. So, just the transportation required in total about 70 man-hours (= nine man-days) for the gravel, and 30 hours (= four man-days) for the sand.[773] Subsequently, we can calculate that for the supply of these materials about 903 hours of work were necessary for the gravel, and 484 hours for the sand.

771 We calculated that the multi-layered foundation system of the western side of the walls extended for 300 m with a width of 3.5 m and consisted of one layer of gravel with a thickness of 0.15 m and of one layer of sand with a thickness of 0.15 m (300 × 3.5 × 0.15 m). In total this gives 157.5 m^3 of gravel and 157.5 m^3 of sand. In addition, we estimate that at least another 157.5 m^3 of gravel were employed on the eastern side of the walls, where this foundation system extended approximately for about 300 m.

772 These figures are given by Pegoretti (for the gravel: Pegoretti 1863, I, analisi 19; for the sand: Pegoretti 1863, I, analisi 25).

773 Pegoretti states that a cart of this kind can transport a cargo of about 1,500 kg (Pegoretti 1863, 6-10). Considering that the gravel weighs 2,000 kg/m^3 and the sand 1,700 kg/m^3, the transport of the materials from the Natissa river to the construction site of the walls required respectively 420 trips for the gravel (315 m^3 × 2,000 kg/m^3 = 630,000 kg/1,500 kg/trip = 420 trips) and 178 trips for the sand (157.5 m^3 × 1,700 kg/m^3 = 267,750 kg/1,500 kg/trip = 178.5 trips). Since a cart of this kind on flat ground can cover a distance of 3.6 km/h with cargo and of 5.5 km/h without cargo, we can assume that each round-trip required less than ten minutes. That means 68 hours for the transport of the gravel (9.7 min/trip × 420 trips = 4,074 min = 68 hours), and 28 hours for the transport of the sand (9.7 min/trip × 178 trips = 1,727 min = 28 hours).

With regard to the stone blocks on the western side of the circuit, we can calculate that at least 810 m^3 of Istrian stone were employed.[774] Given that three workers (one skilled and two unskilled) need about 33.3 hours of work to quarry 1 m^3 of hard limestone,[775] the extraction activity required in total 80,919 man-hours of work (= 10,115 days). Another 221,130 hours (= 27,641 days) were necessary to saw and square the blocks.[776] Furthermore, the stone blocks had to be transported from the quarries to the city. In this case the stone was transported by sea from quarries located along the coast of the Istrian peninsula. Aquileia was located 11 km from the sea, and was connected to it by means of the Natissa river and the *canale Anfora*.[777] However, the quarries were actually quite far from the city, with about 120 km between the Istrian peninsula and Aquileia. It is likely that the stone extracted in the Istrian quarries was transported along the coast by means of boats that then travelled up the Natissa river to reach the city's harbour. Considering that the total distance from the quarry to the site was about 120 km by sea and 11 km by river, we can assume that the round-trip of a ship sailing from the Istrian quarries to Aquileia took about 48 hours.[778] Subsequently, to transport the 810 m^3 of stone from the Istrian peninsula to Aquileia one ship needed to make 45 trips carrying a cargo of 50 tonnes each time. This can be converted into about 2,160 hours of work, or 270 days.[779] Considering all steps of the process, the entire production cycle of the blocks of Istrian stone (extraction, roughing-out, and transport), required about 304,209 hours of work, which means about 38,026 man-days.

Much less man-power was necessary to produce the sandstone blocks employed at the base of the northern gate, the volume of which can be calculated as 729 m^3. [780] Given that the quarrying of 1 m^3 of sandstone required 25 hours of work by three men

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774 The foundations made of stone blocks on the western side of the walls extended for 300 m with a height of about 1 m and were composed by two courses of different width, as can be seen in the photographs taken during the 20th century excavation. Considering that the lower course is wider than the upper course, and that the latter seems to have the same width as the upper part of the wall, we can assume that the lower course had a thickness of 3 m and the upper one of 2.4 m (lower course: 300 m × 3 m × 0.5 m = 450 m^3; upper course: 300 m × 2.4 m × 0.5 m = 360 m^3).

775 Pegoretti 1863, 78, analisi 5. This figure was obtained as follows: 810 m^3/worker × 33.3 h × 3 workers = 80,919 hours.

776 According to Pegoretti, the sawing of 1 m^3 of a hard limestone requires about 8.5 man-hours of work by two workers, while the squaring takes 9 h/m^2 (Pegoretti 1863, 297-298, tab. 9.1, 9.6). Considering blocks of (0.80 × 0.50 × 0.50) m, the surface to be squared of each block was 2.1 m^2. Given that in the foundations of the wall about 4,050 blocks were employed (810 m^3/0.2 m^3/block = 4,050 blocks) 221,130 man-hours of work were needed to square this number of blocks, (4,050 blocks × 2.1 m^2 × 8.5 h × 2 workers + 4,050 blocks × 2.1 m^2 × 9 h). The extraction and the manufacture of the blocks also provided the stone chips employed at the base of the wall, on its western side.

777 Strabo wrote that the distance between Aquileia and the Adriatic Sea was of sixty stadia, that corresponds to about 11 km (Str. 5.1.8).

