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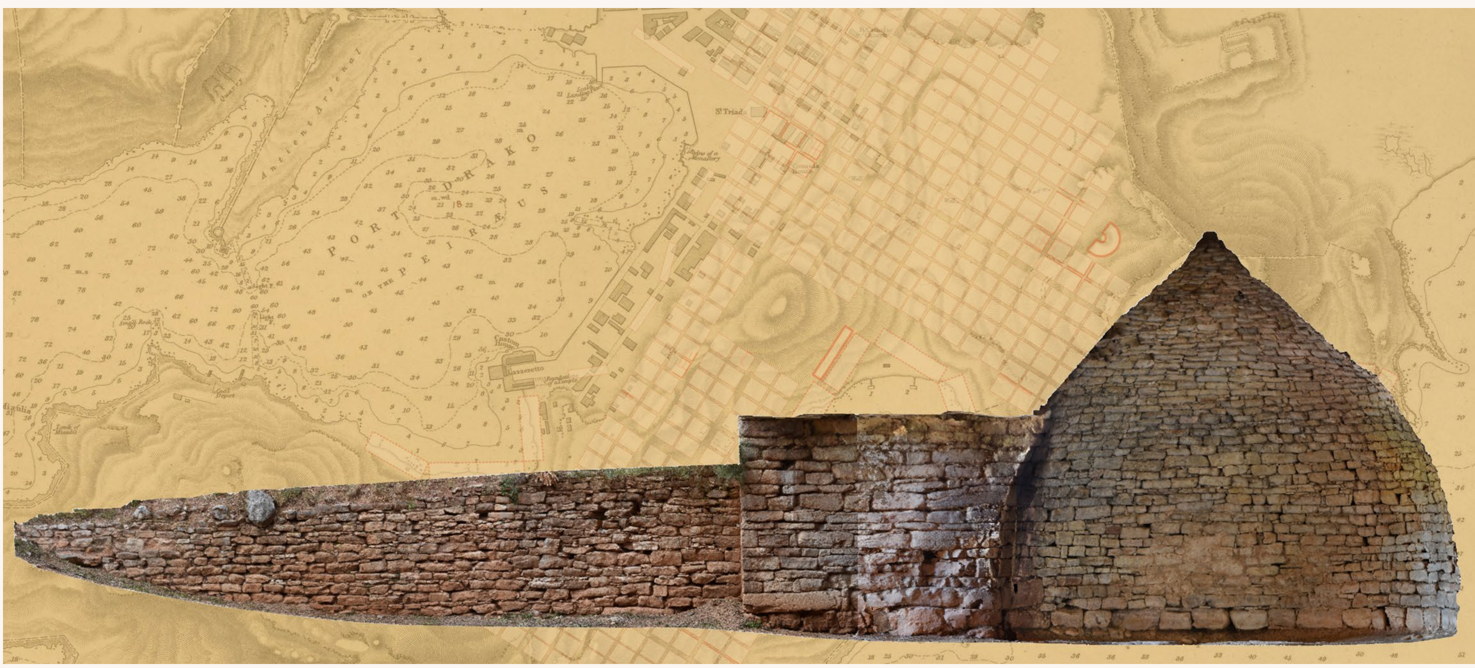

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Building BIG – Constructing Economies: from Design to Long-Term Impact of Large-Scale Building Projects

Panel 3.6

Jari Pakkanen
Ann Brysbaert (Eds.)

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Proceedings of the

19th International Congress of Classical Archaeology

Volume 10: Building BIG – Constructing Economies

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Edited by

Martin Bentz and Michael Heinzelmann

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Cover illustration: Section of the Late Bronze Age tholos tomb at Tiryns superimposed on the reconstruction of the fourth-century BCE city grid of the Piraeus (Jari Pakkanen and Ann Brysbaert).

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PREFACE

On behalf of the 'Associazione Internazionale di Archeologia Classica (AIAC)' the 19th International Congress for Classical Archaeology took place in Cologne and Bonn from 22 to 26 May 2018. It was jointly organized by the two Archaeological Institutes of the Universities of Cologne and Bonn, and the primary theme of the congress was 'Archaeology and Economy in the Ancient World'. In fact, economic aspects permeate all areas of public and private life in ancient societies, whether in urban development, religion, art, housing, or in death.

Research on ancient economies has long played a significant role in ancient history. Increasingly in the last decades, awareness has grown in archaeology that the material culture of ancient societies offers excellent opportunities for studying the structure, performance, and dynamics of ancient economic systems and economic processes. Therefore, the main objective of this congress was to understand economy as a central element of classical societies and to analyze its interaction with ecological, political, social, religious, and cultural factors. The theme of the congress was addressed to all disciplines that deal with the Greco-Roman civilization and their neighbouring cultures from the Aegean Bronze Age to the end of Late Antiquity.

The participation of more than 1.200 scholars from more than 40 countries demonstrates the great response to the topic of the congress. Altogether, more than 900 papers in 128 panels were presented, as were more than 110 posters. The publication of the congress is in two stages: larger panels are initially presented as independent volumes, such as this publication. Finally, at the end of the editing process, all contributions will be published in a joint conference volume.

We would like to take this opportunity to thank all participants and helpers of the congress who made it such a great success. Its realization would not have been possible without the generous support of many institutions, whom we would like to thank once again: the Universities of Bonn and Cologne, the Archaeological Society of Cologne, the Archaeology Foundation of Cologne, the Gerda Henkel Foundation, the Fritz Thyssen Foundation, the Sal. Oppenheim Foundation, the German Research Foundation (DFG), the German Academic Exchange Service (DAAD), the Romano-Germanic Museum Cologne and the LVR-LandesMuseum Bonn. Finally, our thanks go to all colleagues and panel organizers who were involved in the editing and printing process.

Bonn/Cologne, in August 2019

Martin Bentz & Michael Heinzelmann

Building BIG – Constructing Economies: from Design to Long-Term Impact of Large-Scale Building Projects An Introduction

Ann Brysbaert – Jari Pakkanen

The economic growth of modern societies has been closely linked with construction industries: investments, transport infrastructures for materials and labour-intensive building programmes all have a large impact on local, regional and even global economies. The results have shaped the built environment of our every-day lives and have often led to an increased quality of life and affluence, though there are many contrary cases as well. In past pre-industrial societies whenever large-scale building projects took place, extensive manual labour was invested from the moment materials were scouted for, extracted, transported, employed and subsequently maintained. Since most ancient societies were based on subsistence economies, important decision-making was a daily balancing act between building work and agriculture. These decisions often influenced strongly the patterns of land use and may have resulted in circular economic strategies.

We left, on purpose, the concepts 'monumental' and 'monumentality' out of the title of this session since this has been recently discussed in several papers and books.[1] We wished to direct the focus towards the socio-economic and political structures and decision-making that may have resulted in 'Building Big', irrespective of the shape and final size of the projects. Building Big can also relate to constructing several smaller units, such as housing blocks, port installations,[2] qanat and irrigation systems,[3] and transport and road networks.[4] Any form of large-scale building required matching levels of material resources to be brought over (stones, timber, clay) or moved out (bedrock, earth), and human and animal resources such as quarrymen, foresters, gatherers, movers, builders and transporters. Depending on the socio-political structures of given societies, the human resources could have been treated as normal workers, carrying out an acceptable workload per day, commensurate with their capability. In other situations, we know of exploitation of people because of their status as slaves or prisoners, and thus dispensable as commodities by the elites for whom such structures were built. In such specific cases, in which the monuments on which the human and other energy was expended, often risking lives, there is no doubt that the completed structure exuded power that would have rippled through the entire society. Santillo-Frizell has demonstrated with examples from the Mycenaean sphere and comparative data from modern historical Swedish contexts that building large-scale and long-term was a public act and even a ritual performance to demonstrate where the power sat and over whom it was exercised.[5]

In Greek and Roman Archaeology, research on quantification of materials, labour and transport in construction has been carried out for a long time before its recent rebranding as 'architectural energetics'.[6] For example, Stanier published in 1953 an

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account on the cost of quarrying, transport and construction of the Parthenon. His costs and labour constants are largely based on the preserved building accounts of the temple of Asklepios at Epidauros, but he uses also comparative data on working limestone and marble. He arrives at a total cost of 469 talents for the project,[7] and since the day-wage at Athens is known, this 'price tag' can be translated into ca. 2.8 million man-day labour equivalents and compared with more recent studies.[8] It is very likely that using the epigraphical evidence from Epidauros exaggerates the cost of stone compared to an Athenian context of monumental construction,[9] but Stanier's paper remains a highly valuable early contribution to econometric studies. The question of the cost of building stone is an important one, but studies using it as a proxy for the total costs do not necessarily arrive at well-argued conclusions.[10]

A discussion on econometrics, labour cost studies or architectural energetics is in place here, especially in the context of this conference. The approach has gained some opponents, and correctly so. Most methods need time to mature and adapt to new cases, and along the way they are also refined. Mistakes have been made and will be also in the future. Over the past 20 years it has become clear that care needs to be taken which rates are used and for what purpose. However, carrying out a full review of econometric studies is beyond the scope of this paper, so we will in the following concentrate on the Greek Bronze Age and briefly assess the current state of research.

In past studies, there are cases in which analyses and interpretations are built on a single labour rate and it is quite obvious that this might be problematic. However, most scholars have been working with comparisons of several published rates and arguing for those that, in their contexts, can be regarded as the best-suited ones. These studies carefully explain how their chosen work rates were obtained. A very good example of detailed work is the late Minoan study of eight sites on Crete carried out by Devolder.[11] While not everyone would agree with the eight-hour workday or a fixed building period per structure to determine the workforce that she employed, she did use figures extracted from both the new and old world literature on the topic and covered the materials employed at the different sites, both palatial and non-palatial architecture. She also allowed for partial comparative studies between structures that led to solid interpretations of her data. Consideration of different labour constants and presenting the reasoning behind the most plausible one is also part of the core approach in the papers by Brysbaert on the topic of monumental construction in the Mycenaean context of Tiryns.[12] In contrast to Fitzsimons, Brysbaert emphasises the very costly aspect of transport (as has also been done by Devolder where applicable) and comes to a meaningful discussion on what the figures may mean, depending on the size of the workforce. Furthermore, she also takes the aspect of seasonality into account. Initiating large workforces for long-term projects (or one after the other over a period of time) requires serious decision-making in relation to the constant needs of seasonally driven subsistence provision for both people and animals.[13] Even though Fitzsimons uses a limited range of labour cost units, he manages to compare tomb volume digging among the different types of tombs in and around Mycenae.[14] It would have been useful to supplement that work with calculating the stonework of the tholoi as well but the comparison nevertheless supports his socio-political arguments across the presented time slice.

Two subsequent levels of critique have since appeared to these studies. The first is that studies on energetics lack any value if the analyses do not produce any further interpretative value in addition to the figures themselves,[15] and it is almost needless to point out that we also believe that this is correct.[16] An analogy can be drawn with carrying out scientific analyses on materials without placing the results back in their context and stating something meaningful about them. Moreover, the high cost of these analyses and their potentially destructive nature both illustrate how pointless this exercise is if not taken any further. Econometric calculations do have value especially when they become the basis for comparative studies.[17] The second point of critique are the rates themselves and convincing cases are being made to employ ranges of rates rather than single figures.[18]

Finally, considering just a handful of papers, Voutsaki and her co-authors[19] observe many serious problems in the quantitative studies on architectural energetics and the use of rates based on absolute, abstract and universal labour-time units because to them the method does not seem objective and transparent. They criticise the approach as inadequate for comparative work due to several factors they regard as random: (1) choice of figures and rates used in the calculations, (2) which steps in the *chaînes opératoires* that are taken into account for the whole process, and (3) employment of minimum figures to calculate the different steps, processes, resources and cost factors. Instead, the authors suggest a 'new methodology' based on relative assessment of labour input.[20] Since this criticism seems to strike at the core of econometric analyses as they are currently carried out by several scholars, a more thorough analysis of the paper is in place.

While we agree that a certain level of personal choice is present in current scholarship on architectural energetics or labour cost studies, we argue that most scholars do in fact carefully consider which rates to use and also explain why.[21] Also, the criticism of 'personal choice' could equally be directed to the selection of scientific techniques used in artefact studies: what matters is how it is being argued for. The same counts for the steps and processes taken into account in the calculations. We agree that it is difficult to be all-inclusive in calculating values for past labour costs but this does not negate the overall interpretive and comparative value of the method. Carrying out the research reveals in most cases that certain cost categories are far more important to the full picture than others, so the omissions are highly unlikely to have any significant effect on the end results. For example, procurement of stone and transport are often among the categories, which most research projects need to consider, but depending on the site, preparing the foundations of the buildings might be a minor cost. As already pointed out, there are several studies, which place the carefully calculated labour-time figures in their physical and social context.[22] In fact, we very much need such figures in order to get to grips with the contextual interpretation of these figures and how they can be compared to other case studies from different contexts. Osborne argues that there is a dearth of interpretation in studies on architectural energetics,[23] but based on our reading in this field we disagree. Moreover, we also believe that quantitative methods cannot be just swept away by qualitative and relative approaches; we actually believe that they complement each other.[24] Archaeologists also weigh ceramic sherds, bones and shells, they quantify and calculate amounts of grave goods, study different categories of small finds, and enumerate all sorts of other aspects of the archaeological endeavour.

The relative assessment method suggested by Voutsaki, van den Beld and de Raaff[25] in fact misses out on two major factors which can lead to serious interpretive problems: the aspect of time is entirely missing and it does not give any way of estimating the number of people who may have been involved in the construction works. Are not time and the past people involved in the activities two of the major and most indispensable dimensions of the archaeological context itself? In addition, extraction and transport of the stones are assigned arbitrarily into cost categories ranging from 1 to 5. The principle of how the division has been carried out is not explained, not inside each category or in relation to each other. As the authors assert, an extraction value of 5 should not be taken as 5 times more difficult than an extraction value 1.[26] How is it then possible to compare this case study with another one from a different context? The approach sacrifices transparency between procurement and transport of stone, and it will very likely stop the method from becoming more widely accepted.

Furthermore, the new relative method inadvertently results in combining the efforts in the procurement of stone with its transport due to multiplication of the two values. Both values are divided into the five categories. This is highly problematic since transport becomes automatically 'weighted' at the same level as quarrying and extraction. For example: 1 m^3 of stone which is difficult to procure (receives a value of 5) and transport (4) has a 'stone value' of 20, but so would 20 m^3 of small to medium river stones (1) transported from near (1) the cemetery.[27] However, comparison of these two relative stone values of 20 results very easily in wrong ideas about the actual efforts needed to extract and transport each batch of stones since the effort remains physiological being based on the limited capacities of the human and animal bodies. Thus, they are measurable and, to some extent, universal. It should also be pointed out that the authors make several personal choices in terms of what they define as 'significant' variations (type, size, quality of construction of tombs, stone value), thus leaving out other categories (stone density, hardness, cohesion). Considering our argument above this should not be taken as criticism, and it leaves space for others to complement in future work.

Finally, the argument that the tombs were planned and organised in advance[28] would have actually benefited from quantification of the construction process. This would have given an idea of the number of people who would have been needed to carry out this work in the community of Agios Vasileios. Even if people had to travel 4–8 km to the quarry and bring stones back, this would have been within a day's walking distance or less to transport the size of stones employed in these tombs. Without any labour time calculations, we feel that this paper is on less secure ground to analyse the social implications involving labour force size and time needed than a well-argued econometric study would have been. Having said that, it would be a worthwhile exercise to use the values presented in the paper, carry out meticulous calculations, and see how they compare to the new proposed relative method. The result would give an idea of the required labour force and time when sudden death struck. In this line of thought, let us not forget how fast the city walls of Athens with a length of over six kilometres were built to protect her from her enemies in 479/8 BC.[29]

Despite our critique, Voutsaki, van den Beld and de Raaff's paper forms a very valuable contribution to the field for various reasons. First, the comparative/relative aspects of their method is constructive especially in explaining variation in treatment from one grave to another, and indeed, as the authors state, this is applicable to many other contexts such as housing. Moreover, qualitative assessments can be very useful when combined with quantitative results, so our stance is that both should be carefully combined at the interpretive level. We are not aware of another such attempt to systematically investigate labour and its meaning relative to tomb by tomb context in the Mycenaean world and for that alone, this paper is unique. However, here again, we hope that future studies will combine the useful aspects of their approach with a thorough set of labour cost calculations.[30]

The chapters in this publication combine archaeological, experimental, historical and ethnographic/anthropological perspectives to address the socio-economic and political decision-making needed for the construction projects to materialise. With economic and technological processes of construction as a focus, the contributors consider the following questions:

1. How were large-scale buildings constructed from material, logistical and planning perspectives?
2. What types and levels of resources and investment, human and other, were needed to achieve and sustain these construction projects?
3. Given that construction took place diachronically and geographically more or less worldwide, can we recognise common denominators, and which are these? How can multidisciplinary and cross-cultural approaches further our research in the ancient Mediterranean?
4. In economic terms, is it useful to quantify the necessary resources, how can it be done, and what can such data tell us?

The first three papers concentrate on the Aegean Bronze Age. Ann Brysbaert discusses the infrastructure and logistics required for the monumental architecture in the Argolid in the Mycenaean Late Bronze Age. Moving large blocks required well-built roads between the quarries and the building sites, and transport was one of the most expensive aspects of building programmes. Employing the concept of *chaîne opératoire* to construction and landscape proves to be a methodically fruitful approach in highlighting the interaction between constructing as well as providing and maintaining the transport infrastructure. Kalliopi Efkleidou studies the large-scale urban planning and construction history of Mycenae as a whole and diachronically from ca. 1400 to ca. 1200 BC. The chapter gives a clear understanding of the development that resulted in spatial reorganisation of Mycenae in two different phases. The large urban projects were initiated by both the elite and palatial authority. Sabine Beckmann's paper concentrates on agricultural sites built using unworked boulders near Agios Nikolaos in eastern Crete ca. 2000–1650 BC. She has identified 330 dispersed sites and their scale and level of investment in the infrastructure implies that they were intended to last a long time. The remains include dwellings, storage structures, enclosures and roads. She considers both horizontal and vertical models of organisation, which could have been the instigators of such large-scale projects.

The four papers of the second part are on Graeco-Roman antiquity. Jari Pakkanen considers the economic impact of Classical and early Hellenistic private construction and whether the total scale of building can be classified under the heading 'building big'. Concentrating on private housing in the Piraeus and at Salamis, the chapter reveals how house design, especially the choice of roof material, influenced the total cost estimates of the houses. The analysis brings us one step closer towards a general understanding of the scale and economic significance of domestic construction in fourth-century BC ancient Greece. Janet DeLaine summarises her econometric research on the early second-century Capitolium at Ostia. The monumental temple standing on a high podium was the largest single investment of resources in the religious landscape of the harbour town. The study highlights, once more, the very high proportion of transport and marble architectural orders in the total costs of Roman monumental building. Anna Gutiérrez Garcia-M. concentrates on monumental building in Tarraco, the capital of the largest western Mediterranean Roman province. The largest local quarry at El Mèdol provided ca. 150,000 cubic metres of limestone for construction projects from the first century BC onwards. The decorative polychromatic stones used in the buildings linked the city with the rest of the province and as far as the eastern Mediterranean. Large-scale transport of building materials overseas inevitably left behind a number of shipwrecks, as the concluding chapter by Ben Russell demonstrates. He discusses the chronology and size of the cargoes. Different commercial mechanisms contributed in different ways to the shipwreck record: however, ships were the primary carrier of building stones over long distances in the Roman Mediterranean.

Notes

[1] Most recently, see Osborne 2014; Brysbaert et al. 2018.

[2] Pakkanen 2013.

[3] Gray 1963; Goldsmith – Hildyard 1984.

[4] See Brysbaert's contribution on the Mycenaean roads in this publication; also Brysbaert et al. 2020.

[5] Santillo Frizell 1997.

[6] Abrams 1994 is one of the best-known early studies using the term.

[7] Stanier 1953. On the Epidauros building accounts, see Burford 1969; Prignitz 2014.

[8] For example, in her contribution to this publication, DeLaine estimates that the volume of material for the Capitolium at Ostia is 3600 m^3 and total cost 270,000 man-days; Stanier's (1953, 76) stone volume is ca. 11,200 m^3 and his calculated total cost is 10 times higher than at Ostia.

[9] The cases where the polis had to import building stone from outside its boundaries like at Epidauros from Corinth, the recorded price is higher than what we know of Athenian contexts; see Pakkanen 2013, 64 f.

[10] See Pakkanen's contribution in this publication.

[11] Devolder 2013.

[12] Brysbaert 2013; 2015.

[13] See now Brysbaert 2020.

[14] Especially Fitzsimons 2011.

[15] Osborne 2014.

[16] Cf. Brysbaert 2016, 20; 2018, 25. 37; both Fitzsimons 2011 and Devolder 2013 interpret their figures and present comparative results, as does Brysbaert 2013, based on figures analysed in 2012 and published in Brysbaert 2015. Pakkanen (2013, 72–74) compares the cost of shipshed complexes in the Piraeus to other monumental Athenian projects and known income and expenditure of the polis.

[17] Boswinkel 2021. His PhD contrasts Mycenaean cyclopean wall construction with house construction of the same period to indicate differences in labour and material efforts. Brysbaert 2020 compares monumental architecture in the Argolid with domestic house construction and pottery production needed for the region, and relates these figures to the efforts of agricultural subsistence production.

[18] Lancaster 2017; Turner 2018, 2020. Lancaster's PhD is on the econometrics of Archaic monumental and domestic building in the territory of Syracuse. Turner's now published PhD on Mycenaean earth works and his arguments why ranges are needed contributes greatly to this point. However, DeLaine (1997, 105) presents a solid argument why estimating the maximum output and minimum costs can produce the most reasonable baseline result for building projects.

[19] Voutsaki et al. 2018.

[20] Voutsaki et al. 2018, 176–180.

[21] See Devolder 2013; Brysbaert 2015. Outside the sphere of Greek Bronze Age: DeLaine 1997 and her subsequent work is excellent; Pakkanen 2013.

[22] See above nn. 16. 21.

[23] Osborne 2014.

[24] See also Brysbaert 2018, 26.

[25] Voutsaki et al. 2018, 176–180.

[26] Voutsaki et al. 2018, 179.

[27] Voutsaki et al. 2018, 176–180, esp. tables 8.1 and 8.3.

[28] Voutsaki et al. 2018, 186.

[29] Thuc. 1.89.3–91.4; 2.13.7.

[30] However, see now Turner 2020 combining both methods.

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Logistics and Infrastructure in Support of Building BIG in the Late Bronze Age Argolid, Greece

Ann Brysbaert

Introduction

This paper focuses on the Mycenaean Late Bronze Age (hereafter LBA) in the Argolid, Greece (figs. 1–2), where, in the 13th century BC, large-scale elite-sponsored building programmes accumulated in fortified citadels and massive stone-built or dug tombs and dams.[1] In past pre-industrial societies, when large-scale building projects took place, extensive manual labour was invested from the moment materials were scouted for, extracted, transported, employed, and subsequently maintained, and adapted. Since most pre-industrial societies also based themselves on subsistence economies, important decision-making and prioritising would have been a daily balancing act between building and agricultural work.[2] These decisions often impacted strongly on local land-use strategies at several socio-economic levels, and may have also resulted in circular economy strategies. Building BIG may have dominated such decision-making for most, if not everyone, involved. Many efforts must have come together, and needed careful planning, designing and executing.

Past literature indicates that several aspects of building big and its socio-political and technological consequences in the LBA Argolid have been ignored or only partially treated: the logistics and resources needed to transport oversized transport materials; the main research focus on Mycenae and its surroundings; and the lack of considering the topography in the *chaîne opératoire* of building in this landscape (details below). The paper, therefore, aims to redress some of these imbalances.

Brief Overview of Past Work

While Mycenaean monumental architecture has been studied in depth[3] a critical look at studies on the processes involved in large-scale building programmes in the LBA Argolid show that investigating the cost and logistics of transporting big building materials has been ignored or even deemed unnecessary,[4] because stones were considered to be extracted 'locally'. However, many architectural energetics studies worldwide illustrate that transport is not only labour-intensive even when materials were sourced nearby but that it also forms one of the highest cost factors in the entire building process.[5] Even when stones were locally extracted as at the Tiryns citadel where many had been extracted and brought up from the bedrock quarry on which it sits, these still had to be hauled up, without cranes, up to 10 m high and placed securely in 7 m thick walls (fig. 3).[6] Studies on over-land transport of building materials usually do not account for the

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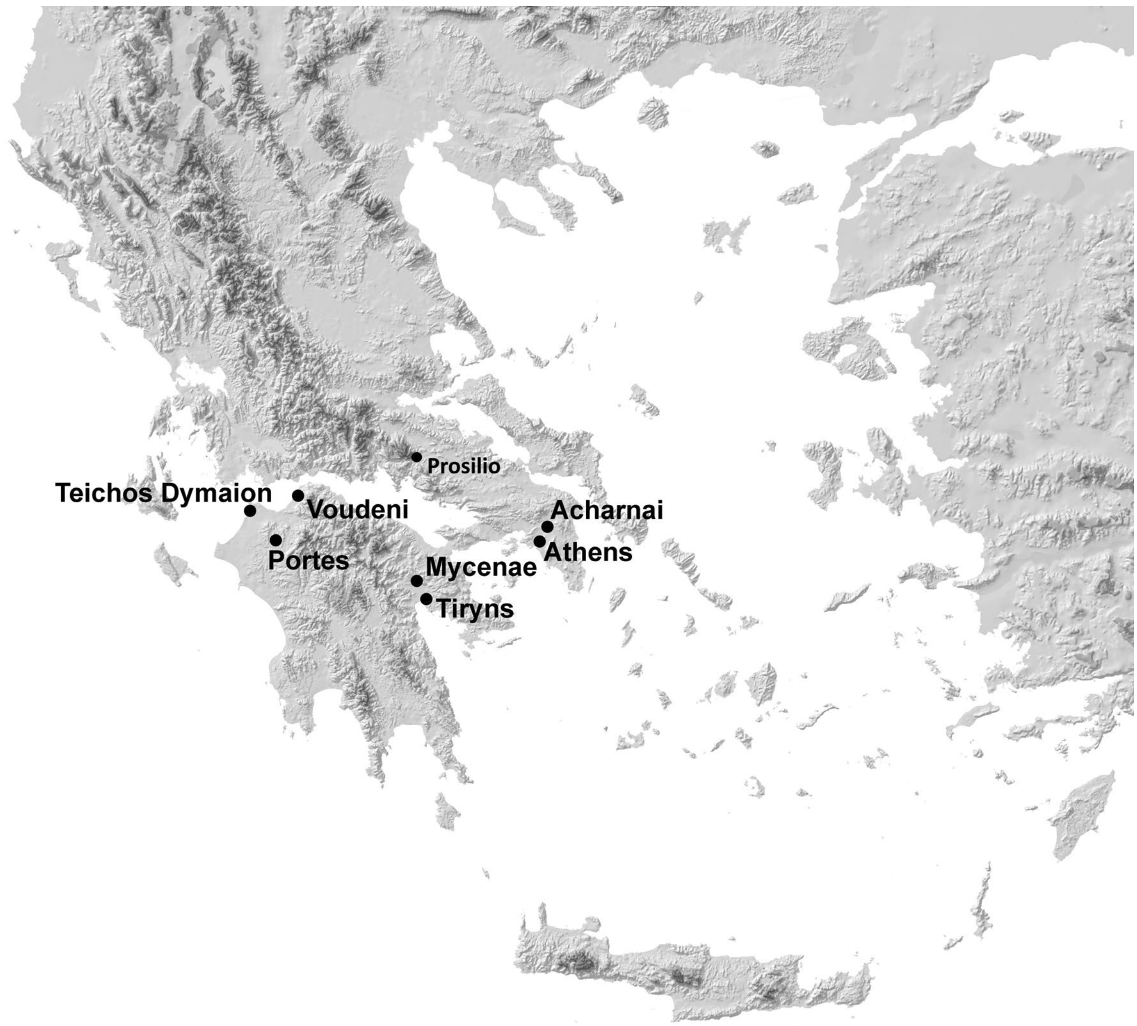

Fig. 1: Map of Greece indicating the sites where team members of SETinSTONE carry out fieldwork.

labour and organisation that may have gone into establishing the *infrastructure network itself,* while separate studies on road systems do exist for the Argolid.[7] Admittedly, when regular-size materials need transport, such as brick loads, soil, or collected fieldstones, existing land-routes and paths may have sufficed in most cases.

Equally problematic is that most road systems surrounding Mycenae have been studied in detail, but their connections to other places (Tiryns, Midea, Mastos and beyond) far less so.[8] Lavery worked intensively on outlining the entire network of Mycenaean routes in the 1990s.[9] Until his death in 2004, he both visualised these in maps but also explored their archaeological remains in comparison to the work B. Steffen had carried out much earlier.[10] The Mycenaean Atlas Project, however, was much larger in scope and mapped the site's nearby stone, clay and other resource extraction points,

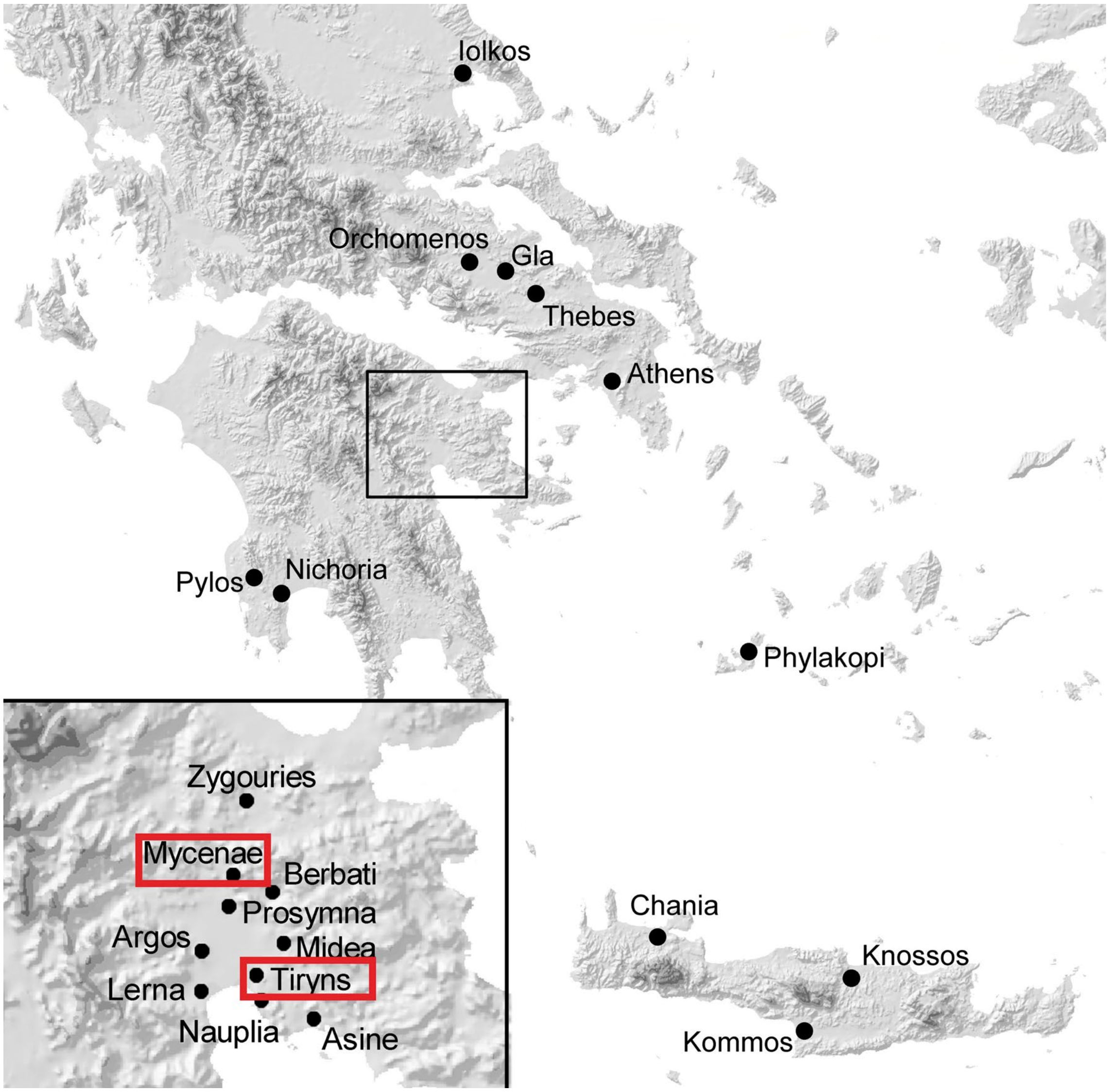

Fig. 2: Map of the Argolid with the important sites around the Argive Plain of relevance to the study/project.

its roads, and the multiple cemeteries in and around Mycenae.[11] As is also the case for the Mycenaean Atlas Project maps, most of the road studies carried out in and around Mycenae, Steffen's 1884 work (fig. 4) is still the followed standard reference.

Finally, the local east Argolid topography in which transport-routes need to be negotiated from extraction point to construction site, is not often taken into the discussion. This is no surprise, given that most traditional maps of the region are published in 2D format despite the sometimes detailed contour lines given. The exception to this, although visually 2D while representing 3D, are the maps generated by the ArchAtlas project at Sheffield University (fig. 5).[12] While a varied topography may not

Fig. 3: West side of Tiryns citadel: bedrock quarry lines following natural layering sloping up north.

have impacted normal-size loads transport too much, moving multi-tonne blocks, over 1 or 100 km, may have changed such picture drastically.

To address these shortcomings, this paper presents the first findings collected when we traced the Mycenaean roads and paths in the Argolid, mentioned in the publications above. I focused specifically on those around Mycenae, and between Mycenae and Tiryns, in order to assess their suitability for the transport of multi-tonne blocks of conglomerate since the transport question of differently-sourced heavy blocks to the Tiryns citadel was the starting point.[13] The conglomerate blocks that were used in various places in the Tiryns citadel likely came from Mycenae.[14] The volume and mass of these specific blocks has been calculated and an estimated transport system suggested.[15] However, the roads themselves were not studied in detail, and the distance of c. 20 km known from modern local routes in the area was taken as a point of departure. The local topography with slope gradient differences was not integrated – even though such considerations (i.e. friction) had been mentioned earlier[16] – because the entire actual past route was not known. Transport by means of oxen and wagons seemed logical and was calculated on the basis of data in earlier studies.[17] It was further assumed that the wagons would be able to hold these blocks, and the weight of the wagons themselves was not calculated either.[18] Beyond the transport issue but (in)directly linked to it, this paper also presents potential connections between roads and other landscape modifications, such as specific monumental tombs. Finally, it looks at the potential of combined road usage laid out in this already strongly modified Bronze Age landscape.

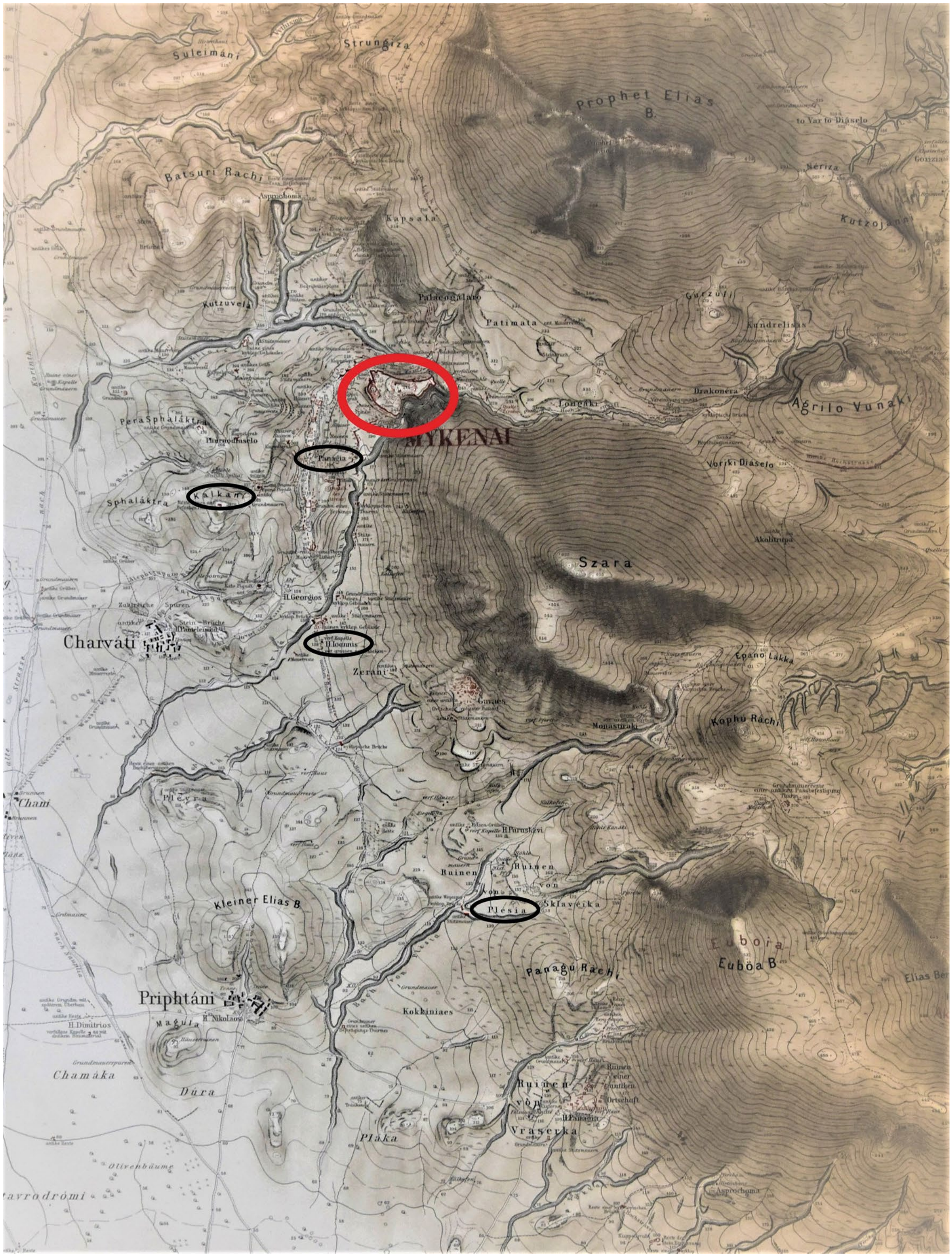

Fig. 4: Map of Mycenae and surroundings, indicating Mycenae citadel (red), Panagia, Kalkani, Plesia and Agios Ioannis (black).

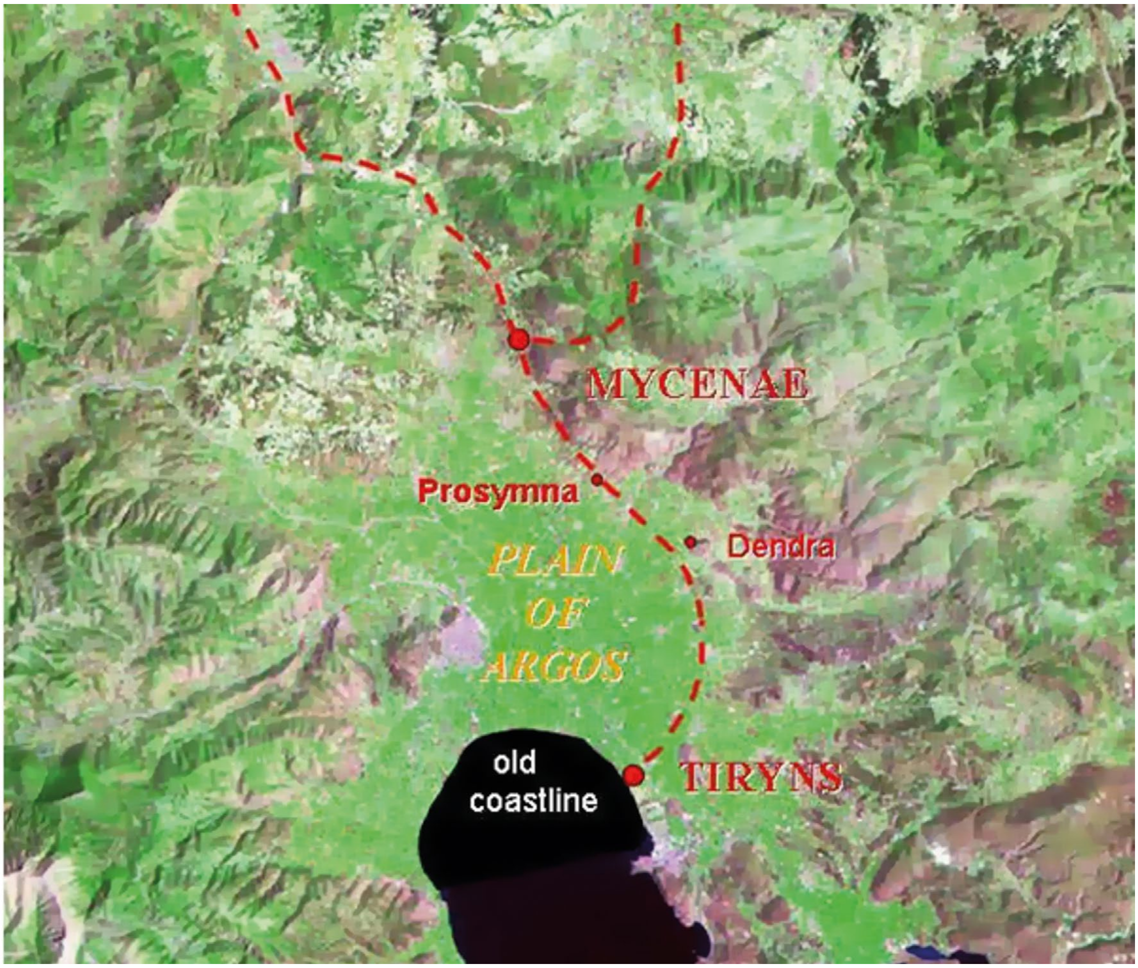

Fig. 5: 3D representation of the Argive plain, based on satellite imagery.