778 An ancient vessel can cruise at a speed of 4.8 km/h when laden, or at 6 km/h when unladen: Pegoretti 1863, 15-16, which means that the outward journey from the quarries to Aquileia took 27 hours (25 hours by sea and two hours by river), while the return trip took about 21 hours (20 hours by sea and one hour by river).

779 The specific weight of Istrian stone is 2,757 kg/m^3, so the 810 m^3 of stone employed on the western side of the circuit weighed 2,233,170 kg = 2,233 tonnes. Considering that each ship could carry 50 tonnes, we obtain a figure of 45 trips for 1 ship.

780 The northern gate has a square plan with a side of 27 m. We assumed the presence of two courses of sandstone blocks, with a total height of 1 m: 27m × 27m × 1m = 729 m^3.

(one skilled and two unskilled), the extraction of all the required sandstone took about 54,675 hours (= 6,834 days).[781] The sawing and the squaring activities necessitated 111,660 hours of work (= 13,957 days).[782] Much less time was needed to transport the stone blocks from the quarries to Aquileia. The sandstone quarries were located along the coast, near Trieste, at a distance of about 50 km, and like for the limestone, it was transported by sea. After travelling 45 km along the coast, the ships went up the Natissa river for 11 km and reached the harbour of Aquileia.[783] Following Pegoretti's figures, a round-trip from the sandstone quarries to Aquileia required about 21 hours.[784] So, presuming the use of a ship carrying 50 tonnes, at least 32 trips and 672 hours were necessary (= 84 days) to carry the stone blocks.[785] Subsequently, we can calculate that the extraction, manufacture, and transport of the sandstone blocks required a total of 170,164 hours, which means about 21,270 man-days of work.

We now consider the fired bricks which constitute the predominant building material of the republican walls of Aquileia, both in the foundations and in its upper part. To evaluate the number of bricks employed in the structure we first estimated the volume of the wall: the circuit was 3,000 m long, the foundations were on average 3 m wide and at least 0.6 m deep, while the upper part of the wall had a width of 2.4 m and a height of about 6 m. Given that the volume obtained (55,400 m^3) [786] in fact represents the sum of the volume occupied by the fired bricks and the volume of the lime mortar, we then calculated the ratio between one fired brick and the mortar surrounding it. Given that the mortar joints had a thickness of 1 cm, we established that the fired bricks occupied approximately the 85% of the total volume.[787] In this way, it was possible to estimate that there were about 46,786 m^3 of fired bricks in the wall, which means 1,333,053 fired bricks of 50 × 42 × 8 to 9 cm, and 2,316,473 bricks

781 Pegoretti 1863, 78, analisi 5. This figure was obtained as follows: 729 m^3 × 25 h × 3 workers = 54,675 hours.

782 According to Pegoretti, the sawing of 1 m^3 of sandstone requires about 5.5 man-hours of work by two workers, while the squaring takes 4 h/m^2 (Pegoretti 1863, 313-314, tab. 11.1 e 11.6). Considering blocks of (0.80 × 0.50 × 0.50) m, the surface to be roughed out on each block was 2.1 m^2. Given that in the foundations of the northern gate about 3,645 blocks were employed (729 m^3 / 0.2 m^3/block = 3,645 blocks), 111,660 man-hours of work were needed to rough out this number of blocks, (3,645 blocks × 2.1 m^2 × 5.5 h × 2 workers + 3,645 blocks × 2.1 m^2 × 4 h).

783 The exact location of the sandstone quarries has not been yet determined, but we assume that they were on the outskirts of Muggia, where sandstone was quarried until the last century.

784 An ancient vessel can cruise at a speed of 4.8 km/h when laden, or at 6 km/h when unladen (Pegoretti 1863, 15-16). This means that the outward journey from the quarries to Aquileia took 11 hours (nine hours by sea and two hours by river), while the return trip took about nine hours (eight hours by sea and one hour by river).

785 The specific weight of sandstone is 2,222 kg/m^3, meaning that the 729 m^3 of stone employed in the northern gate weighed a total of 1,619,838 kg = 1,620 tonnes. Considering that a ship could carry 50 tonnes, we obtain a figure of 32 trips with one ship.

786 Foundations: (3,000 × 3 × 0.6) m = 5,400 m^3. Upper part of the wall: 3,000 m × 2.4 m × 6 m = 43,200 m^3 + 15% of 43,200 m^3 (considering the fired bricks employed in gates and tower) = 50,000 m^3.

787 Firstly, we calculated the volume of each type of brick: type 1 = 50 cm × 42 cm × 8.5 cm = 17,850 cm^3; type 2 = 37 cm × 37 cm × 7.25 cm = 9,925 cm^3. Then we calculated the volume of a fired brick plus the mortar surrounding it, considering that on each side of the brick there was a layer of mortar 0.5 cm thick: type 1 = 51 cm × 43 cm × 9.5 cm = 20,833,5 cm^3; type 2 = 38 cm × 38 cm × 8.25 cm = 11,913 cm^3. Subsequently, we calculated the proportion between the fired brick and the mortar surrounding it: type 1 = 17,850 / 20,833,5 = 0.86 → type 1 = 86% fired brick (and 13% mortar); type 2 = 9,925 / 11,913 = 0.83 → type 2 = 83% fired brick (and 17% mortar).

measuring 36 to 37 × 36 to 37 × 7.5 cm. This calculation assumes that in the structure, half of the fired bricks were of the first type, and half of the second type.[788] Therefore, taking into account both the foundations and the upper part of the wall, we can calculate that a total of about 3,649,526 fired bricks were needed to build the wall. To produce this amount of fired bricks, a great quantity of clay was required, but this was not a problem because clay is abundant in the subsoil of Aquileia plain. However, the number of fired bricks employed in the wall is remarkable, especially considering that fired bricks were a novel building material, and were never used in this area before the foundation of Aquileia. Consequently, specific kilns had to be made to produce them.