From Mycenae to Tiryns

The building materials for the Tiryns citadel came from a wide range of places: from the actual rock outcrop itself to minimum 15 km away, and, considering that half of the quarry sources are not yet identified, perhaps even from further afield.[19] Tiryns is known to be the only Argive citadel where *red* building stones are employed,[20] not only in the fortification walls, several doorways and gates, but now also identified at the Tiryns Tholos tomb, dated to the 15th century BC (LH IIB).[21] The geologists determined that the red stone originated from Aria near Nafplio and from the hill near Profitis Ilias, but it was unclear which Profitis Ilias.[22] Several walks (2014–2015) clarified outcrops of this red stone in several locations south, east and north of Tiryns. Since we now also noted red stone embedded in the Tholos, the Profitis Ilias outcrop, which sits just above it, seems the most logical one, but loose massive boulders seen in the quarried area of Agios Georgios makes it a possible additional candidate.[23]

While either distance was maximum 1 km to the citadel and the terrain was flat, moving red stone blocks of 4–6 tonnes would still have needed solid and wide road surfaces, perhaps aided by either sledges pulled on top of rollers or sleepers, or oxen yokes pulling sturdy wooden wagons at a rate of 1 oxen yoke per tonne of material, plus an oxen guard per yoke.

The conglomerate blocks employed at Tiryns during its largest remodelling phase ca. 1250–1200 BC, weighed between ca. 1.6 and 10 tonnes.[24] Some were identical in shape and size as those used at Mycenae. These were not the earliest conglomerate blocks found in monuments nearby. The carved and polished lintel block of the Prosymna tholos and several early tholoi at Mycenae witness this.[25] While both the Prosymna and the early Mycenaean tholoi sit in conglomerate-rich areas, some level of local transport was required. Which roads and means were used for the earlier tomb lintels, and were the same or other ones employed for the transport of conglomerate from Mycenae to Tiryns? The Mycenaean road systems, such as the M-highways,[26] are dated up to three centuries later than the construction of these early tholoi. Lavery gave many of the highways an LH IIIB date based on construction techniques used.[27] Only highway M1, excavated by Mylonas, was dated by two sherds to possibly LH IIIA2 or IIIB1. This date would be in line with the period when the Berbati valley was exploited as agricultural land by Mycenae, but Lavery considered these sherds as fill of that fortified road.[28] Several questions then arise: were these highways ever used for such heavy transport, or were they designed mainly for pack animals and chariots,[29] or for military defence and territorial control?[30] And even if enough road surface along their entire trajectory to transport the blocks are traceable, do they have, over their entire length, (1) a sufficient width to let the needed Heavy Transport Vehicle (HTV) pass, irrespective of its type and how it was powered, and (2) were the slope gradients realistic for the animals to allow such transport? (3) Are these roads sufficiently solid and 'weatherproof' to avoid subsidence and mud pools in which the transport system might get stuck?

Mycenae is surrounded by at least four so-called highways, M1 to M4, several secondary roads, m1 to m7, and plenty of smaller paths.[31] Fig. 4 indicates the important sites mentioned below. Highway M4, of concern to transport conglomerate multi-tonne blocks from Mycenae to Tiryns, was known to run from Mycenae over the Chavos ravine and descending into the valley near Prosymna, located ca. 4 km SE of Mycenae and near the later Argive Heraion. There it split off in the direction of Tiryns following the contour level at ca. 100 masl (fig. 6). In walking this road from its start by the modern car park at Mycenae citadel,[32] it descends along possibly two lines: (1) either following the modern road, along the Atreus Treasury and the cemetery at the 3rd km, then crossing the Chavos ravine near the church of Agios Ioannis at the Agios Giorgios bridge, or (2) on the other side of the Chavos ravine from the start, to the same bridge. If, however, this conglomerate came from the better quality material outcrops at Mycenae village[33] or even the Kalkani ridge further west, additional road surface

Fig. 6: Map indicating the citadel of Mycenae, the Argive Heraion and the Citadel of Tiryns with the likely trajectories between the locations: M4 between Mycenae and Argive Heraion (green), and its possible continuation options to Tiryns (light blue).

from there to the Agios Giorgios bridge needs to be calculated. From the latter bridge, the M4 went south, likely through the modern village of Monastiraki, where it may have linked up with a relatively wide and flat agricultural dirt road, still in use today. However, outside the village, once the road passed the chapel of Zoodohou Pigis, it had to cut into gentle upward slopes, towards the direction of Prosymna, while following the landscape contours. In the section from the Chavos ravine onwards, Lavery noted that nine bridges were needed until the Heraion was reached, in order to negotiate the topography. We found remains of several, at least two near Mycenae itself, while others were likely destroyed during modern modifications of the landscape (for example at the Plesia ravine junction, which, however, is not located along the M4). Interestingly, the M4 also passes within less than 20 m from the Prosymna Tholos tomb near the later Argive Heraion, located further to the south. This tholos tomb has been dated roughly between 1600–1400 BC and features a well-worked conglomerate lintel block.[34] Conglomerate lintel blocks are also known from the contemporary Mycenaean tholoi but this is perhaps no surprise considering that these are located within or near the conglomerate outcrops of the village of Mycenae, and the Kalkani and Panagia ridges. In contrast, the Tiryns tholos does not feature any conglomerate at all. Once Prosymna and the location of the later Argive Heraion were reached, Lavery saw visible tracks of the M4 continuing south to Tiryns. While there were no large road gradient problems with a steady walking height between 110–135 masl from the Agios Giorgos bridge to the Argive Heraion, we could not identify Lavery's visible tracks present after that point. Instead, we decided to follow all possible modern routes, that were as flat and as direct as possible, leading to the Tiryns citadel (fig. 1.6). Currently, the most likely candidate is difficult to determine[35] but one runs very close to the Profitis Ilias red outcrop with its tholos, and could have linked up to the local route between the Tiryns tholos and citadel.

The M4 did not preserve any trace of its original construction and surface, likely due to long-term usage afterwards: plenty of it is still in use as a dirt road. This leaves the dating of this road hard to solve, but not entirely. Let us not forget that Tiryns may have been the harbour and subordinate of Mycenae by 1400 BC and that wide and solid roads would have been fully functioning by then to transport cargoes from Tiryns to Mycenae. The entire trajectory that we traced from Mycenae to Tiryns was wide enough, i.e. ca. 3–5 m, for an oxen yoke with a multi-tonne load to pass. It also had accessible road gradients for HTVs in both directions: up-slope is harder work but safer than down-slope for draught animals attached to multi-tonne cargoes.

Finally, the weatherproofness of the M4 was considered of importance if it was used during all seasons. Even though there are good reasons to believe that the heavy stone transport likely did not take place in months with heavy rains, this road quality is difficult to assess, considering the state of its preservation. However, if we can extrapolate the known information from the well-preserved and well-investigated M1, the Mycenaeans certainly knew how to make weather-proof roads and bridges. According to Mylonas, the foundations of the M1 consisted of a fill of stones and earth whose depth varied according to the slope gradient. On top, a layer of earth with small stones with a diameter of ca. 25 cm was deposited. That supported the pavement of well-packed earth with pebbles and sand and continued over bridges and culverts that, with additional help of under-surface drain channels, very efficiently diverted water run-offs from the hill slope into the valley below.[36] We could verify this in our exploration of the M1 and a similar layering of materials was also noted on top of and near the Arkadiko bridge. This multi-layered composition, together with a useable road width, allowed a steady trot,

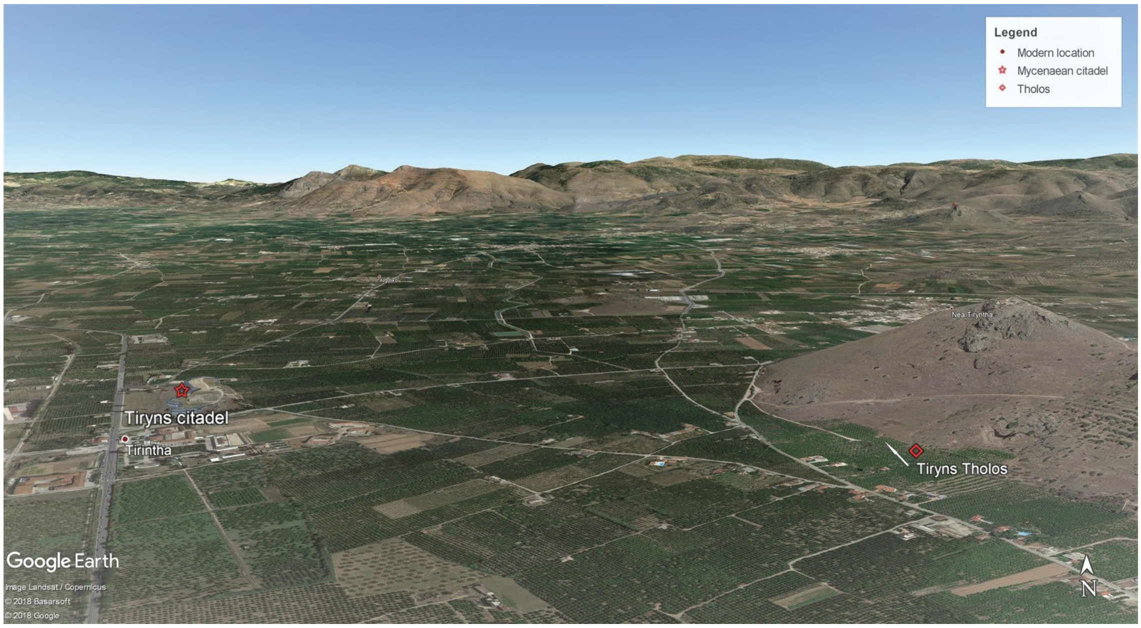

Fig. 7: Tiryns citadel (Left) and tholoi (Right) 3D view of their intervisibility, bridging about 1 km.

rather than high speed, for horses and chariots on these roads under the condition that the flat and even surface was maintained and repairs conducted[37]. In contrast to such light transport, I suggest that oxen too would have been able to use these and would have been protected from getting stuck during sudden or seasonal rains. However, the M4 had far less of its length cut out in such relatively steep slopes as the M1 does and perhaps the former never had to be built up using multiple layers and such an intricate drainage system.

Conclusions

This paper discussed specific aspects of the infrastructure of and its impact on moving large blocks from Mycenae to Tiryns from a practical viewpoint, its cost calculation will be discussed in a subsequent paper.[38] While maps and photographs remain restricted to illustrate walking, 3D images give a better impression of the negotiated topography and of the intervisibility between places which may have been of significance in choosing a trajectory, also beyond its purely practical usage (figs. 7. 8).

The first results from tracing published Mycenaean roads and paths, specifically those between Mycenae and Tiryns, seem to suggest that the M4 was suitable enough over its entire length for the transport of multi-tonne blocks of conglomerate. The road was wide enough and the road gradient did not vary largely along most of the route,[39] allowing both draught animals and human resources to work in relative comfort.

Fig. 8: 3D view of the route between Mycenae (Left) to the Argive Heraion (Right) along M4.

Certain efforts may have gone into improving existing roads to allow HTVs and without any calculations yet to offer, these logistics and its infrastructure impacted many human and animal resources. These road constructions also impacted on the surroundings, some are still in use as roads today and thus changed the landscape for ever. Where they cut into the slopes, they needed regular maintenance to remain usable and farmers who knew how to cut terraces to extend their subsistence levels were certainly useful labour and knowledgeable on such matters. Therefore, without taking the topography into account we would be unable to understand how it must have dictated the initial road survey to find the best route (albeit perhaps not the shortest), and the efforts and logistics undertaken, prior to building other monuments nearby or further afield.

The M4 was likely employed for a variety of activities,[39] ranging from transporting goods back and forth between Tiryns (harbour and citadel) and Mycenae (citadel), patrolling along this important artery if/when needed, bringing heavy conglomerate blocks from near Mycenae to Tiryns, visiting important tholoi, and perhaps even holding races with chariots. Moreover, stops could be made along the route at significant places: at the Prosymna tholos and the Tiryns tholos, perhaps even at Zoodohou Pigis for water. Walking away from Mycenae, while remaining visible for a long time, also entails crossing other landmarks. Once Mycenae was out of view, the Larissa at Argos loomed on the horizon in a southwest direction at the height of the Prosymna tholos, and, further on, the main landmark is the Profitis Ilias hill to the south, below which lies the Tiryns tholos, marking the anticipation of arrival.

Acknowledgements

Warm thanks are due to E. Vikatou who helped in preparing Figs. 6–8 for this paper and its presentation at AIAC Bonn 2018. Both Dr. H. Stöger, who passed away too young too soon (in August 2018) to see the first results of our joint work, and E. Vikatou were of great help on the many walks looking for the published remains of roads and bridges in Argolid's stunning landscape. E. Vikatou and I warmly thank Walter Laan (Leiden University) who assisted to carry out this plotting work on Google Maps and Earth by means of QGIS (freeware program).

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Notes

[1] Simpson – Hagel 2006; also Maran 2010.

[2] Brysbaert 2013; 2017.

[3] E.g. Wright 1978; Küpper 1996; Loader 1998.

[4] E.g. Fitzsimons 2011.

[5] Crucial work by Burford 1969; Delaine 1997; Russell 2013; Brysbaert 2015b; half of the papers in Brysbaert et al. 2018.

[6] Brysbaert 2015b with references.

[7] Jansen 2002; Simpson – Hagel 2006 for overview; useful on road functions: Lavery 1990; 1995. See now also Brysbaert et al. 2020.

[8] Jansen 2002, map 1.

[9] Lavery 1990; 1995, 226–227, maps 1–2.

[10] Steffen 1884.

[11] Iakovidis et al. 2003.

[12] Sherratt 2004.

[13] Only partially dealt with in Brysbaert 2015a.

[14] Müller 1930; Wright 1978; Küpper 1996; Maran 2006; but see Varti-Matarangas et al. 2002, and for some critique to the latter paper, Brysbaert 2015a.

[15] Brysbaert 2015a.

[16] Brysbaert 2013.

[17] Burford 1969; DeLaine 1997 among others.

[18] But see Boswinkel 2021. Omitting the wagon weight is not necessarily a problem: for later periods, the later Greek and Roman epigraphic and literary sources can be used to calculate costs of effective (net) loads, e.g. related to the volume of the stone carried. This means that there is no compulsion in these cost calculations to take into account the wagon mass. However, multi-tonne blocks may have needed

heavier transport platforms. Equally, in later periods, iron axles were able to hold larger masses but iron technology was not yet available in the LBA. Boswinkel 2021 suggests wooden axles.

[19] See Varti-Matarangas et al. 2002; for Tiryns with comments, see Brysbaert 2015a, table 1; for Mycenae, see Brysbaert, in press, for stones seemingly brought in from beyond Corinth.

[20] Already in Müller 1930.

[21] See Brysbaert et al. forthcoming.

[22] Varti-Matarangas et al. 2002.

[23] Brysbaert 2018, fig. 3.

[24] Brysbaert 2015a, table 3.

[25] Wace et al. 1921-1923; on dates, see Fitzsimons 2011, 93.

[26] Lavery 1990; 1995; Jansen 2002; Simpson – Hagel 2006.

[27] Lavery 1995 ; but see now Brysbaert et al. 2020 for a complete review on all dates for the M-highways.

[28] Simpson – Hagel 2006, 149, 156 for a summary.

[29] Crouwel 1981; Simpson – Hagel 2006.

[30] E.g. Simpson – Hagel 2006, 156.

[31] Lavery 1995, maps 1–2.

[32] Where conglomerate quarries are located all the way to the ridge above the Atreus tomb.

[33] Cavanagh – Mee 1999, 95–96 mention two qualitative types of conglomerate.

[34] Wace 1921–1923.

[35] Least Cost Path Analysis is currently being carried out; Brysbaert, in press; Brysbaert et al. 2020.

[36] Mylonas 1966.

[37] Hope-Simpson – Hagel 2006.

[38] Brysbaert, in press.

[39] The initial descent from Mycenae is rather steep, but over the whole route, the height difference between Mycenae and Argive Heraion is only ca. 35 m over a distance of 4–5 km, resulting in a negligible average slope.

[39] Also suggested by Jansen 2002.

Image Credits

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Understanding Large Urban Planning Production in Mycenaean Greece: the Case of Mycenae

Kalliopi Efkleidou

Introduction

The LH IIIA2 and LH IIIB periods constitute an era known for the large urban planning schemes taking place at Mycenaean palatial centres of southern mainland Greece.[1] Current research has tended to treat different parts of these large building programmes individually and not as a unit.[2] This approach, however, does not help us understand the extents or discuss any large urban planning scheme as such nor understand in depth the principles and aims behind it. An alternative approach is to retrace the construction history of a settlement as a whole and analyse its spatial organisation through time.[3]

In this paper, I focus on the changing urban plan of palatial-period Mycenae and review the various stages of its transformation through to the end of the period (ca. 1200 BC). My aim is to gain a better understanding of the parameters that led to its restructuring during two episodes, the first towards the end of the LH IIIA and the second during the LH IIIB2 period.

Episode 1: the End of LH IIIA Period

For the early Mycenaean period (LH I–LH II), the evidence available for Mycenae derives mainly from mortuary architecture: shaft graves and grave circles, chamber tombs and tholos tombs (fig. 1). Remains of domestic architecture are scanty and known mostly as partially preserved features underneath later (palatial-period) buildings.[4] Only late in the LH IIIA2 period does the emphasis on mortuary architecture seem to decline and the work-force is put to the task of raising the first fortification of the Acropolis hill and the building complex now known as Palace IV.[5]

Very few buildings belong to the LH IIIA period displaying a rather dispersed urban plan, consisting of small groups of houses (one or two) at various locations: the 'Workshop',[6] the House of the Wine Merchant, the Petsas House and a series of walls above, and post-dating the use, of the Middle Helladic Prehistoric Cemetery (fig. 2).[7] For the first two cases, our knowledge of their biography and function is limited. We know, for example, that the House of the Wine Merchant was named after a set of 50 stirrup jars, probably used for exporting wine;[8] and the 'workshop' from the small quantities of colour pigments found in various rooms.[9]

The Petsas House, however, was clearly something larger and more important.[10] This was a building complex of elite status, a pottery and figurine workshop, a storage

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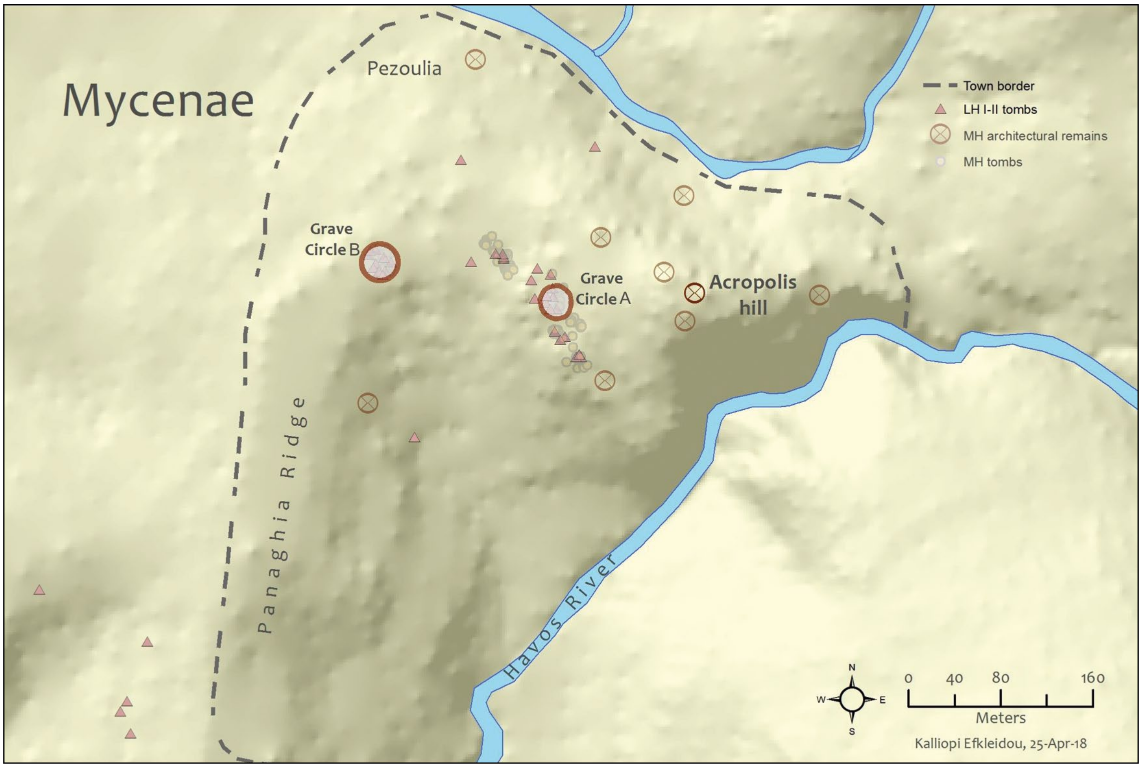

Fig. 1: LH I and II period remains at Mycenae and its environs.

and trading post, and the house of the earliest administrative Linear B archive on the mainland demonstrating a direct connection with the Palace authority of the time.[11] The destruction of the Petsas house late in the LH IIIA2 is attributed to an earthquake that left the building into ruins.[12] The same earthquake probably destroyed the House of the Wine merchant, the 'workshop', and Palace III (on the acropolis hill).

After the earthquake, most structures were built over by new, small or medium-sized, as a rule, residential ones, such as the Onassoglou House group,[13] the 'workshop' (Phase 2)[14] and the Cyclopean Terrace Buildings.[15] New areas, further, at the outskirts of the town were occupied, as in the case of the House of Lead.[16] However, the area of the elite and palace-related Petsas House was never rebuilt.

Elite housing, rather, focused on the area of the eastern side of the Panaghia ridge (fig. 3). The earliest structure built there was the West House.[17] This was the first to be built of a group of houses, the 'Ivory Houses', and probably oversaw the entire group; in addition to its residential use, it housed administrative functions as attested by the Linear B tablets registering the feeding of various individuals and groups of people and the allocation of raw materials.[18] The other buildings, built soon after the construction of the West House, were: The House of Shields, the House of the Oil Merchant and the House of the Sphinxes. All three are

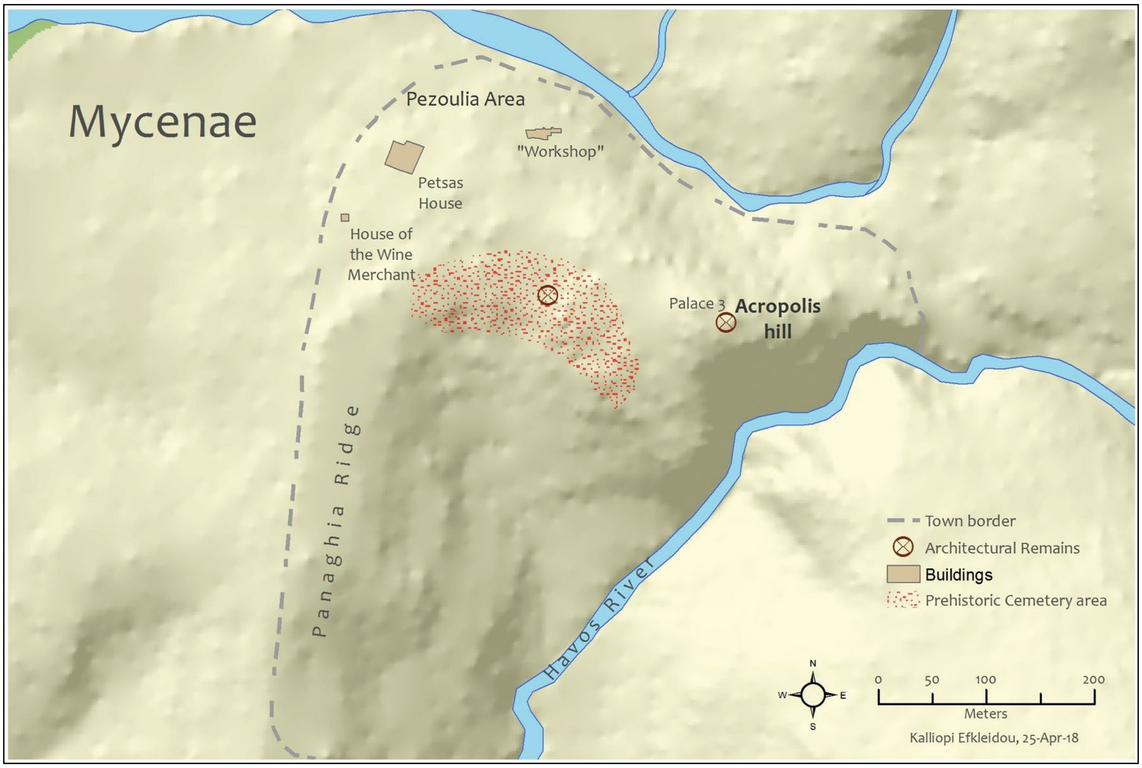

Fig. 2: LH IIIA period building remains at Mycenae.

characterised by their extensive storage capacity for various goods (pottery, oily substances, semi-precious stone finished and partly-finished objects, and raw materials) to be redistributed or processed in the possible workshop areas of the Houses of Shields and of the Sphinxes. A second group of three, erected very close and to the north of the 'Treasury of Atreus', were the Panaghia Houses.[19] This group has been widely interpreted as moderate residential structures compared to the complex Ivory Houses.[20] Their architecture, size, number of spaces, general storage capacity, wall decoration with painted plaster, the presence of clay sealings, as well as their location neighbouring the Treasury of Atreus, all indicate that these were not mere domestic structures, but structures capable of accommodating more complex functions and higher-status social groups.[21]

Opposite these house-groups, on the western side of the acropolis hill, another group of buildings was erected during the same period (end of LH IIIA2 – early LH IIIB1).[22] These were the structures of the cult centre, located, at the time, outside the confines of the acropolis. The centre's religious nature is well documented,[23] but there is also significant evidence for increased storage capacity and a connection of its personnel with the industrial production of prestige goods.[24] The plan and organisation of the centre's structures allowed for all of Mycenae's community to have access to the ritual activities taking place there.[25] Nevertheless, there are

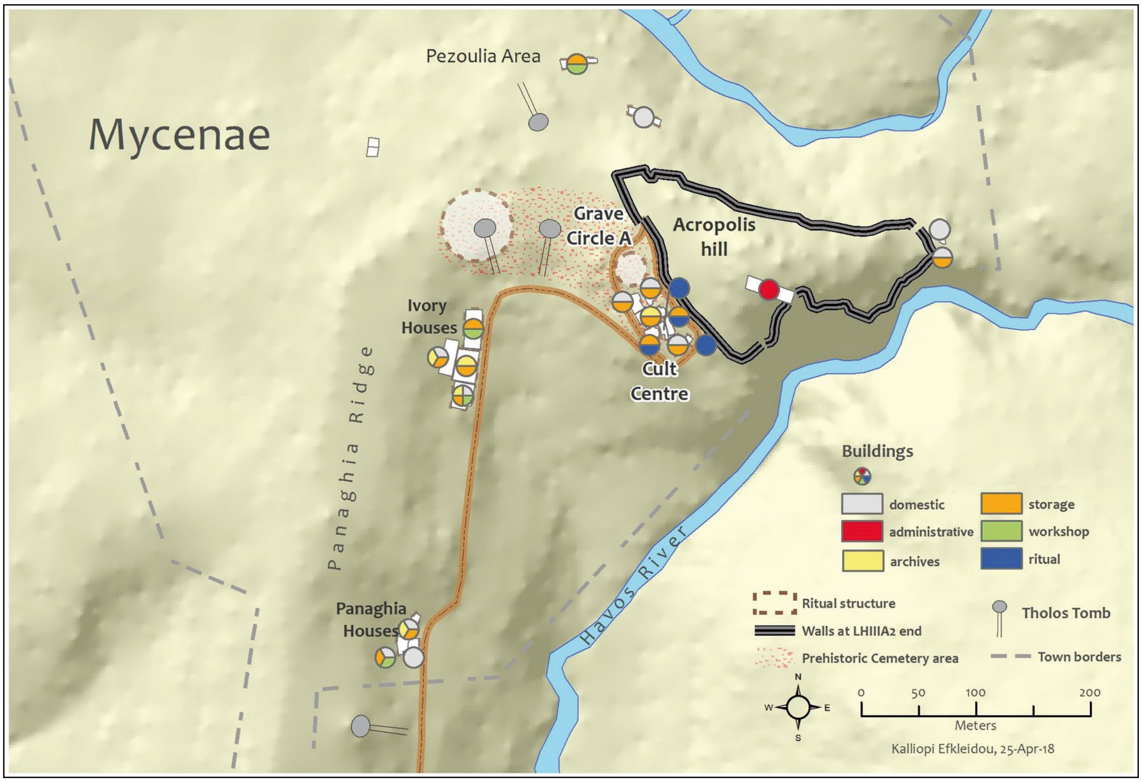

Fig. 3: LH IIIB1 period remains at Mycenae and analysis of the range of activities attested at the various buildings used during this time.

subtle indications for a hierarchical diversity of accessibility to the various areas of the centre,[26] while the acquisition and handling of the exotic materials and objects found in the centre's vicinity[27] provide us with a legitimate basis to argue for a close connection of the cult centre with the elite and the palatial authority of the time.

As part of the same urban reorganisation scheme, I believe, Grave Circle A was refurbished into a monumental ritual structure. Approximately on the location of the initial burials of the LH I period, in the open area between the Aegisthus tholos tomb and the cult centre, it was built to commemorate the elite burials of 300 years prior whose idealised memory remained in the community's collective memory, even though the exact location of each and every original burial was only vaguely remembered.[28]

The question here, however, is not why the settlement was largely rebuilt following the significant destruction horizon that left large parts of it into ruins, but rather why all structures associated to the community's elite and palace authority were built within the amphitheatrical area that forms between the eastern side of the Panaghia ridge on one end and the western side of the acropolis hill on the other.

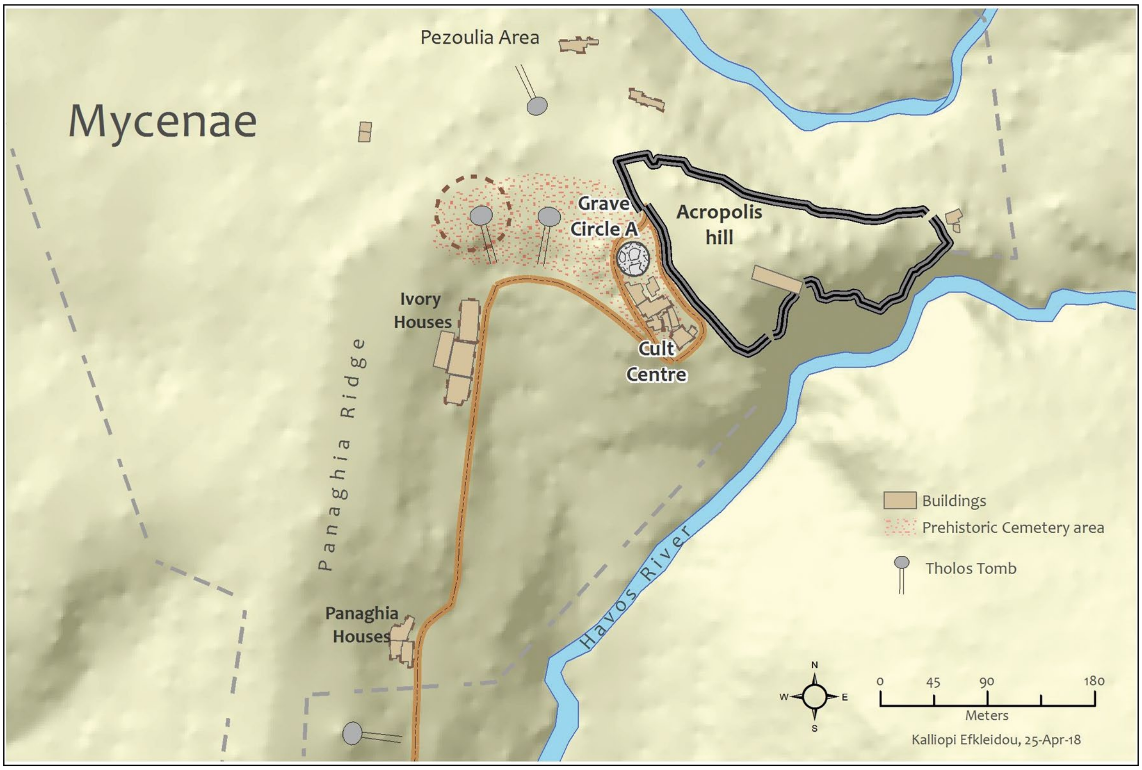

Fig. 4: LH IIIB1 period remains at Mycenae.

It Is All about Location!

To understand the choice of construction location for the LH IIIA2 elite of Mycenae, one needs to bring the history of the area to mind. During the middle Helladic period, the saddle between the Panaghia ridge and the acropolis hill was the location of the 'Prehistoric cemetery' (fig. 4).[29] Originally the settlement's dedicated cemetery for women and small children, it became associated towards the end of the MH period with the construction of Grave Circles B and A.[30] The grave circles, known for the wealth deposited with the latest burials, were the burial sites of social groups aiming to rise and gradually form the settlement's aristocracy.[31] The area was subsequently left largely undisturbed, except for the construction of only a few, elite-related, tombs over a period of 150 years: chamber tomb 222,[32] three tholos tombs (the Aegisthus, the Lions and the Clytemnestra Tombs),[33] and two shaft graves[34] (outside the Grave Circles). In the meantime, the Treasury of Atreus[35] was built at the eastern side of the Panaghia hillside on a location marking the southern boundary of the town and of the amphitheatrical area of interest here.[36]

As a result, the area gradually became associated through burial ritual with past and current members of Mycenae's aristocracy. This concentration of elite burial monuments in the area was what attracted the elite to build there the Ivory Houses and the Panaghia Houses. These buildings were associated with the trade and production of goods that interested the palatial economy[37] and signified the close bond and cooperation of their occupants with the palace. These are functions that are largely missing from buildings outside this area of the settlement. The cult centre and the refurbished Grave Circle A similarly made references to the past and to a direct line of descent from an elite ancestry. This series of burial monuments/landmarks, religious places and centres of palatial economic activity was probably unified by means of a road, remains of which have been found between the Ivory house and the East house.[38] This road, designed to follow approximately the same contour line along this amphitheatrical area, would pass in front and provide access to all the above places, especially during various processional rituals that would have culminated in ceremonies in honour of the dead inside the burial monuments.[39]

It seems, thus, the amphitheatrical area between the acropolis hill and the Panaghia ridge was rebranded, towards the end of the LH IIIA2, into an elite urban neighbourhood displaying the foundations of elite status and power at the time: (1) a key role in the palatial economy, (2) association with the divine and its protection, and (3) association with the community's elite ancestry.

Episode 2: the LH IIIB2 Period

This unified area was violently ruptured by the expansion of the acropolis fortifications to the west incorporating Grave Circle A and the cult centre inside its confines and under the immediate control of the palatial authority (fig. 5).[40] This rupture of the palace with the wider community and the system of cooperation with the elite was made more pronounced by the almost total abandonment of the eastern slope of the Panaghia ridge,[41] where elite houses/workshops had been destroyed (the Ivory Houses) or reduced into 'simple' houses (as might have been the Panaghia Houses II and III[42]) after another earthquake horizon marking the end of the LH IIIB1 period. It appears, rather, that all the infrastructure related to the palatial economy (the workshops, the large storage facilities) was incorporated into the acropolis.

This is the period when the House of Columns (with its basements filled with pithoi, stirrup jars, and a Linear B tablet), the Artisans' Quarter (with rooms containing unfinished objects, raw materials, precious and semi-precious stones indicating its function as a palatial workshop for processing ivory and making jewellery), buildings C and D (associated with processing and large storage capacity), the north storerooms (with ground floor pithoi for the storage of dry food and objects made of ivory, lead, bronze and semi-precious stones stored on the second floor and two fragments of a Linear B tablet), the buildings of the northwest quarter above the Lion Gate, as well

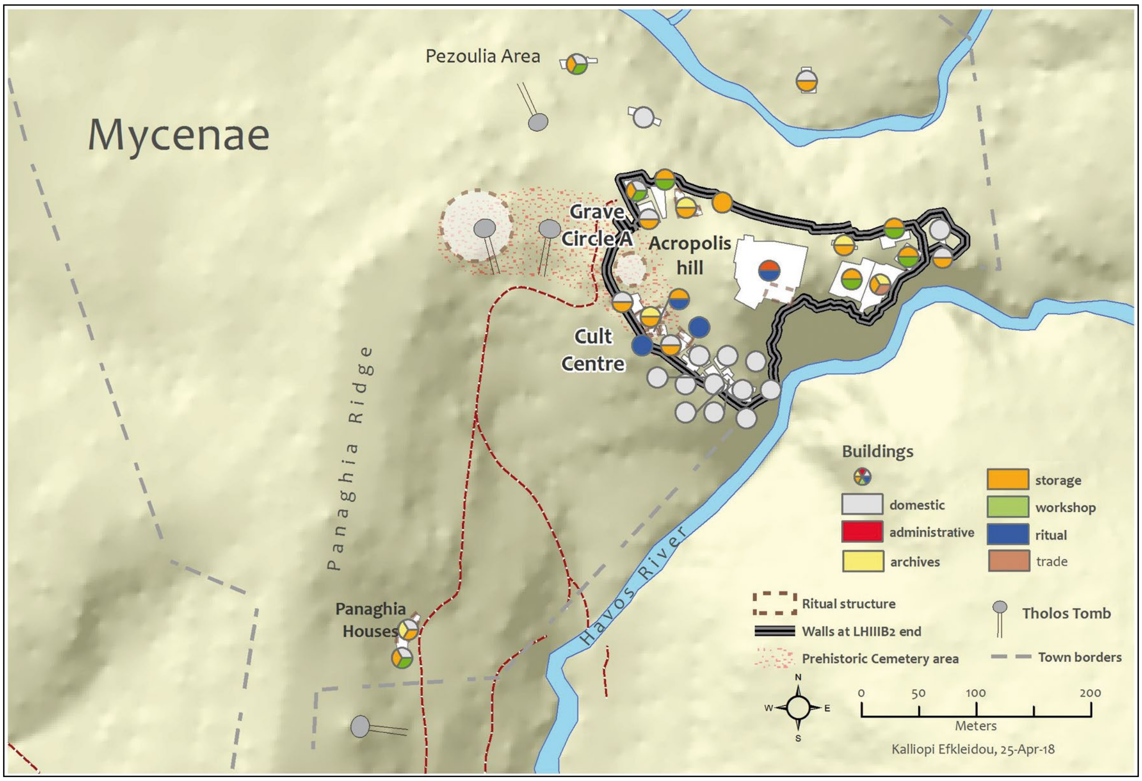

Fig. 5: LH IIIB2 period remains at Mycenae and analysis of the range of activities attested at the various buildings used during this time.

as building M with the storage spaces around it,[43] all these were built on the higher terraces of the fortified acropolis.