With the data provided by the 19th century building manuals, and the available information about brick production in Roman times, we can now try to calculate the man-power required for the production of such a quantity of fired bricks. The production cycle of fired bricks consisted of different steps. Firstly, the clay had to be quarried, an operation which normally took place in the period between the end of summer and winter.[789] Considering the overall volume of the bricks employed, we can postulate that about 66,837 m^3 of clay were needed to make them. Given that a man can dig 1 m^3 of clay in 1.5 h, and that to shovel it he needs 0.75 h/m^3, this operation required about 18,797 man-days for all the bricks.[790]

The second step was the moulding of the bricks. Pegoretti provides a table of values for making bricks of different sizes, some of which are similar to those employed in the walls of Aquileia. In particular, he suggests that a brickmaker helped by an assistant can produce 330 squared bricks with a length of 0.35 m within 10 hours, or 200 squared bricks with side of 0.45 m, or 167 squared bricks with side of 0.50 m.[791] Following these figures, we assumed that within 10 hours a man could have moulded about 300 type 1 bricks or 180 type 2 bricks. So, the moulding of the bricks, which was usually carried out during spring and summer,[792] required 37,818 man-days of work.[793] Next, the bricks had to dry, and then to be fired. With regard to the firing process, we lack data concerning what kind of kiln was used in this area in the Republican age. However, we assumed that in order to produce the fired bricks employed in the defensive walls of Aquileia, kilns with a firing capacity of 65 m^3 of bricks were used, analogous to the analysis made by DeLaine for the Baths of Caracalla.[794] Considering the volume of a single brick, a kiln of this type could contain about 3,641 bricks of type 1 or 6,549 bricks of type 2 at a time. Pegoretti states that the loading of 1,000 large squared bricks takes 1.5 hours of work of a team

788 To obtain the number of the bricks we divided the total volume of the fired bricks in half, and then each half by the volume of a single fired brick.

789 DeLaine 1997, 114. After the quarrying, the clay was left to weather until the following spring since during the winter the frost and rain broke down the clay.

790 Pegoretti 1863, 93-94, analisi 18. This figure was obtained in this way: 66,357 m^3 × (1.5 + 0.75) h = 150,383 hours = 18,797 man-days.

791 Pegoretti 1863, 186.

792 DeLaine 1997, 114.

793 Fired bricks of type 1: 1,333,053 × 10 / 180 = 74,058 hours = 9,257 man-days. Fired bricks of type 2: 2,316,473 × 10 / 300 = 77,216 hours = 9,652 man-days. Total time = 9,257 + 9,652 =18,909 man-days. Considering that this activity was carried out by two workers, we obtained a figure of 37,818 man-days.

794 DeLaine 1997, 114-121.

made by two skilled workers, four assistants and five to six workers.[795] So, the loading of the kiln required 65 hours of work for type 1 bricks and 118 hours for type 2 bricks.[796] Considering the time for firing and cooling, we assumed that each firing cycle took on average 100 hours, according to the values calculated by DeLaine.[797] This figure does not differ significantly from the values provided by Pegoretti.[798] Then, the unloading of the kiln required respectively 26 hours for a load of type 1 bricks and 47 hours for a load of type 2 bricks.[799]

Thus, each firing cycle (loading of the kiln, firing, unloading of the kiln) needed 191 hours for a load of bricks of type 1 (= 3,641 bricks),[800] or 265 hours for a load of bricks of type 2 (= 6,549 bricks).[801] This results in a total of 20,464 man-days of work to cook all the bricks employed in the walls, and of 720 firing cycles.[802] In total, the entire production process (*i.e.* digging of the clay, moulding of the bricks, firing time) of the fired bricks of the Republican walls of Aquileia required about 77,079 man-days. The time needed to transport the bricks from the kilns to the construction site should be added to this total, but this figure cannot be estimated because the location of the kilns remains unknown at present. Still, the transport time was probably not significant, because it is likely that the kilns were built in the immediate surroundings of the city, along the perimeter of the rising circuit.

Finally, another element must be considered in the evaluation of the production process of the fired bricks, that of the fuel necessary for the kilns. Considering the consumption of about 23.4 tonnes of fuel for each firing cycle,[803] the total amount of fuel required by the kilns can be calculated at approximately 16,848 tonnes of wood. In the absence of data about the type of fuel used in Aquileia, we cannot calculate the time needed for its acquisition. Nevertheless, the fuel's location probably did not greatly impact the production of the bricks because the territory around the city in the

795 Pegoretti 1863, 186.

796 Fired bricks of type 1: 1.5 h / 1,000 bricks = 0.0015 h/bricks × 3,641 bricks = 5.46 hours → type 1 = 5.46 h × 12 workers = 65 h. Fired bricks of type 2: 1.5 h /1,000 bricks = 0.0015 h/bricks × 6,549 bricks → type 2 = 9.82 h × 12 workers = 118 h.

797 DeLaine 1997, 118, table 9.

798 Pegoretti assumes that the firing required eight man-days of work by two men taking turns: Pegoretti 1863, 186.

799 This figure derives from the ratio between the time needed for loading and unloading a kiln filled with *sesquipedales* in the analysis proposed by DeLaine 1997, 118, table 9. She assumed that the loading time was about 15 man-days, and the unloading time six man-days. So, considering that the loading time for a load of 3,641 type 1 fired bricks is 65 hours, we can calculate that to unload that number of bricks 26 hours were needed. Likewise, given that to load 6,549 type 2 fired bricks about 118 hours were needed, we can calculate that the unloading required 47 hours.

800 This figure was obtained as follows: 65 h (loading time) + 100 h (firing time) + 26 h (unloading time) = 191 hours.

801 This figure was obtained as follows: 118 h (loading time) + 100 h (firing time) + 47 h (unloading time) = 265 hours.

802 Considering the total number of bricks employed in the walls (1,333,053 of type 1 and 2,316,473 of type 2) and the number of bricks that a kiln could contain (3,641 for type 1 or 6,549 for type 2) we obtained: type 1 bricks = 1,333,053 / 3,641 = 366 firing cycles × 191 hours = 69,906 hours = 8,738 man-days; type 2 bricks = 2,316,473 / 6,549 = 354 firing cycles × 265 hours = 93,810 hours = 11,726 man-days.

803 This figure is provided by DeLaine, who assumes that a kiln with a capacity of 65 m^3 required 23.4 tonnes of wood: DeLaine 1997, 118, table 9.

Material	Action	Minimum number of workers	Man-power	Total quantity	Total man-power (man-days)
Gravel	Digging	1	0.90 h/mc	315 mc	35
	Shovelling	1	0.75 h/mc	315 mc	30
	Transport (by carts)	1	0.16 h/trip AR	420 trips	9
Sand (foundations and mortar)	Digging	1	0.90 h/mc	5,900 mc	688
	Shovelling	1	1 h/mc	5,900 mc	729
	Transport (by carts)	1	0.16 h/trip AR	6,457 trips	131
Istrian stone	Quarrying	1 + 2 assistants	33.3 h/mc	810 mc	10,115
	Manufacturing	3 + 2 assistants + 1 supervisor	8.5 h/mq (sawing) + 9 h/mq (squaring)	8,505 mq	27,641
	Transport (by ships)	?	27 h + 21 h	45 trips	270
Sandstone	Quarrying	1 + 2 assistants	25 h/mc	729 mc	6,834
	Manufacturing	3 + 2 assistants + 1 supervisor	5.5 h/mq (sawing) + 4 h/mq (squaring)	7,444 mq	13,957
	Transport (by ships)	?	12 h + 9 h	32 trips	84
Fired bricks	Clay quarrying	1	1.5 h/mc	66,837 mc	12,442
	Clay shovelling	1	0.75 h/mc	66,837 mc	6,221
	Moulding	1 + 1 assistant	1 h/18 bricks type 1 or 30 bricks type 2	3,649,526 bricks	37,818
	Loading kiln	2 + 4 + 6 assistants	65 h/1 cargo bricks type 1 or 118 h/1 cargo bricks type 2	366 cargos bricks type 1/354 cargos bricks type 2	8,195
	Firing	1 + 1 assistant	100 h/1 cargo	366 cargos bricks type 1/354 cargos bricks type 2	9,000
	Unloading kiln	2 + 4 + 6 assistants	26 h/1 cargo bricks type 1 or 47 h/1 cargo bricks type 2	366 cargos bricks type 1/354 cargos bricks type 2	3,269
	Transport (by carts)	1	?	?	?
Lime	Quarrying limestone	?	?	?	?
	Firing	1 + 1 assistant	4.07 days/mc	2,770 mc	11,274
	Transport (by carts)	1	?	?	?
Pozzolanic ash	Quarrying	?	?	?	?
	Transport (by ships)	?	?	?	?
Timber	Cutting	1	?	24,465 tonnes	?
	Transport (by carts)	1	?	?	
				TOTAL	**148,742**

Table 14.1: The building materials employed in the republican walls of Aquileia and the man-power required for their supply or production.

Roman period was occupied for the most part by an oak and hornbeam forest, which could easily provide great quantities of bush and heartwood.

To complete this series of processes, we should consider the lime mortar employed in the foundations and in the upper part of the wall, which can be calculated to 8,310 m^3.[804] In the Roman period mortar was made usually from one third of lime and two thirds of sand;[805] in order to produce the required amount of mortar about 2,770 m^3 of lime and 5,540 m^3 of sand were needed. The supplying of the sand was not a problem, because it could be taken from the nearby Natissa river. Given the basic units stated

804 This figure results from the above calculations, which figures the total volume of the walls to be 55,400 m^3, and the wall's composition to be 85% of bricks and 15% of mortar (see above).