Urban Planning at Mycenae

What we have just traced is the transformation of an urban centre through time. Most approaches to ancient urban planning tend to distinguish between planned and organic (unplanned) cities.[44] The term 'planned' implies that historians recognise a definitive point in time that a master plan for the orderly growth of the city or its hinterland is conceived to the greatest social and economic benefit for its people and enforced.[45] Most prehistoric cities, thus, fall within the category of 'organic' ones either because this definitive point in time cannot be identified or because, with their sketchy and incomplete city plans, it is highly difficult to identify standardised planning principles.

If we accept the scheme proposed by M. Smith,[46] who suggests that planning should not be understood in terms of presence or absence, but rather as 'a series of ordinal scales' designating various levels of coordination, formality of structures or

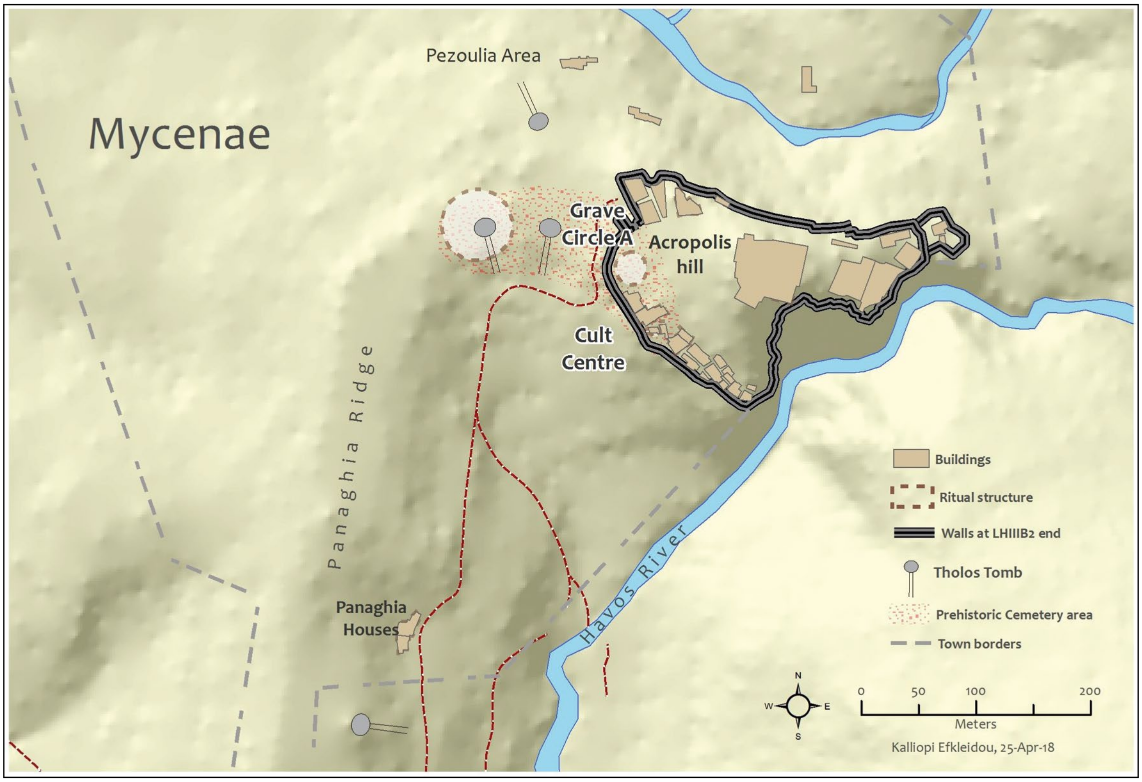

Fig. 6: LH IIIB2 period remains at Mycenae.

spatial extent of planned areas within a city, then the history of Mycenae's urban transformations during the late Bronze Age should be viewed with caution. Mycenae's site plan gives the impression that structures were organised in clusters randomly placed within the wider settlement area. It is my contention, however, that there was more conscious and deliberate planning in the way this centre developed than has hereto been acknowledged.

The alternative approach to urban planning proposed by Smith[47] is based on two concepts: *coordination* among urban buildings and spaces and *standardisation* of urban forms. At Mycenae, we find coordination of structures (buildings, tombs and cult places) that did not evolve haphazardly. Triggered by a significant destruction horizon in the LH IIIA2, elite residences/ workshops/storage facilities were built with reference (in terms of location, accessibility and visibility) to tombs of current and past elite members and cult places.

This urban restructuring involved only part of the total urban space or the town's population. It took place after a period of intense socio-political rivalries and identities' negotiation (LH I – LH IIIA1), when the community's hierarchical structure had been established and various elite groups had come together forming a unified social stratum with common activities and economic and political goals.[48] These elite groups practically had control of part of the town's economy, that part that was of interest to the ‘Palace’, and sought to establish socio-political legitimation through their spatial and symbolic association with Mycenae’s elite ancestry - buried at the tholos tombs and at the grave circles. They also wanted to be spatially and symbolically associated with the divinities revered at the cult centre for their protection and possibly for the role that the sanctuaries played in the palatial economy of Mycenae.

When this scheme was overturned during the LH IIIB2 period, after the expansion of the citadel, we can once more see a planned urban restart that is exceptionally well-conceived and executed (fig. 6). This time, however, the monumental dimensions of the building projects that took place[49] (expansion of the fortifications, the Lion Gate, the processional roads leading to the palace and the cult centre), the high level of architectural design,[50] and the coordination of monumental and ritual structures on one end of the acropolis and the places of economic interactions on the other, are such that one must ask whether there existed a master-mind, a late Bronze Age urban planner, behind its design and the palatial authority that had the power and capability to fund and see this urban project through.[51] The aim was to promote the power of the palace, which had come to control the piers of socio-political power, as they were known and accepted at the time, and demonstrated it by usurping the respective locales[52] from the elite: workshops and large storage facilities (total control of palatial economy), the Grave Circle A (control of the community’s elite ancestry), the cult centre (control of the community’s cult places and the divinities’ protection).[53]

To sum up, scholars who follow a top-down approach argue that urbanism was an ‘administration strategy’[54] to control the physical organisation and architecture of a settlement and ultimately its inhabitants.[55] In the case of Mycenae, there was a double reorganisation of its urban space. The first was initiated by an elite, until then divided by constant antagonisms, that had gained a clear understanding of their place in the socio-political hierarchy of the settlement, of what it meant to belong to the aristocracy and who belonged to it. The second was initiated by a palatial authority that had managed to concentrate in its hands all legitimate axes of power and had evolved into the sole authority at the head of Mycenae’s social pyramid. In both cases, however, these urban planning schemes involved mostly the elite and the palace, not the entire populace of Mycenae nor its entire urban space. This likely explains what has hindered us from identifying any urban planning scheme as such at Mycenae and not as random structures built in random locations.

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Notes

[1] For a synopsis, see Shelmerdine 2008.

[2] A prominent example: French 2002.

[3] Hillier et al.1976; Hillier – Hanson 1984; Banning 1996; 1997. Cf. discussion in Efkleidou 2017.

[4] French – Shelton 2005.

[5] For the sequence and date of the various Palace phases at Mycenae, see French 2002; French – Shelton 2005, 177. The shift in interest from mortuary architecture to domestic architecture is discussed in Dabney – Wright 1990.

[6] Danielidou 2008.

[7] For recent brief reviews of the evidence on all the structures known at Mycenae and their biographies, see French 2002; Andreadi – Braggiotti 2003.

[8] Wace 1953, 16.

[9] Danielidou 2008, although these colour pigments date to the later phase of the building.

[10] Pullen 2013, 440; Shelton 2015a; 2015b.

[11] Shelton 2002–2003; 2010.

[12] Shelton 2004.

[13] Onassoglou 1995.

[14] Danielidou 2008.

[15] French 2002.

[16] Andreadi – Braggiotti 2003, 56.

[17] For the West House and the rest of the 'Ivory Houses' group, see Tournavitou 1995; 2006; 2017.

[18] Tournavitou 1995, 257–265.

[19] Mylonas Shear 1987.

[20] Mylonas Shear 1987, 4–6; Tournavitou 1995, 292–296; Shelmerdine 2001, 334; Burns 2007, 113.

[21] Efkleidou 2017, 101 f.

[22] Regarding the date and sequence of events related to the expansion of the fortifications at Mycenae, see Wardle 2003; 2015.

[23] Mylonas 1972; Whittaker 1997; Moore and Taylour 1999; Albers 2004; Moore and Taylour forthcoming; Shelton forthcoming.

[24] Lupack 2008, 138–149.

[25] Efkleidou 2017, 106 f.; forthcoming.

[26] Efkleidou forthcoming.

[27] Taylour 1981; French and Taylour 2007; Krzyszkowska 2007; Lupack 2008, 149.

[28] Gates 1985.

[29] Alden 2000.

[30] Karo 1915; Mylonas 1973.

[31] Voutsaki 2012.

[32] Konstantinidi-Syvridi et al. 2009.

[33] Wace 1921–1923.

[34] Alden 2000.
[35] Wace 1921–1923.
[36] Mason 2007; 2008.
[37] For a discussion of the extent of Mycenaean palatial economy and administrative control, see Shelmerdine 2006.
[38] Verdelis 1966, 111; Tournavitou 1995, 67.
[39] Evidence for ritual practices have been found at both the Clytemnestra tholos tomb (Taylour 1955, 212 f.) and the Treasury of Atreus (Wace 1956, 117; Mason 2007, 117).
[40] French 2002; Wardle 2015.
[41] Burns 2007, 119.
[42] A scenario that could possibly explain the small quantity of pottery and precious objects recovered from their interiors.
[43] For a comprehensive presentation of all structures at Mycenae, see Mylonas 1968; French 2002; Andreadi – Braggiotti 2003.
[44] For example, see Carter 1983; Owens 1991.
[45] Ashmore 1989, 272.
[46] Smith 2007, 7.
[47] Smith 2007, 8–29.
[48] For a discussion see Voutsaki 1999; 2010a; 2010b.
[49] Maran et. al. 2006; Fitzsimons 2007; 2011.
[50] Maran 2006; Efkleidou 2018.
[51] The closest indication that such a person might have existed is found on the Linear B tablet PY Fn 7 (Melena 1996–1997) which lists 20 builders, five sawyers and one pa-te-ko-to (an all-builder or architect). This man receives rations in quantities by far larger than the rest, while the fact that he is mentioned without his personal name is an indication that he was well enough known not to be mistaken with anyone else (Nakassis 2012; Brysbaert 2013).
[52] Cf. Maran 2009; 2012; Brysbaert 2016; 2018.
[53] For a different interpretation of this periods' urban reorganisation as a sign of instability, see Deger-Jalkotzy 2008.
[54] MacKay 1997.
[55] Based on Rapoport's middle-level meaning in built environments; Rapoport 1982; 1988.

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Built to Last – Middle Bronze Age Landscaping Development and Its Economic Implications in the Region of Agios Nikolaos, Crete

Sabine Beckmann (†)[*]

Introduction

The mountain slopes west of Agios Nikolaos, settled more or less simultaneously in Minoan Protopalatial (PP) times (ca. 2000–1650 BC) with over 330 dispersed agricultural sites constructed in massive, unworked stone blocks, are situated far from known Minoan settlements and palaces. They present an otherwise unknown feature of Bronze Age (BA) landscaping, comprising not just of dwelling ruins, but also of ample traces of an intricate network of connecting paths/roads, small enclosures (pens, gardens), long enclosure walls (in sum over 150 km, originally probably up to 200 km, length) and a notable amount of round structures, probably for storage (water, grain). The enclosure walls attribute on average 3.5 ha of varying rocky and arable land to the sites, defining their function as 'mixed agriculture'. Due to the demanding investment of human resources needed to build these installations, the question arises if they were connected in some way with larger PP settlements of the wider area.

The massive architecture of the few known until recently preserved ruins and walls on the east- and south-facing mountain slopes west of Agios Nikolaos has led scholars

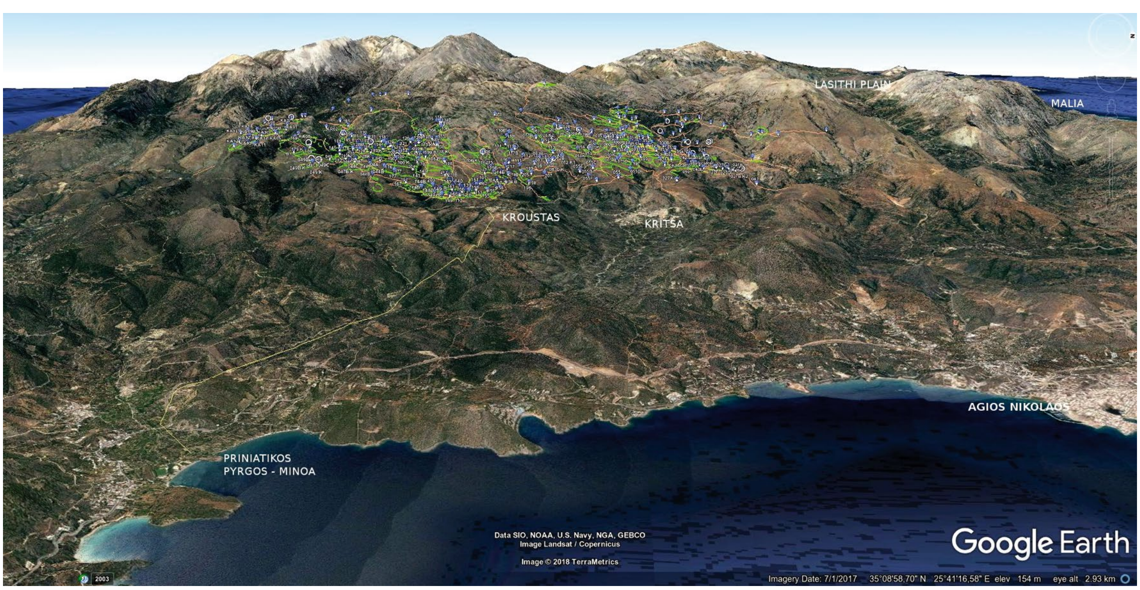

Fig. 1: Google Earth map of the studied area as seen from the East (orange lines Minoan paths/roads, blue dots sites, white circles round structures. Not all data are visible due to their dense positioning).

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Fig. 2: Two examples of oncolithic ruins (Beckmann Site 98, Kroustas Forest Park; Site 50, Kritsa mountains).

in the past to see them as military installations. Only due to the actually extant large number of dwellings with their enclosure walls and their mostly strategically unsuitable positioning in the landscape, it could be made clear[1] that these installations were not part of a defence system along a 'Mycenaean Military Road',[2] but rather of a well-organized hinterland landscape development. These installations would have been capable of providing the coastal urban settlements with a range of commodities needed to expand power structures and international trade. The sheer massiveness of the dwelling ruins' foundation constructions,[3] with their associated circular storage structures,[4] elsewhere named 'kouloures',[5] also show them to have been an effort appropriate for the first Cretan 'palatial' society's political economy. Still, in contrast to later Cyclopean or 'Megalithic' architecture, they were probably not built to impress, but 'built to last'.[6]

In numbers, and for comparison, the variety of BA structures in the area (ca. 32 km^2, fig. 1) can be detailed thus:

– 340 dwelling ruins (fig. 2) with built space in sum double the size of the Neopalatial (NP) palace of Knossos.

– ca. 150 km of enclosure walls (*perivoloi*) (fig. 3) that would have amounted to ca. 240,000 cubic metres of ancient walls in volume[7] (including many terraces in addition[8]).

– ca. 100 km of connecting paths/roads (fig. 4), partly cobbled and furnished with steps (none of them negotiable by wheeled vehicles).[9]

– over 60 round structures (fig. 5) with aboveground and underground architecture.[10]

While dwelling sites in the studied area were built with oncolithic architecture, they had still much smaller floor sizes than houses in NP towns: PP houses had between

Fig. 3: Examples of different Minoan enclosure walls (in the Kroustas and Kritsa areas).

25–50 m^2, NP townhouses had rather 50–100 m^2 or even more.[11] Together with the agricultural topography these differences give evidence for the vernacular character of the mountain installations. Also the surface pottery seen in the dwellings' surroundings does not indicate any of the 'riches' that could have been gained with the surplus of the larger arable plots in the region. Hence the situation suggests that at least the farmers of the latter did not work for their own gain, but either as dependent farmers (vel sim.) for someone else not present within the same area, or, in an imaginary world, were sharing their surplus with (or re-distributing it to) their poorer neighbors in times of need.

Fig. 4: Examples of BA paths/roads (in the Kroustas and Kritsa areas).

Fig. 5: Above ground and underground round structures, Kroustas Forest Park area (Beckmann site 189, 100).

Approaching Bronze Age Land Use

Usually the scholarly perspective on Minoan agriculture and its possible productivity is based on storage facilities found (or assumed[12]) at elite structures. Their function was for many decades seen as either (re-)distributive[13] or as centres for conspicuous consumption.[14]

Contrary to this centralized perspective, the Minoan mountain landscape with its *perivoloi* allows a focus on production rather than just storage. Regions[15] within the studied area were chosen where the enclosure walls are well enough preserved to allow a clear attribution to specific sites,[16] so as to estimate the actual arable surface according to the Minoan sites' clearly defined arable plots. (fig. 6). For these plots three categories of arability were established:

– Good fields: mostly alluvial/colluvial plots in small valleys or depressions with 85% and more arable[17] soil surface and very good soil.

– Medium fields: often plots on slopes, mostly terraced even in areas with very little gradient, 50–85% arable surface. The possible yield was calculated using factor ½ of the yield from good fields.

– Non arable spaces: with more than 50% rocky surfaces. They might have been used as spaces for grazing animals – as they are today.[18] That these spaces are not necessarily exclusively 'non-arable' is proven by the fact that some of them (e.g. the tiny soil patches of 2–10 m^2 just W of the ruin Beckmann site 33) were agriculturally used as hoed 'fields' (for barley[19]), as locals report.

Judging from the data provided by the Greek encyclopedia Ilios, 1000 m^2 of Greek field (before the time of artificial fertilizers) would have produced between 80–260 kg of barley per year.[20] Thus an amount of 8–26 kg per 100 m^2 of possible barley yield seemed

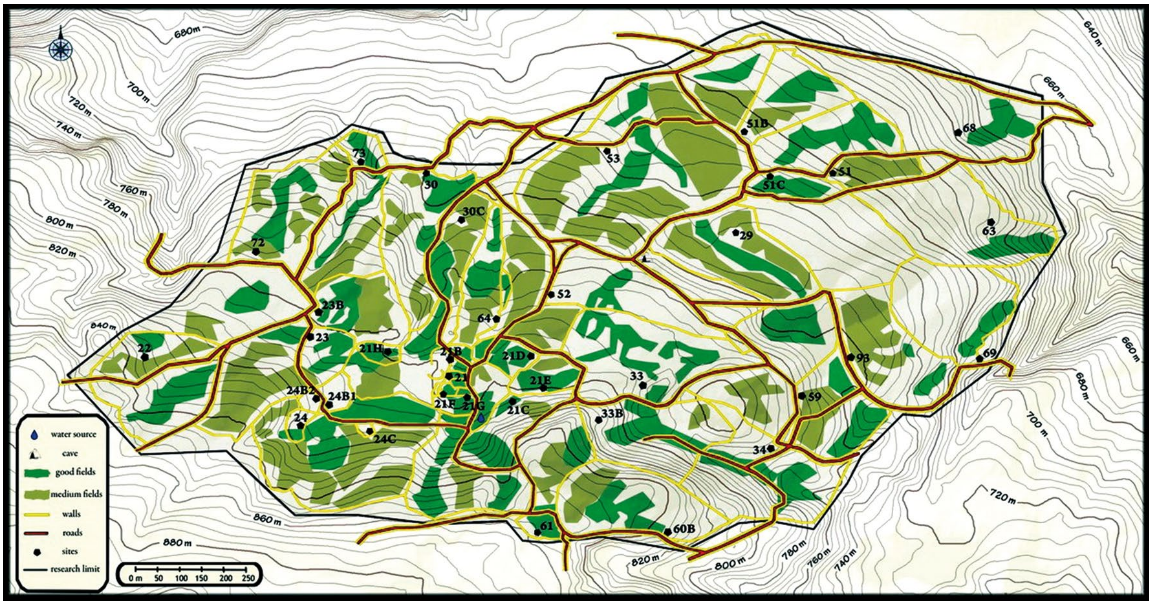

Fig. 6: Map of part of the studied region (Pateragiorgis, Kritsa) with good fields (green), medium fields (light green) and non-arable areas (uncoloured). Enclosure walls yellow, roads/paths red, dwelling sites at numbers. Data outside the land use study area not shown.

a reasonable computational foundation for the carrying capability of Minoan mountain fields in the author's calculations.[21] Note that the large range of possible yields also means an important *caveat* for anyone trying to define sizes of plots 'needed to feed a family'.[22]

The collected data result in a total of about 1500–2700 people that could have been fed by the studied area's yields. The accounts for the probable amount of barley cultivated on the enclosed fields per site[23] showed that most households would have been self-sufficient, while some must have produced a surplus that could possibly have been stored in the round structures. As a rule, the size of the main dwelling ruins is not proportional to other features, namely the extent of arable land, thus the size of groups inhabiting the sites may not have been related to the amount of its arable land or its possible yield.