805 This is the ratio given by Vitruvius (Vitr. 2,5,1) for mortar made with sand taken from the sea or from a river, as happened in Aquileia.

by Pegoretti for digging and shovelling 1 m^3 of sand (digging: 0.9 h/1 m^3; shovelling 1 h/1 m^3),[806] this operation took 10,526 man-hours of work. The average distance between the river and the construction site was about 350 m. Assuming the use of two-wheeled carts pulled by two donkeys, another 1,015 man-hours of work were necessary to transport the sand.[807]

Unfortunately, we have no information about the type of lime kilns used for the construction of the walls of Aquileia. This study assumes that lime kilns were used with a capacity of 100 m^3, and that they were able to produce 66 m^3 of lime from 66 m^3 of limestone. Additionally, by using the labour and fuel requirements for such a kiln provided by DeLaine,[808] the production of 1 m^3 of lime required 2.25 man-days by skilled workers and 1.82 man-days by unskilled workers. The production of the lime also required 2.75 tonnes of timber. Considering the total amount of lime employed in the mortar of the wall of Aquileia (2,770 m^3), we can calculate that its production required about 11,274 man-days of work and 7,617 tonnes of timber.[809] To this evaluation, the time needed for the transport of the lime from the kilns to the construction site should be added, but in the absence of data about the location of these production structures this operation is not possible.

Finally, the time required for the production of the concrete employed in the foundations should be added to these figures. However, since only a short stretch of the concrete blocks have been excavated near the south-eastern corner of the wall, the total volume and extent of these blocks are unknown. Thus, in this case it is also not possible to calculate construction costs.

When all factors are considered, the production and supply of the building materials employed in the walls of Aquileia required no less than 148,742 man-days of work (Table 14.1).

14.4 The construction process: man-power and logistics

Once these calculations were completed, we considered the workforce required for the construction process itself, by examining the logistics of the operations. As in the previous section, the time and workforce required by the different construction tasks were determined using the labour values contained in 19th century building manuals, and in particular Pegoretti's book.

To construct the wall, ancient builders first dug the foundation trenches. The foundations of the wall had a width of about 3 m and a minimum depth of 0.6 m, and the

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806 Pegoretti 1863, I, analisi 25.

807 As referred by Pegoretti 1863, 6-10, a cart of this kind can transport a cargo of about 1,500 kg. Considering that the sand weighs 1,700 kg/m^3, the transport of this material from the Natissa river to the construction site required 6,279 trips (5,540 m^3 × 1,700 kg/m^3 = 9,418,000 kg / 1,500 kg/trip = 6,279 trips). On flat ground a cart of this kind can cover a distance of 3.6 km/h with cargo, and of 5.5 km/h without cargo, we can assume that each round-trip required less than 10 minutes. In total, that means 1,015 hours for the transport of the sand (9.7 min/trip × 6,279 trips = 60,906 minutes = 1,015 hours).

808 DeLaine 1997, 111-114 and table 7.

809 These numbers were obtained as follows: 2,770 m^3 (lime employed in the walls) × (2.25 h (skilled workers) + 1.82 h (unskilled workers)) = 11,274 man-hours of work for the production of the lime; 2,770 m^3 (lime) × 2.75 t/m^3 (fuel) = 7,617 m^3.

total circuit was 3,000 m long. We calculated that a trench of the same length with a width of 5 m and a depth of 1 m had to be dug to accommodate the foundation blocks. So, at least 15,000 m^3 of earth had to be removed before the construction of the wall could start.[810] According to Pegoretti, a skilled worker needs 0.60 h to dig 1 m^3 of marshy soil, while another 0.80 h/m^3 of work are needed to throw the earth behind.[811] Therefore, these operations required in total 21,000 hours.[812] Then, the earth had to be taken away by means of carts. Considering the use of two-wheeled carts pulled by two donkeys, and assuming that the earth was taken at a distance of about 350 m, this action needed about 1,778 hours.[813] So, the execution of the foundation trenches required 22,778 hours in total, which means 2,847 man-days of work.

Then, alternating layers of gravel and sand were laid down in the foundation trenches of the western side of the wall to improve the soil's stability. Similarly, a level only with gravel was put in the foundation trench of the eastern side of the circuit. According to Pegoretti, a man needs 0.25 h to lay down 1 m^3 of gravel, and 0.15 h for 1 m^3 of sand,[814] so this operation took respectively 79 and 24 hours (= 10 and three days). Subsequently, both the gravel and the sand had to be tamped down. Since one skilled man helped by two labourers can tamp down 1 m^2 of soil in about 0.40 h,[815] we estimate that this activity required 1,200 hours (= 150 days) for the gravel, and 600 hours (= 75 days) for the sand.[816]

Once these operations were completed, the Istrian stone blocks were laid down in the foundation trench of the western side of the wall. According to the labour constants provided by Pegoretti, we can assume that at least five workers (three skilled and two unskilled) plus one supervisor were involved in this activity. So, 8.25 hours were needed to lay down 1 m^3 of stone blocks.[817] Since each block had a volume of 0.2 m^3, about five blocks could be laid down in one day of work. Given that the foundations

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810 This number was obtained as follows: 3,000 m (length of the trench) × 5 m (width of the trench) × 1 m (depth of the trench) = 15,000 m^3 of earth to be removed.