Storing Spaces for Farms on Rocky Slopes?

Sites with larger plots at their disposal could have easily lived off their land while having extra space for raising animals, planting gardens, etc.[24] The by far largest site (as enclosed plot) in the region of Pateragiorgis, Beckmann site 53, with (good and medium) arable land of nearly 6 ha could have produced (following Ilios' amount of 8–26 kg per 100 m^2)

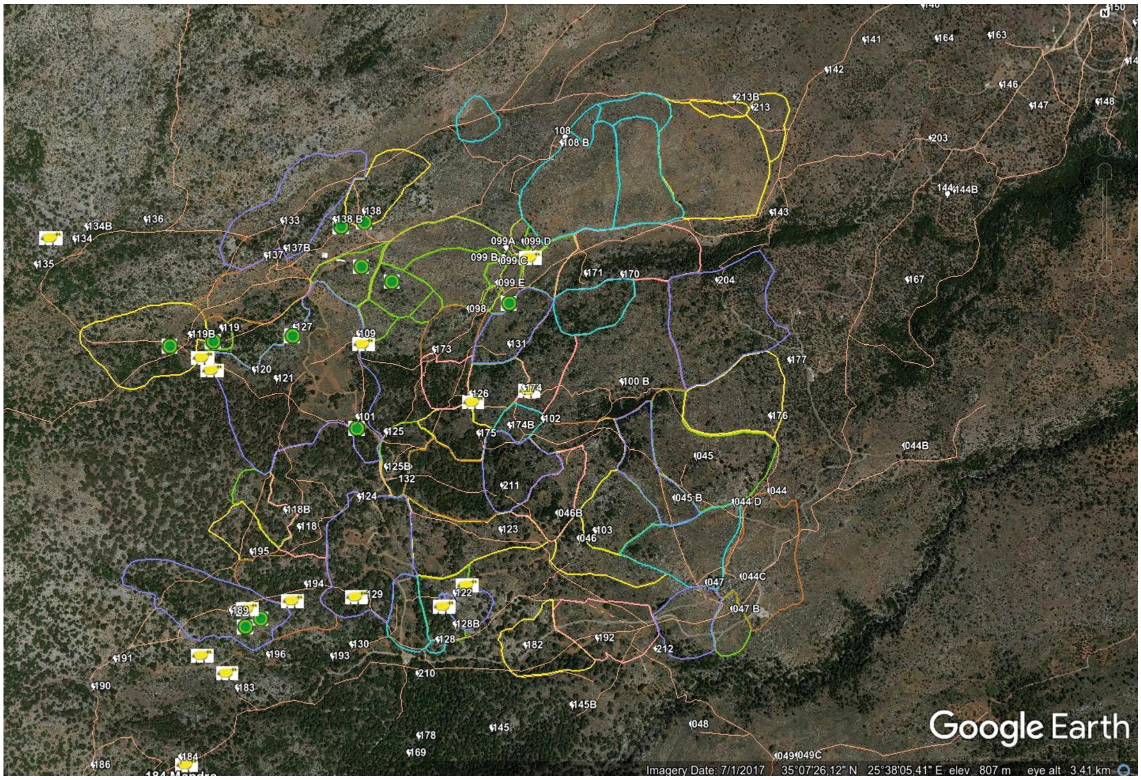

Fig. 7: Google Earth map of the Asfendamous/Kroustas Forest Park area with sites (numbered), above ground round structures (green dots), Minoan animal pens (sheep), Minoan roads/ paths (light orange) and enclosure walls (multi-coloured, one colour per site).

2,800–9,100 kg,[25] a cereal surplus for 3–13 families (with Allbaugh's 640 kg/family/ year, cf. note 31).[26] In this context it seems interesting that while e.g. the site's dwelling ruin (without its half-round extension[27]) very much resembles the simple rectangular McEnroe Type 3 Minoan NP house, the site's production capacity[28] could have exceeded the storage capacity of the much larger McEnroe Type 2 NP house type (that "does not exceed ca. 3,000 litres"[29]) or would possibly even have yielded amounts for the storage capacity range of McEnroe Type 1 NP houses of 5,000–14,400 litres.[30] Here we certainly deal with a serious possible surplus.[31] The amount of different pithos sherds visible on the slope below the half round structure might indicate its original use as storage area.

Site 53 might have used its half round extension as storage space for surplus, and there are other sites with similar extensions in the area. Possibly even some of the rectangular structures were storage spaces (e.g. what looks like a small house ruin, Beckmann Site 99B). Still the over 60 independent round structures (two architecturally different kinds[32]) detected[33] in the study region are of major interest here.

The two architectural variants are:

– Type 1. Constructed oncolithically and underground (probably cisterns[34]), dug out as a pit or vertical shaft/well with inner diameters up to 5 m and wall widths between

Fig. 8: Minoan animal pen at Beckmann Site 174 (Kroustas Forest Park area, dwelling ruin behind and right of girl).

0.7 and 1.3 m. The 22 of them with a well-visible shape might have contained ca. 460 m^3 of water.[35]

– Type 2. Built with mostly rubble and on slightly raised rocky positions. In diameter most popular sizes are between 3–4 m and wall widths 0.8–1.2 m (often difficult to judge because of fallen rubble). These are roughly comparable to a group of round structures at the Minoan 'palace' of Malia,[36] and interpreted by the author as probable granaries.[37] Those with clearly visible construction alone – 25 – have an estimated capacity of at least 565 m^3 (when computing with a height of 3 m)[38] and a maximum of ca. 900 m^3 when computing with a height of 1.5 times[39] the width but max. 5 m,[40] i.e. yearly rations for ca. 880–1400 people. If one compares these numbers with the storage capacity of the PP Knossos 'kouloures' with a capacity of 480–670 yearly rations,[41] it becomes clear that the current (re-)distribution theories concerning the 'palaces' (see above) should be reconsidered. Privitera's suggestion concerning a "high possibility that peripheral storehouses did exist"[42] (for Mycenaean times) could be seen as documented for PP times with the existence of the mountain round structures in the Agios Nikolaos area.

From these, albeit highly conjectural, computations it is still possible to say that, even if for modern eyes the studied region may not seem to be apt for farming, in a period when the 4.2 kiloyear aridification event[43] must have afflicted Minoan coastal settlements, the mountains with their larger rainfall amounts must have been important as hinterland even for cereal production,[44] and certainly for raising livestock – sheep, goats, bees (figs. 7–8). The possible surplus in barley is rather impressive in itself, when added to other resources that could have been gained in the surrounding mountainous landscape, from timber to animal products, the area can certainly be described as plentiful.

As it seems that urban (mostly coastal) areas in Minoan Crete are always also trading centres as well as elite settlements, it seems logical to look to the closest PP town/economical center for the predominant strata of Minoan society the mountain dwellers would have been subordinate to or trading with, in an imaginary world of independent Minoan farmers. In the case of the sites studied here, the ancient coastal settlement of Priniatikos Pyrgos[45] comes to mind, especially as some of the mountain paths/roads seem to be directed there.[46] Following the Istron river to the sea, ancient roads/paths provide the necessary connectivity from the mountains to the coast/urban settlement within a distance of ca. 10 km (following modern roads the two regions seem much further apart).

That the mountains were settled by an – imaginary – egalitarian community, peacefully sharing their crops and living in a proudly massive, self-constructed[47] landnam area off the reach of 'palatial' elites, sharing and exchanging (or 'redistributing') local products for non-local is theoretically just as possible as the area having been owned by a (topographically distant) elite who could "mobilize staple resources in return for access to the land by commoners"[48] – the material record visible in the landscape does not yield enough information for more.[49] Both horizontal (i.e. egalitarian) and vertical (hierarchical) models seem to fit the currently visible facts.

On the other hand, when applying Ockham's razor, one might suggest that a hierarchical model seems more logical for a conclusive explanation of such a well engineered 'project' as the PP landnam of the Agios Nikolaos mountains seems to have been.

While this is not the place to discuss the kind of possible local overlordship extant in PP times (secular or religious), it seems certain that a dynamic elite must have been interested in the agricultural and natural resources that could have been provided by the mountain dwellers in their hinterland. Thus the great investment that the installation of the many massive structures necessitated should also have come from this elite, with its administrative and technical know-how, thinking big enough to manage the topographically intricate and probably contemporary installation of the many kilometers of oncolithic dwellings,[50] enclosure walls, and roads – not as conspicuous architecture, but as a long-term investment, all built to last.

Notes

* Sabine Beckman died on 6th June 2019. She was a generous colleague and friend. She knew the Cretan terrain as no other as she walked it extensively for several decades. As a real fighter against illness, she passed away far too early. Her fresh and passionate input in Cretan archaeology will be sorely missed.

1 Beckmann 2012a, 2012b.

2 Evans – Myres 1895 in Brown 2001, 205.

3 Named 'oncolithic' by the author for typological reasons; cf. Beckmann 2012a, 92–96; 2012b, 37.

[4] Beckmann 2012a, 137–144, Appendix E.

[5] Cf. most recently Keßler 2015 passim, with extensive bibliography.

[6] Hence many have been re-used in the recent past for mixed agriculture. It is unclear if the big foundation blocks were actually visible in the BA.

[7] Cf. the building volume of the Menkaure/Mykerinos pyramid, ca. 235,000 m^3.

[8] Hence Orengo and Knappett's (2018, 504) notion that there "has been little recognition of such systems" ("terraced fields") is clearly spurious. Also, their statement "there must be many other examples of Bronze Age terracing yet to be described as such" might be correct, but Beckmann 2012a (the existence of which they seem to have noticed without taking any of its data into account, ibid. 502) gives ample examples of well-documented enclosed (and often terraced) BA fields (regardless of the fact that due to centuries of re-use most of the terraces do not seem to be in their original BA structure any more, while the enclosure walls are mostly datable due to their characteristic oncolithic building style).

[9] Beckmann 2019.

[10] Beckmann 2012a, 251–260.

[11] Whitelaw 2001; Beckmann 2012a, 131.

[12] Cf. Privitera 2014, 430.

[13] E.g. Renfrew 1972, Halstead 1981; cf. the forum on Redistribution in Aegean Palatial Societies, AJA 115, 2011, 175–244.

[14] E.g. Schoep 2004.

[15] The areas of Pateragiorgis south of Kritsa and the area of what is now 'Kroustas Forest Historical Landscape Park' (cf. www.kroustas-park.gr), for one of its main toponyms called 'Asfendamous' in Beckmann 2012a, passim.

[16] Beckmann 2012a, 272–292.

[17] This is corroborated by recent land use. Being enclosed by Minoan walls preventing most erosion, it stands to reason that the fields' arable qualities were at least as good as they are now (for the geo-archaeological basics of this cf. Beckmann 2012a, 18–20).

[18] During the rainy seasons (winter-spring) spaces between rocks are especially green and fertile (cf. already Sieber 1823, 53). For the geo-physical background of this phenomenon, cf. Krusche et al. 1982, 52 f.

[19] For the reasons for barley as main crop see Beckmann 2012a, 72. Note also Halstead's (1987, 84) comments on the better seed:yield ratios in hoed agriculture.

[20] Ilios 1941/52, vol. 11, 551, lemma >κριθή<.

[21] Yield amounts accordingly calculated per m^2 of the studied area's good fields plus half of the amount per m^2 of medium fields. Allbaugh (1953, 379) refers to an average yield of ca. 74 kg per 1,000 m^2 in post WWII Crete. The 'in situ' data of experimental yields (Beckmann 2012a, 75–79) are similar.

[22] Here taken to be an average 5 (adult) persons as usual in such computations. A good size of family has always been desirable in agricultural societies if only for economical/practical reasons.

[23] Beckmann 2012a, 313; Ch.II,d 4.

[24] Studying in a similar way the possible amount of animals that can be raised by natural means – i.e. no added fodder – on the Agios Nikolaos mountain slopes (in keeping with modern local information), approximately 50 sheep and goats could have constituted the livestock per site and household (cf. Beckmann 2012a, 291–293 and fig. 206; 313)

[25] I.e. ca. 1,900–6,100 litres of local Cretan barley weighing 0.67 kg/litre. Judging from Keßler's computations (Keßler 2015, 145–148, citing Christakis 2005), when accounting with the largest PP pithos size of 300 litres, 6 to 20 pithoi could house this amount, even if stored in a different containing object (sack, bulk) in the ca. 30 m^3 (30,000 litres) space the half round structure could have provided if built 3 m high.

[26] I agree with Keßler's statement (2015, 138) as for the possible 'precision' and use of such computations: only "to determine an order of magnitude of the people that could at most have been subsidized with the storage capacities present" (Keßler's italics). Note that there is a mistake in Beckmann 2012a, 285, giving an amount of 4–14 families' supply as surplus, not taking into account the family of the dwelling.

[27] Cf. Beckmann 2012a, fig. 200.

[28] Judging from the possible revenue from its plot of arable land within its well-preserved enclosure.

[29] Christakis 1999, 10.

[30] McEnroe 1982.

[31] Based on Allbaugh's data (Allbaugh 1953, 107), who measured an actual average need of 128 kg of cereals per person (i.e. 640 kg for a whole hypothetical household of 5) per year in a household. Note that there is an important element of uncertainty in these computations for various reasons: Keßler differentiates between cereals, but due to this very approximate approach that seems to be too much detail here. The same has to be said for caloric needs of BA people that probably can only be guessed at as a very vague amount. Keßler assumes 1.23 litres of husked barley as average daily need, i.e. nearly 280 kg/year (following his calculations in Keßler 2015, 143, applying 20% of the caloric need covered by olive oil). I assume that Allbaugh's lower cereal data are probably closer to the BA reality, even though he gives a rather large amount of olive oil (29% of the caloric need, Allbaugh 1953, 126) as part of the post WWII Cretan diet. This, as well as the legumes omnipresent in the modern Cretan diet, would in modern times not be produced in the studied mountain region as it is supposed to be situated too high for most of the olive species to bring optimal yield, while legumes were recently only grown in the lowlands because they needed more tending than cereals but could have been grown in the mountains if people lived in the dwellings during winter (for the probability of winter use, cf. Beckmann 2012a, 291). For the BA, facts like these show that there would have been an exchange in goods that cannot be taken into account here, as other products of the mountains – timber, honey, herbs etc. – plus the animal products – meat, wool, cheese etc. – cannot be quantified.

[32] cf. Beckmann 2012a, 137–144.

[33] As especially the underground structures could have been buried under colluvium easily, there may have been many more.

[34] In rainy winters e.g. the large cistern at site 100/100B still fills temporarily with ca. 1 m of water.

[35] For an example, see Beckmann 2012a, 300 f. The region has relatively few springs (cf. Beckmann 2012a, 249), so cisterns must have been very useful.

[36] The 'kouloures' at Knossos and Phaistos are underground constructions and their function is still unclear (Strasser 1997, Keßler 2015, Privitera 2014).

[37] Cf. Strasser 1997 and Keßler 2015 with extended bibliographies.

[38] Cf. Keßler 2015, 161.

[39] For the reasons, cf. Beckmann 2012a, 300.

[40] Examples from the Levant and Egypt seem to suggest for height ca. 1.5 times the width (cf. Currid 1985), but it seems improbable they could have been higher than 5 m.

[41] Keßler 2015, 161.
[42] Privitera 2014, 437.
[43] Kaniewski et al. 2008.
[44] Beckmann 2012a, 20, 314.
[45] At Kalo Chorio/Istron, currently excavated under the auspices of the Irish Institute of Hellenic Studies at Athens, a site probably mentioned as Minoa by Strabo, Geographica 10.4.5; cf. Boyd-Hawes et al 1908, 20.
[46] Beckmann 2012a, 312; Beckmann 2019.
[47] Modern examples show that the local oncolithic BA architecture could easily have been done by clans vel sim.; Beckmann 2012a, 95.
[48] Earle 2011, 242.
[49] This is the necessary place for assuring that future excavations might provide more detailed information.
[50] Even if their 'built big' foundations were probably embedded in mortar and plastered (if only to prevent mice and scorpions from getting in) and thus invisible.

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Building Big and Greek Classical and Hellenistic Houses? Estimating Total Costs of Private Housing in Attica

Jari Pakkanen

Introduction

This paper uses different types of source materials to estimate the construction costs of private housing in late Classical and early Hellenistic Attica. The reconstructed city blocks and houses of the Piraeus are the basis of the first case study and data from the new fieldwork project on the island of Salamis supplements previously published data of the second one[1] (fig. 1). The ancient urban remains at Athens and the rest of Attica are mostly covered by dense modern blocks, so the archaeological data from Salamis is important. The insulae in the Piraeus follow a strict rectangular plan, so the limited extent of the excavated remains is sufficient for a reliable reconstruction of a typical block and the city grid, and probably also the employed design unit.[2] Archaeological data, building accounts, other ancient textual sources and modern ethnographical data are the most important categories of evidence for estimating the volumes of different materials and how much energy was required to build private houses in ancient Greece.[3] The cost of constructing an individual house was small but the total private expenditure can be shown to have been substantial. A model of how to estimate the total cost of building materials and construction process of private ancient houses at Athens and Attica is presented in the chapter.