811 Pegoretti 1863, I, analisi 76.

812 This number was obtained as follows: 15,000 m^3 (volume of the earth to be removed) × (0.6 h/m^3 (digging) + 0.8 h/m^3 (throwing behind)) = 21,000 h.

813 As stated by Pegoretti 1863, 6-10, such a cart can transport a cargo of about 1,500 kg. Considering that marshy soil weighs 1,100 kg/m^3, 11,000 trips were needed with one cart to take away the earth (15,000 m^3 × 1,100 kg/m^3 = 16,500,000 kg / 1,500 kg/trip = 11,000 trips). Since such a cart can, on flat ground, cover a distance of 3.6 km/h with cargo and of 5.5 km/h without cargo, we can assume that each round-trip required less than 10 minutes: this means 1,778 hours (9.7 min/trip × 11,000 trips = 106,700 minutes = 1,778 hours).

814 For the gravel see Pegoretti 1863, I, analisi 40: 315 m^3 (quantity of gravel) × 0.25 h/m^3 = 78.75 h. For the sand see Pegoretti 1863, I, analisi 32: 157.5 m^3 (quantity of sand) × 0.15 h/m^3 = 23.6 h.

815 Pegoretti 1863, I, analisi 35.

816 These numbers were obtained as follows: for the gravel: [300 m (length of the gravel layers along the western side of the walls) + 300 m (length of the gravel layers along the eastern side of the wall)] × 5 m (width of the foundation trenches) × 0.4 h = 1,200 h; as regards the sand: 300 m (length of the sand foundation along the western side of the walls) × 5 m (width of the foundation trenches) × 0.4 h = 600 h.

817 Pegoretti 1863, II, analisi 158, provides the following formula to calculate the time needed to build a fortification wall made of squared stone blocks: t/2 + 0.015t (a-1) + t'/2g. Considering the size of the foundations of the Aquileia wall, which were 1 m high, 3 m wide and made of stone blocks weighing more than 80 tonnes, we obtained: 11 h / 2 + 0.015 × 11 h × (1 m -1) + 0.30 / 2 × 3 m = 5.5 h/m^3. The work of the supervisor can be considered to be half of this time, which means 2.75 h/m^3. We thus obtain a combined figure of 8.25 h/m^3.

Activity	Action	Number of workers	Man-power	Total quantity	Total man-power (man-days)
Digging the foundation trench	Digging trench < 1.6 m	1	0.60 h/mc	15,000 mc	1,125
	Throwing out earth	1	0.80 h/mc	15,000 mc	1,500
	Carrying earth over 350 m (by carts)	1	0.16 h/trip round trip	11,000 trips	1,778
Laying foundations (gravel)	Laying down gravel	1	0.25 h/mc	315 mc	10
	Tamping down gravel	1 + 2	0.4 h/1 mq	1,800 mq	150
Laying foundations (sand)	Laying down sand	1	0.15h/mc	157.5 mc	3
	Tamping down sand	1 + 2	0.4 h/1 mq	1,500 mq	75
Laying foundations (Istrian stone blocks)	Laying down Istrian stone blocks	3 + 2 + 1	8.25 h/mc	810 mc	835
Laying foundations (sandstone blocks)	Laying down sandstone blocks	3 + 2 + 1	5.5 h/mc	729 mc	752
Laying wall (bricks and mortar)	Slaking lime	1 + 1	1.10 h/mc + 0.40 h/mc	2,871 mc	538
	Mixing mortar	1 + 1	2.25 h/mc	8,614 mc	4,845
	Laying down bricks	1 + 2 + 1	0.87 or 1 h/100 bricks	3,649,526 bricks	9,707
				TOTAL	**21,318**

Table 14.2: The man-power required for the different phases of the construction process of the republican walls of Aquileia.

made of Istrian stone had a volume of 810 m^3, we calculated that a total of 6,682 hours (= 835 days) were needed for laying down this part of the wall.

Hypothetically, the sandstone blocks of the foundations of the northern gate were laid down at the same time. By applying the same labour constants used for the Istrian stone blocks and considering the size of this structure (27 × 27 × 1 m), we calculated that another 6,014 hours (= 752 days) were necessary to lay down the 729 m^3 of sandstone blocks employed in the northern gate.[818]

We then considered the time needed for the construction of the other parts of the wall made of fired bricks. This involved calculating both the time needed to slake and to mix the mortar, and the time to lay down the bricks. Regarding the mortar, a worker needs on average 1.1 h to slake 1 m^3 of lime and 0.4 h to provide 1 m^3 of water. Therefore, we calculated a total of 4,306 hours of work was required by two men to slake the lime.[819] Given that the mixing of 1 m^3 of mortar requires 4.5 hours of work by two men (one mixing and one watering), we calculated that this operation took another 38,763 hours.[820] So, the preparation of the mortar needed in total about 43,069 hours, equivalent to 5,383 man-days of work.

818 Considering the size of the foundations of this gate, which were 1 m high, 3 m wide, and made of stone blocks weighing more than 80 tonnes, we obtained: 11 h / 2 + 0.015 × 11 h × (1 m -1) + 0.10 / 2 × 27 m = 5.5 h/m^3. The work of the supervisor can be considered to be half of this time, that means 2.75 h/m^3. In this way, we obtained a combined figure of 8.25 h/m^3.

819 Pegoretti 1863, II, analisi 162. These figures were obtained in this way: for the slaking of the lime: 2,871 m^3 (lime) × 1.10 h = 3,158 hours; for the supplying of the water: 2,871 m^3 × 0.4 h =1,148 hours → 3,158 + 1,148 = 4,306 hours.

820 Pegoretti 1863, II, analisi 162. These figures were obtained in this way: 8,614 m^3 (mortar) × 4.5 h = 38,763 hours.

Applying Pegoretti's formula to calculate the time needed to build the defensive wall made of fired bricks, we assumed that a team composed of one bricklayer, two unskilled workers and one supervisor could lay down 100 bricks in about two hours.[821] So, given the total amount of bricks employed in the walls of Aquileia, we calculated that their laying down required a total of 77,660 hours of work (=9,707 man-days). All factors taken into account, the construction of the defensive wall of Aquileia requested approximately 21,318 man-days of work (Table 14.2).

14.5 The construction process of the Republican walls of Aquileia: workforce and timing

The figures produced by this quantitative analysis are useful when examining the labour effort required at the different stages of the construction process of the walls of Aquileia. Interesting results emerge when comparing the man-power needed to get the building materials and the man-power necessary for the construction process itself. Firstly, the activities connected with the supplying and production of the materials took much more effort than the actual construction process. The provision of the materials took approximately 149,000 man-days, while the construction process took just 21,000 man-days, which means a ratio of 7:1. Furthermore, if we add up the time needed for the supply and production of building materials (about 149,000 man-days) together with the time needed for the building activities (21,000 man-days of work), we obtain an amount of 170,000 man-days of work to realize the walls. Several factors could increase the actual labour costs, and due to a lack of data we could not calculate the time needed to: build the kilns, to produce the concrete of the foundations of the south-eastern corner, or to supply the timber used in the kilns.

To use this estimation to evaluate the actual time needed to erect the walls of Aquileia we have to consider the number of people involved in the construction process. We lack information regarding the quantity of workers employed in the building process, both from literary sources, and if we consider the space available on the construction site. Thus, we can only make an approximate estimation of the number of people involved, which might conceivably be minimally 100 people, but could be much higher. We propose a minimum estimation of 100 workers involved, and consider the scheduling of the different activities together with their operational relationships. As a result, we can calculate a hypothetical timeline of the construction process of the republican walls of Aquileia.

821 Pegoretti 1863, II, analisi 162. The formula provided by Pegoretti is: t + 0.03 × t (a – 1) + t' / g, with t = 0.75 h/100 bricks, t' = 0.40 for a two-faced wall, a = height of the wall and g = width of the wall. Considering the size of the wall of Aquileia, we calculated that laying the bricks of the foundations required: 0.75 + 0.03 × 0.75 × (0.6 – 1) + 0.4 / 3 = 0.87 h of work for a brickmaker. If he was helped by two unskilled workers and one supervisor, whose work was respectively 1/2 and 1/10 of that of the bricklayer, we obtain that the laying down of 100 bricks required in total 1.83 h of work. Given the number of bricks employed in the foundations: (128,571 bricks type 1 + 225,793 bricks type 2) × 1.83 / 100 = 6,485 hours. The same calculation was made for the upper part of the wall: 0.75 + 0.03 × 0.75 × (6 – 1) + 0.4 / 2.4 = 1.03 h of work of a brickmaker. If he was helped by 2 unskilled workers and 1 supervisor, we calculate that the laying down of 100 bricks required in total 2.16 h of work. Given the number of bricks employed in the foundations: (1,204,482 bricks type 1 + 2,090,680 bricks type 2) × 2.16 / 100 = 71,175 hours.

Aquileia republican walls														
Months	Man/days	2	4	6	8	10	12	14	16	18	20	22	24	26
MATERIAL PRODUCTION/WORKERS														
Quarrying of Istria stone	10,000	60	20	20	25	25	25	25						
Manufacturing of Istria stone	27,000		40	40	55	55	55	55	55	60	60	65		
Transport of Istria stone	300								5			5		
Quarrying of sandstone	6,800	50	50	40										
Manufacturing of sandstone	14,000		25	30	30	30	30	30	30	30	30	15		
Transport of sandstone	100								5			5		
Digging and transport of gravel and sand	1,500				10	5	5	5	5					
Bricks production	77,000	150	140	140	140	135	140	140	140	140	140	135		
Lime production	11,000		15	15	20	20	20	20	20	20	25	25	25	
CONSTRUCTION/WORKERS														
Digging foundation trenches	4,800		10	10	10	10	10	10	10	10	10	10		
Laying of gravel and sand	250								5					
Laying of stone blocks	1,600								5	10	10	10		
Mixing lime	5,400					5	5	5	5	10	10	10	30	30
Construction of the bricks wall	9,700					10	10	10	10	20	20	20	50	50
Workers		260	300	295	290	295	300	300	295	300	305	300	105	80
Man/days	**169,450**													

Table 14.3: The scheduling of the construction process of the walls of Aquileia.