Econometric analyses of *monumental* Greek architecture have one major advantage over most other building types and construction projects outside the sphere of the Hellenic world: most of the public construction programmes have left some trace in the archaeological record; also, due to the employed materials and conservative designs by Greek architects, very limited number of preserved architectural fragments can result in sufficiently reliable reconstructions to estimate used building resources.[4] The picture we have of private residences could be viewed as quite the opposite. With the exception of stone foundations, the houses were very often built of materials which have now entirely disappeared: the mudbrick walls and flat clay roofs quickly dissolved and wooden beams rotted after they were no longer maintained, and even before that everything recyclable had already been removed. The pitched roofs were covered by large durable terracotta rooftiles, but since they were valuable, only broken fragments were often left at the sites after abandonment. However, the excavated stone foundations and tile fragments give the most important variables in the analysis of total costs of private residences: the size of the rooms and the house and the material used for the roof. Also, an estimation of the built-up and habited area of the town inside the city walls is a significant factor in calculating the total costs of residential building in ancient cities.[5] The cost estimates in this paper are expressed in terms of ten-hour man-days.[6] The prices known from

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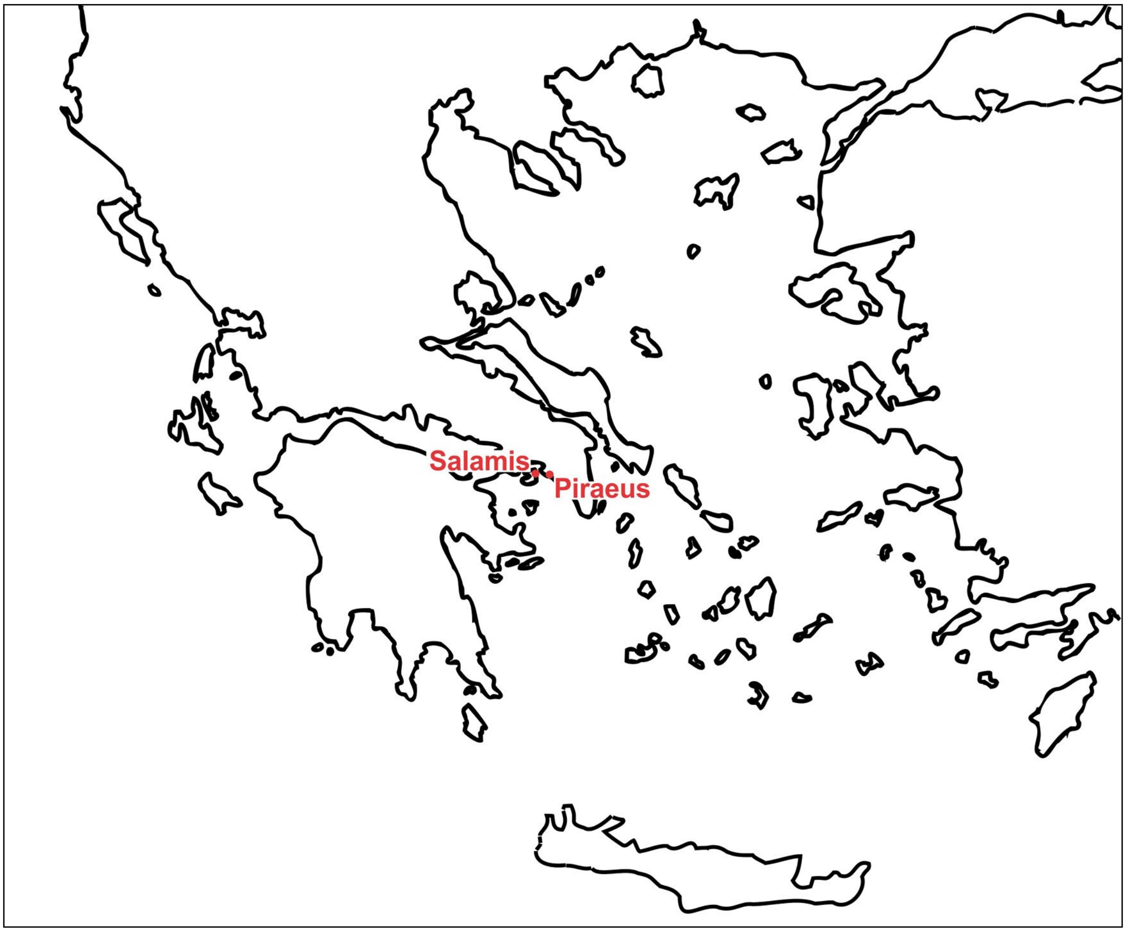

Fig. 1: Map of Greece with discussed sites indicated.

Greek inscriptions can approximately be translated into man-days by using for the fifth-century a day-wage of one drachma and for the fourth-century two drachmas a day.[7]

Econometric approaches to ancient building can be criticised for the impossibility of reaching precise figures for estimating the 'true' costs of construction projects.[8] However, it is more fruitful to compare labour cost analyses to a 'Fermi question' in physics: it is often constructive to give an approximate estimation for a quantity, which cannot be measured directly or which is very difficult to measure.[9] This approach emphasises the process how these questions can be tackled in different ways and also facilitates evaluating whether a significant amount of further research to reach a more precise estimate could conceivably give new results. It is important to keep the calculations transparent: they do not have to clutter the main text, but they should be presented in the footnotes, tables or appendices. It is not possible to arrive at an exact or 'correct' answer, so keeping in mind the number of significant digits, just as in physics, is important.[10] For example, unrounded figures should be used in the calculations and rounding can then take place at the end of the process. For example, Hurst gives in

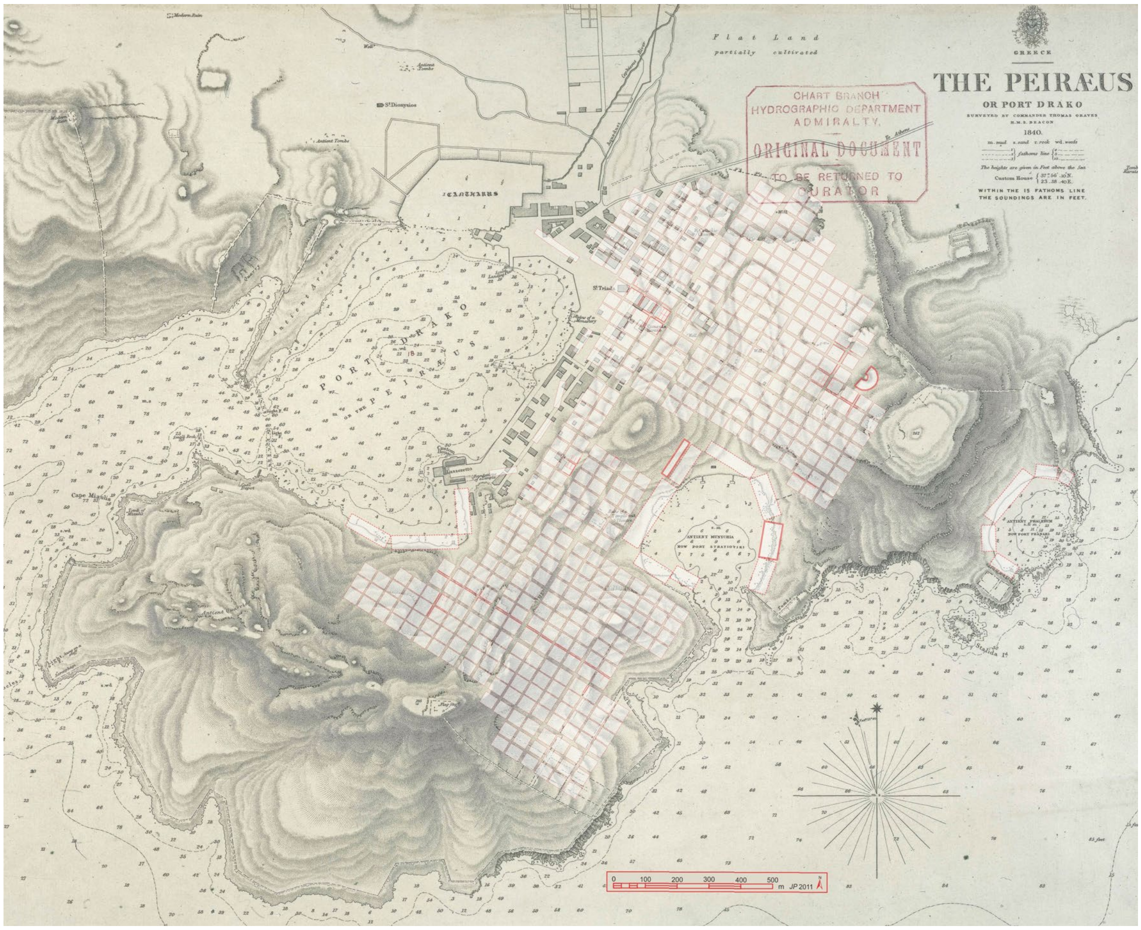

Fig. 2: The Piraeus. New reconstruction of the fourth-century city grid superimposed on top of Graves 1843.

his architectural handbook an estimate that a labourer can excavate a cubic yard of earth mixed with gravel in 1.5 hours,[11] which can be translated to ca. 0.196 man-days per cubic metre, assuming a ten-hour working day. Based on Hurst's figure, the labour constant could be rounded either to one or two significant digits, so 0.2 or 0.20 md/m^3. In this paper, I have systematically followed the procedure of using the precise figures in multiplications and then at the end rounding the results. In the tables the intermediary results are rounded to the nearest full man-day.

City Blocks and Houses in the Piraeus

After the victory over the Persians in 479 BC, the fortifications of Athens and the Piraeus were quickly built[12] and the Piraeus with its three natural harbours was developed as an outport of Athens. Hippodamos of Miletos designed the grid plan of the new town, most

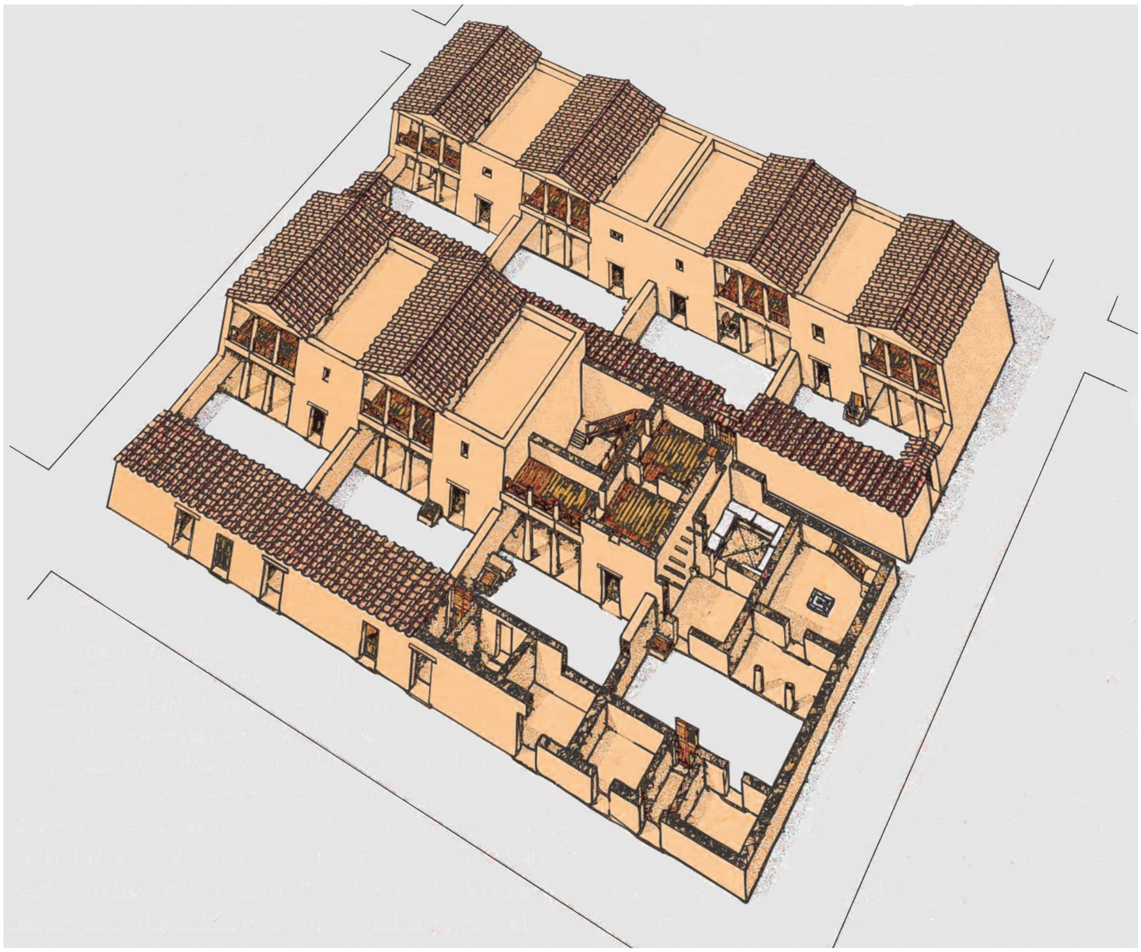

Fig. 3: The Piraeus. Perspective reconstruction of a city block.

likely in the years following the Persian Wars.[13] The ancient city is entirely covered by the modern urban development so that only the shape of the peninsula and the harbour basins are currently visible. However, the excavations of the Classical street grid and house plans have since 19th century brought to light enough details to reconstruct the city grid.[14] Graves's admiralty chart gives the best idea of the town topography before modern building started changing its outline.[15] Graves surveyed the Piraeus in 1840 and he recorded all visible features of the landscape including the ancient remains.

The reconstruction of the city blocks and the features of the harbours in fig. 2 are in many places hypothetical, but Graves' chart gives a better starting point for placing the archaeological features than later city plans of the Piraeus.[16] The solid red lines in fig. 2 superimposed on the chart indicate excavated structures and streets.

The econometric calculations of the cost of building a house in the Piraeus is based on Hoepfner and Schwandner's *Typenhaus* (fig. 3; table 1). They argue that there is enough

A1. Excavating the foundation trenches 3 md Volume: depth 0.25 m, width 0.60 m, total length of trenches 90.2 m = 13.5 m^3 Soil used for lifting the floor levels, no transport Digging and throwing behind: 0.196 md/m^3 (Hurst 1902, 376) 2.65 man-days, supervision (10%) 0.26 md
A2. Excavating a cistern 2 md Volume: 3.9 m^3 Quarrying rubble limestone (meteogene travertine): 0.250 md/m3 (DeLaine 1997, 111) 1.96 man-days, supervision (10%) 0.20 md
A3. Stone rubble foundations 47 md Volume: height 0.50 m, width 0.55 m, total length 78.6 m (excluding door openings) = 21.6 m^3 (2.6 tonnes/m3; Kidder-Parker 1946, 1924) Quarrying rubble (as above): 0.250 md/m^3 4.61 man-days (cistern volume subtracted), supervision (10%) 0.46 md Loading & unloading: 0.396 md/m^3 (Pakkanen 2013b, 63, esp. n. 55) 7.01 man-days (cistern volume subtracted), supervision (10%) 0.70 md Carting 500 m: 0.75 md/tonne/km (Pakkanen 2013b, 62–63, esp. nn. 45, 55) 17.26 man-days (cistern volume subtracted), supervision (10%) 1.73 md Construction of rubble foundations: 0.629 md/m^3 (half skilled; Hurst 1902, 381) 13.59 man-days (cistern volume included), supervision (10%) 1.36 md
A4. Stone threshold blocks 22 md In an insula of 8 houses: 27 large (2.0 × 0.9 × 0.3 m) & 26 small (1.5 × 0.6 × 0.3) blocks Average volume per house: 2.7 m^3 Quarrying limestone blocks in the Piraeus: 2.0 md/m^3 (Pakkanen 2013b, 64–65) 5.40 man-days, supervision (10%) 0.54 md Loading & unloading: 0.396 md/m^3 (as above in A3) 1.07 man-days, supervision (10%) 0.11 md Carting 500 mm: 0.75 md/tonne/km 2.63 man-days, supervision (10%) 0.26 md Finishing: 4.0 md/m^3 (Pakkanen 2013b, 65, esp. n. 81) 10.80 man-days, supervision (10%) 1.08 md
A5. Mudbrick walls 248 md Total floor height 3.0 m, total height to apex of pediment 6.8 m Volume of mudbrick in walls 192.1 m^3 (door openings subtracted) Price per cubic meter including transport in man-days: 0.853 md/m^3 163.87 man-days Construction of mudbrick walls: 0.4 md/m^3 (Devolder 2005, 169) 76.83 man-days, supervision (10%) 7.68 md
A6. Timber and doors 177 md Doors, door frames, posts, steps, floors, timbers for flat & tiled roofs Doors (numbers for the 8-house insula): 13 double doors: 20 dr per double door (Pritchett – Pippin 1956, 238), 16.25 md per house 63 single doors: 10 dr per door, 39.38 md per house Door frames: 27 × 2.0 m (width) + 26 × 1.5 m (width) Each frame would have needed 3 pieces of 10–14 footers priced at 3.667 dr (Clark 1993, 247–249), no construction or sawing costs due to extra material, 36.44 md per house Posts + beams (architraves): 8 × 4 × 3.667 = 117.344 dr; beams 8 × 2 × 3.667 = 58.672 dr, so 11.00 md per house Steps: one 14-footer cut into 3 planks, third plank cut into steps Sawing: 0.143 md/m2 (Pakkanen 2013b, 62, esp. n. 50) 2 cuts of 0.3 m × 4.2 m + construction 1 md, so 3.19 md per house Floors: 14 beams for the floor above anteroom & andron: 14 feet not enough, so price 5 dr per piece; 4 timbers sawn lengthwise into 16 beams; anteroom: one 10-footer sawn into 4 beams, 15.76 md per house (includes construction, 2 md) Planks for floors: 61.8 m2, 23.44 md per house Tiled roof above shops: 15 rafters of 5.2 m needed, from one 16-footer 9 rafters, 7.28 md per house (includes construction 0.5 md) Flat roof: similar to first part of constructing floors, 14.65 md per house (includes 3 md for construction; also reeds & clay included) Ridged roof: ridge timbers, one 10-footer, one 22-footer, 9.53 md per house (includes 3 md for construction)
A7. Roof tiles 119 md Recorded price of a pair of Laconian roof tiles in late 4th c: 4 ob. (so 1/6 md per tile) Ridged roofs: 180 pantiles, 170 covertiles Inclining roofs: 153 pantiles, 144 covertiles 107.80 man days Setting the roof tiles: 15.2 m^2/md (Pakkanen 2013b, 70, esp. n. 128) 9.88 man-days, supervision (10%) 0.99 md

Table 1: The Piraeus. Cost averages for a single house in an eight-house insula based on the reconstruction of a 'modular' house by Hoepfner and Schwandner.

evidence from the Piraeus that the houses were built on plots of equal size and had a similar ground plan with limited range of variation.[17] Because of modern construction the extent of archaeological evidence is limited, but what has been uncovered is consistent with an interpretation of high degree of uniformity.[18] Each city block very likely had eight house plots and the total number of city blocks in the reconstruction is 472.

Layout of the Town Plan and Houses at Salamis

Based on the new survey of the excavated areas of the town and the geophysical prospection carried out in 2016–2018 the street network at Salamis is orthogonal but the sizes of the city blocks are not uniform (fig. 4). Archaeological remains could be detected in nearly all the surveyed areas inside the city walls. The limited areas of previously excavated remains of the ancient town have very recently received a thorough evaluation by Chairetakis.[19] The city walls are partially preserved on three sides of the town but the extent of the built area on the south side and in the submerged parts can only be estimated. The area covered by housing inside the walls was most likely 60–80 per cent. The single so far entirely excavated house, *Oikia Theta* (fig. 5), forms the basis of the figures presented in table 2. It is dated to the early Hellenistic period but it is built on top of an Archaic house.[20]

Cost Estimates of Houses in the Piraeus and at Salamis

The analysis presented here includes a partial departure from estimating the minimum costs used in analyses of large monumental building projects:[21] an individual constructing a private house in the Piraeus and at Salamis very likely had to resort to buying more of the materials such as mudbricks, timber and rooftiles than the official Athenian building programmes, which could have relied on the continuity, scale and infrastructure of the *polis* projects. Therefore, for several cost categories inscriptional evidence of the 'market' prices of these commodities in Attica has been used instead of estimating the minimum costs.[22] The private individuals are also likely to have been involved themselves in the construction.[23] In the presented calculations skilled and unskilled work is not separated to reduce the complexity of the tables.

The detailed estimates of the cost in man-days of a single Hoepfner and Schwandner *Typenhaus* in the Piraeus is presented in table 1 and *Oikia Theta* at Salamis in table 2. The tables give the detailed cost calculations and references. The results are summarised in table 3. I have recently analysed most of the construction cost categories in Attica in the context of econometric assessment of the shipshed complexes in the Piraeus.[24] However, the cost of mudbrick walls and rooftiles in private houses require an additional discussion here.