If the same team of workers carried out all the different activities required for the building needs, we calculated that a team of 100 men could have completed the construction of the walls of Aquileia in nine years. But if 300 men were involved, the erection of the structure would then require about three years (Table 14.3). Theoretically, with a higher number of men the construction time would also be reduced, but the estimation of 300 or 400 men working for three to two years seems the most plausible. Indeed, if even more workers were employed in the construction process, then the building activity would have required less than two years. An important constraint in these calculations comes from the production of the fired bricks, which could not have been completed in a shorter period, considering the time to build the kilns, to find the fuel, to dry and to fire such a high number of bricks. Therefore, it is clear that if the procurement of the materials was not completed, the construction of the wall could be started, but not finished.

14.6 Conclusions

The quantitative analysis presented here is strictly hypothetical and requires further work to more precisely define the numerous variables. Considering these methodological constraints, much of our analysis is based on real quantities, materials, and processes. Such a methodological approach has been a useful tool to produce a realistic estimate of the required costs and time frames of the building process.

The figures obtained are coherent with the known historical context in which the construction took place. Indeed, the colony of Aquileia was founded as a military outpost in a territory inhabited by hostile populations. Consequently, soon after the foundation of the colony it became necessary to erect a defensive wall as quickly as possible. So, the estimate of two to three years of work to build it seems really plausible.

Our evaluation also seems likely when compared with the figures obtained by another analyses regarding the construction of the Republican walls of Rome.[822] These differ from the walls of Aquileia as they are made of stone, while those of Aquileia are mainly made of fired bricks. For the Republican walls of Rome, the construction of the defensive circuit (11 km long, 9-10 m high and made entirely of squared blocks of Grotta Oscura yellow tuff) required about 2,310,000 man-days of work. This figure does not include the time required to extract the stone.[823] If Rome's wall had been the same length (3 km) and height (6 m) of that of Aquileia, about 420,000 man-days of work would have been necessary, not considering the time for the extraction of the stone. This amount is almost two and a half times the workforce we have calculated for the construction of the walls of Aquileia. This is not surprising given the different building materials and techniques employed in Rome's walls. The production cycle of the stone, and the time needed to transport the blocks from the quarries to the construction site, required much more time than the production cycle of fired bricks. The laying of the stone blocks also requires more time than the laying of bricks.

Finally, how can we interpret the data obtained within the historical context in which the construction of the walls of Aquileia took place? As said, we do not have precise chronological data about the construction of the wall. However, the majority of scholars believe that the construction process was completed in the first half of the second century B.C.E.[824] Assuming that our calculations are realistic, and that the construction of the wall was completed in about two to three years, we can try to determine when construction began. In this respect, a first clue is given by the use of Istrian stone blocks in the foundations of the western side of the wall. The presence of this material gives a likely *terminus post quem* of 177 B.C.E. for the construction of at least this side of the wall; Istrian stone blocks could be imported only after the defeat of the Istrian people, which occurred in 177 B.C.E. But it is highly unlikely that the construction of the wall took place directly after that date. Indeed, Livy states that in 171 B.C.E. Aquileia asked the Roman Senate to send a *supplementum* of settlers because the colony was *infirmam necdum satis munitam*,[825] which means that the colony was still without a defensive wall in 171 B.C.E. Thus, we can assume that the construction of the circuit started only after the arrival of the new settlers (and maybe new workers?) in 169 B.C.E., and was then completed in just a few years.

822 Volpe 2014.
823 Volpe 2014, 63-65.
824 Bonetto 2004, 167-170.
825 'weak and not protected' enough (Liv. XL, 53, 5-6).

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CONSTRUCTING MONUMENTS, PERCEIVING MONUMENTALITY & THE ECONOMICS OF BUILDING

In many societies monuments are associated with dynamic socio-economic and political processes that these societies underwent and/or instrumentalised. Due to the often large human and other resources input involved in their construction and maintenance, such constructions form an useful research target in order to investigate both their associated societies as well as the underlying processes that generated differential construction levels. Monumental constructions may physically remain the same for some time but certainly not forever. The actual meaning, too, that people associate with these may change regularly due to changing contexts in which people perceived, assessed, and interacted with such constructions.

These changes of meaning may occur diachronically, geographically but also socially. Realising that such shifts may occur forces us to rethink the meaning and the roles that past technologies may play in constructing, consuming and perceiving something monumental. In fact, it is through investigating the processes, the practices of building and crafting, and selecting the specific locales in which these activities took place, that we can argue convincingly that meaning may already become formulated while the form itself is still being created. As such, meaning-making and -giving may also influence the shaping of the monument in each of its facets: spatially, materially, technologically, socially and diachronically.

The volume varies widely in regional and chronological focus and forms a useful manual to studying both the acts of building and the constructions themselves across cultural contexts. A range of theoretical and practical methods are discussed, and papers illustrate that these are applicable to both small or large architectural expressions, making it useful for scholars investigating urban, architectural, landscape and human resources in archaeological and historical contexts. The ultimate goal of this book is to place architectural studies, in which people's interactions with each other and material resources are key, at the crossing of both landscape studies and material culture studies, where it belongs.

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