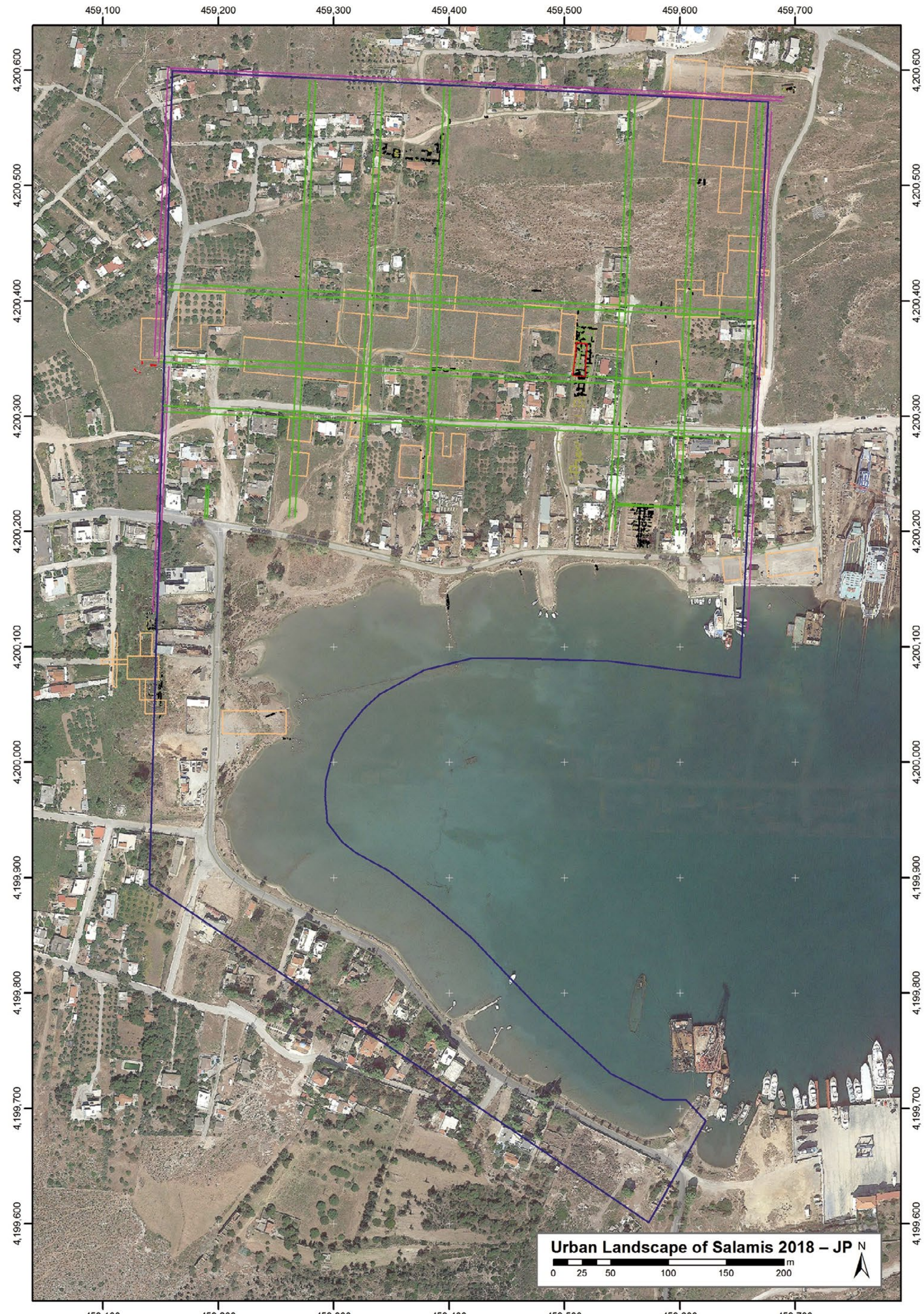

Fig. 4: Salamis. Reconstruction of the probable extent of the area of the ancient town at Ambelakia based on past excavations and new fieldwork 2016–2018. Total station survey data and reconstruction superimposed on top of Google Earth satellite image. Orange = GPR survey areas; green = reconstructed grid; red = *Oikia Theta*.

Fig. 5: Salamis, *Oikia Theta*. Total station survey of 2018 superimposed on the 2016 aerial orthomosaic of the excavated area.

B1. Excavating the foundation trenches 3 md Volume: depth 0.25 m, width 0.50 m, total length of trenches 117 m = 14.6 m^3 Soil used for lifting the floor levels, no transport Digging and throwing behind: 0.196 md/m^3 2.86 man-days, supervision (10%) 0.29 md
B2. Excavating a cistern 2 md Volume: 3.9 m^3 Quarrying rubble limestone (meteogene travertine): 0.250 md/m^3 1.96 man-days, supervision (10%) 0.20 md
B3. Stone rubble foundations 52 md Volume: height 0.50 m (measured 0.4–0.6 m), width 0.45 m, total length 105.6 m (excl. door openings) = 23.8 m^3 Quarrying rubble (as above): 0.250 md/m^3 4.96 man-days (cistern volume subtracted), supervision (10%) 0.50 md Loading & unloading: 0.396 md/m^3 7.85 man-days (cistern volume subtracted), supervision (10%) 0.79 md Carting 500 m: 0.75 md/tonne/km 19.34 man-days (cistern volume subtracted), supervision (10%) 1.93 md Construction of rubble foundations: 0.629 md/m^3 14.95 man-days (cistern volume included), supervision (10%) 1.49 md
B4. Stone threshold block 4 md One large threshold block (others of timber): volume: 0.54 m^3 Quarrying: 2.0 md/m^3 1.08 man-days, supervision (10%) 0.11 md Loading & unloading: 0.396 md/m^3 (as above) 0.21 man-days, supervision (10%) 0.02 md Carting 500 mm: 0.75 md/tonne/km 0.53 man-days, supervision (10%) 0.05 md Finishing: 4.0 md/m^3 2.16 man-days, supervision (10%) 0.22 md
B5. Mudbrick walls 136 md Floor height 3.25 m (inwards sloping roofs, no pediments, average height) Volume of mudbrick in walls: 104.9 m^3 (door openings subtracted) Price per cubic meter including transport in man-days: 0.853 md/m^3 89.51 man-days Construction of mudbrick walls: 0.4 md/m^3 (Devolder 2005, 169) 41.96 man-days, supervision (10%) 4.20 md
B6. Timber and doors 112 md (with 75% tiled roof); 149 md (with flat roof) Doors, door frames, timber thresholds, timbers for flat & tiled roofs Doors: 1 main entrance, 6 interior doors 1 double door: 20 dr = 10.00 man-days 6 single doors: 10 dr per door = 30.00 md Door frames: 1 × 2.0 m (width) + 6 × 1.5 m (width) Each frame would have needed 3 pieces of 10–14 footers No construction or sawing costs due to extra material, 38.50 md Small timber thresholds: 6 thresholds of 1.5 m × 0.6 m × 0.3 m 6 pieces of 10–14 footers No construction or sawing costs due to extra material, 11.00 md Beam (architrave): 1 × 3.667 dr (opening next to dining room), 1.83 md Tiled roofs above E & S parts: 13 + 32 rafters of 5.2 m needed, from one 16-footer 9 rafters, so 5 of them, 5.96 md (includes construction 1.5 md & sawing) Flat roof above NE part of house: 4 timbers of 4.5 m sawn into 16 beams, 14.54 md (includes construction 3 md; reeds & clay) Alternative of a flat roof above the whole house (area 4 times NE part) Cost of tiled roof rafters subtracted + additional area of flat roof: -5.96 md + 3 × 14.54 md = 37.66 md
B7. Roof tiles 154 md Price 4 ob. per pair of Laconian tiles Tiled roof: 459 pantiles, 387 covertiles 141.00 md Setting the roof tiles: 15.2 m2/md 11.50 man-days, supervision (10%) 1.15 md

Table 2: Salamis. Cost estimate of constructing *Oikia Theta* (275–250 BC).

An inscription from Eleusis gives the price of 1000 mudbricks including transport as 38 dr. in 329/8 BC.[25] Since the size of standard mudbricks at Eleusis is known from excavations,[26] the cost can be calculated as 0.853 md/m^3. This price would have included extraction of clay, production and drying of the bricks and their transport to the building site. Comparison with modern scholarship indicates that the market price at Eleusis was quite well in line with the probable production costs.[27]

	The Piraeus (plot size ca. 240 m², total floor area ca. 340 m²)	Salamis with 75% tiled roof (plot and floor area ca. 280 m²)	Salamis with flat roof (plot and floor area ca. 280 m²)
C1. Excavating the foundations	3 man-days	3 man-days	3 man-days
C2. Excavating a cistern:	2 man-days	2 man-days	2 man-days
C3. Stone rubble foundations			
quarrying:	5 man-days	5 man-days	5 man-days
transport:	27 man-days	30 man-days	30 man-days
construction:	15 man-days	16 man-days	16 man-days
C4. Stone threshold blocks			
quarrying:	6 man-days	1 man-day	1 man-day
transport:	4 man-days	1 man-day	1 man-day
finishing:	12 man-days	2 man-days	2 man-days
C5. Mudbrick walls			
material & transport:	164 man-days	90 man-days	90 man-days
construction:	85 man-days	46 man-days	46 man-days
C6. Timbers, including the cost of construction	177 man-days	112 man-days	149 man-days
C7. Rooftiles			
material:	108 man-days	141 man-days	
construction:	11 man-days	13 man-days	
Totals	ca. 620 man-days	ca. 460 man-days	ca. 350 man-days
Converted to 4th-c. day wage 2 dr.	ca. 1,200 dr.	ca. 900 dr.	ca. 700 dr.
Cost per m² of floor area	ca. 1.8 md/m²	ca. 1.7 md/m²	ca. 1.2 md/m²
In the Piraeus estimated 472 city blocks of 8 houses: Total cost ca. 2.3 million man-days or ca. 780 Talents (day wage of 2 dr)			
Cost estimate ranges for Salamis 60-80% coverage inside city walls: 80–110 Talents if all built with flat roof; 110–150 Talents with tiled roof			

Table 3: Comparison of costs of private houses in the Piraeus and at Salamis.

The type of rooftiles used in the Piraeus and at Salamis for private houses would have most likely been simple Laconian tiles with a large concave pan-tile and narrower convex cover-tile.[28] Fourth- and third-century inscriptional evidence points towards a price of four obols for a pair of tiles.[29] This is only one third of the typical cost of more complex Corinthian tiles used in monumental buildings.[30] Interestingly, the minimum production cost of a pair of Corinthian tiles would have been less than two obols calculated in fourth-century prices.[31] The difference between the sale price of approximately two drachmas for the pair and the low manufacturing costs is most likely explained by the profits made by the craftsmen and the risk of breakage of large ceramic tiles in production and transport.

Conclusions

Based on table 3, it can be argued that the mudbricks, timbers and rooftiles formed the main cost categories of building a private house. Production of mudbricks could have been carried out by the owner of the house to drive down the cost: it did not require any special expertise but a large open space would have been needed. After the initial phases of construction, it is unlikely that such a space would have been available for all households at a reasonable distance from the Piraeus, though that is more likely in the case of Salamis. Both the Piraeus and Salamis were built on limestone promontories with easy access to rubble and ashlar blocks for construction, so the cost of stone for the rubble foundations and threshold blocks would have been reasonable. The households had few alternatives to buying the needed timbers at market prices. The greatest opportunity for saving costs would have been in the choice of roof material: a flat clay roof would have required annual maintenance to keep it water resistant, but its material and construction costs were a fragment of buying rooftiles at the recorded Attic prices.

The total cost of a single storey house with a flat roof would have been approximately the same as an annual salary of a craftsman, which is quite reasonable. If the owner could not afford to have a tiled roof from the beginning, the houses could have been upgraded later. The more complex house in the Piraeus with two storeys on the northern side of the plot would have been considerably more expensive but it also utilised the available space more efficiently than at Salamis. Despite the smaller plot in the Piraeus, due to having two storeys in the main part, the total area of usable space is slightly larger than at Salamis (ca. 340 and ca. 280 sq. m.). The construction costs of the three options per square metre of floor area are presented in table 3. The greatest difference in the total price of a house in the Piraeus and at Salamis was made by the choice of either using a pitched roof with tiles or a flat clay roof.

Pritchett and Pippin have collected the epigraphical and literary evidence for house prices in Classical Attica. In the sales lists the fourth-century prices for a private house, *oikia*, varies between 145–575 dr. and the only recorded price of a tenement house, *synoikia*, is 3705 ⅓ dr.; in the speeches of Attic orators the price range for an *oikia* is 300–5000 dr. and the two cases of a *synoikia* 1600 and 10000 dr.[32] Based on the cost of materials and constructions costs (tables 1–3) it is quite probable that sums related by the orators include in most cases the price of the plot and not only the house. The relatively low sums of the realised sales could be explained by the unusual circumstances of the sales of confiscated properties. Occasional underestimation of the importance of a house as part of personal assets[33] might be due to fact that it is difficult to gain a full understanding of the overall importance and scale of the domestic architecture and construction[34] – the literary sources are able to paint only one part of the picture, but an econometric assessment can fill in the gaps by combining the information from both archaeological and inscriptional sources.

The cost estimates explain also why Athenians considered the window shutters, doors and rooftiles of the private properties as movable property: they were expensive and transportable, so they could be taken by the tenant when moving house and evacuated from farm houses when there was a risk of plundering during campaigns of war.[35] Razing of a private house, *kataskaphe*, was in some cases used as a punishment for a crime in Archaic and Classical Greece.[36] This chapter gives the practice an economic context in addition to its legal and symbolic one. The analyses presented here also highlight the risks of partial econometric calculations using, for example, only the cost of stone to estimate the total labour and material expenditure involved in monumental and private construction.[37]

The number of metic households in the fourth century has been estimated as 10,000 in Attica and most of these would have been in the Piraeus.[38] In order to accommodate this number, most of the house plots would have been shared between several families (*synoikiai*): the reconstructed plan has space allocated for 3776 plots (fig. 2). I have calculated the total cost of private houses in the Piraeus as 2.3 million man-days or ca. 800 talents and at Salamis in the region of 100 talents using the inflated day wage of two drachmas per day (table 3). This could be contrasted with the approximate fifth-century prices of 500 talents for the Parthenon[39] and 200 talents for 300 shipsheds in the Piraeus,[40] both calculated using the day wage of one drachma per day. Even though these sums are impressive, the costs of private and public construction projects can be set into perspective by keeping in mind the level of Athenian income and expenditure in the Classical period: for example, Xenophon gives the annual fifth-century Athenian income from the Delian league as 1000 talents,[41] and 200 talents would have been able to pay the wages of the rowers of 100 triremes only for a month or a little more.[42]

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Earlier versions of the work on econometrics of houses in the Piraeus have been presented at the Finnish Institute at Athens in 2015 and in the session organised by Ann Brysbaert and Anna Gutiérrez Garcia-M. at the 23rd European Association of Archaeologists meeting in 2017, Maastricht. The comparison between the Piraeus and Salamis has been presented at AIAC and Royal Holloway in 2018. Very warm thanks are due to all the audiences for their questions and comments.

Notes

[1] For the project by the Ephorate of Antiquities of West Attica, Piraeus and the Islands and the Finnish Institute at Athens, see acknowledgements at the end of the paper.
[2] Hoepfner et al. 1994; Pakkanen 2013a, 52–56.
[3] Pakkanen 2013b.
[4] Cf. Salmon 2001, 195.
[5] For discussions of the habited area inside the cities, see Muggia 1997; Hansen 2006, 35–63.
[6] DeLaine 1997, 106; Pakkanen 2013b, 56.
[7] Loomis 1998, 104–120. Stanier (1953, 70) already points out that inflation and regional differences in drachma standards complicate calculation of day-wages; cf. Pakkanen 2013b, 64–65, esp. nn. 70, 78.
[8] For an assessment of the range of studies and principles used in econometric studies in Greek Classical contexts, see Pakkanen 2013b.
[9] Morrison 1963. On estimation problems in general, see Weinstein – Adam 2008.
[10] Cf. DeLaine 1997, 109.
[11] Hurst 1902, 376.
[12] Thuc. 1.93.2–3; Diod. Sic. 11.41.2; Plut., Them. 19.2. On the walls of the Piraeus, see Garland 1987, 163–166.
[13] Arist. Pol. 2.5.1267 b 22–1268 a 14. For a discussion of the sources and archaeological material on dating the grid, see Pakkanen 2013b, 52. There is a recent tendency to date the plan towards the middle of 5th cent. or even later (see e.g. Shipley 2005, 352; Gill 2006). However, these arguments do not take into account the house remains under the Skeoutheke at Zea dated by pottery to the first half of the 5th cent. The house follows the typical Classical ground plan in the Piraeus and orientation of the 'Hippodamian' grid (Kraounaki 1994). On the role of Hippodamos in city planning, see Gehrke 1989 and Shipley's perceptive analysis (2005, 356–375).
[14] Hoepfner et al. 1994; Kraounaki 1994.
[15] Graves 1843; Rankov 2013, 423–435.
[16] Most of the features in fig. 2 follow Hoepfner et al. 1994 and Steinhauer 2000; for the suggestion of topography Zea, see Pakkanen 2013b, 57, esp. n. 16; see also Rankov 2013, 423–435.
[17] Hoepfner et al. 1994.
[18] However, as Shipley (2005, 368–373) points out, uniformity does not need to be interpreted as an expression of democracy as has been argued by Hoepfner and Schwandner (1994, 306).
[19] Chairetakis 2018, 97–257.
[20] Chairetakis 2018, 145–148.
[21] For the argument why the principle of estimating maximum output and minimum costs is often the most suitable approach, see DeLaine 1997, 105.
[22] Pritchett and Pippin (1956) provide a survey of textual evidence of construction materials in Attica; for more recent work with discussions of the building inscriptions and other textual sources, see Clark 1993; Pakkanen 2013b.
[23] Acton 2014, 226 f.

[24] Pakkanen 2013b.
[25] IG II2 1672, line 26; see also Pritchett – Pippin 1956, 286.
[26] Martin 1965, 56: 0.492 m × 0.492 m × 0.092 m (range 0.088–0.095 m).
[27] Wulff 1976, 109–111; Devolder 2005, 170–173; Lancaster 2017, 66–68.
[28] For a summary of the archaeological evidence, see Jones et al. 1973, 427, esp. n. 187.
[29] Pritchett – Pippin 1956, 281–283: IG II2 1672 from Eleusis gives the price for a pair as 4 ob., and 11 other prices from Epidauros and Delos are 3.5 ob.–1 dr. 2 ob.
[30] Pritchett – Pippin 1956, 283.
[31] A kiln-load of 1900 Corinthian pan-tiles had a minimum cost of 162 md and 4,100 cover-tiles of 197 md (Pakkanen 2013b, table 5.2), so manufacturing a pair would have cost ca. 0.13 md or ca. 1.6 ob.
[32] On the texts and terminology, see Pritchett – Pippin 1956, 261–276. On similar variation of property values at Olynthos, see Nevett 2000, 334–336.
[33] See, e.g., Acton 2014, 226.
[34] See also Nevett 2000.
[35] Thuc. 2.14.1; Dem. 24.197; 29.3; Lys. 19.31; Hell. Oxy. 12.4. For a discussion of the textual sources, see Hanson 1998, 108–110.
[36] Connor 1985.
[37] De Angelis (2003, 164–166) uses the cost of stone construction estimates as a proxy for the total costs of monumental temples in Sicily and Fitzjohn (2013) for private houses at Megara Hyblaia. For a more thorough discussion of the econometrics and early Greek architecture in south-eastern Sicily, see Lancaster 2017.
[38] Thür 1989, 118.
[39] Stanier 1953, 68–73.
[40] Pakkanen 2013b, 72–74.
[41] Xen. Anab. 7.1.27.
[42] Pakkanen 2013b, 72.

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Fig. 1, 4–5: by the author. – Fig. 2: by the author, based on a map by Graves 1843. – Fig. 3: by the author, based on Hoepfner – Schwandner 1994, fig. 33. –Tables 1–3: by the author.

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Building for the Gods: the Capitolium at Ostia

Janet DeLaine

The early Hadrianic Capitolium at Ostia was the largest and most imposing of the city's temples,[1] erected in a prestige location at the head of the forum and linked to the Tiber by a processional way. The hexastyle pseudo-peripteral temple represents the greatest input of resources in terms of materials and construction in Ostia's religious landscape, and has been argued to have been the gift of the emperor Hadrian.[2] The podium and cella were in a high-quality version of the brick-faced concrete typical of the period at Ostia,[3] but the 38-foot order was marble with Phrygian columns (fig. 1). The marble decoration was exceptional in the context of Ostia, with some elements, including the threshold of Lucullan marble weighing c. 3.5 tonnes, having their closest parallels in the Pantheon at Rome, built just a few years previously.

This paper tests our current understanding of this building project by putting it on a firm economic footing, and comparing it quantitatively both to the other major temple in Ostia and to the Pantheon itself. The calculations of materials, transport and manpower are based on a now well-established approach, and the basic assumptions are well published.[4] A few assumptions specific to this analysis should be noted. The roof timbers and some minor elements have been omitted, the calculations have been based on a simplified geometry, and all elements have been reduced to equivalents in man-days of unskilled labour (mdle) in order to allow the inclusion of transport and fuel for the production of building materials. For transport I have used the generally accepted ratio of 1 : 8 : 42 for sea : river : land,[5] but converted it to equivalents of land transport for each km for each tonne, taking the distance from ORBIS.[6] The resulting figures, rounded to a single significant digit,

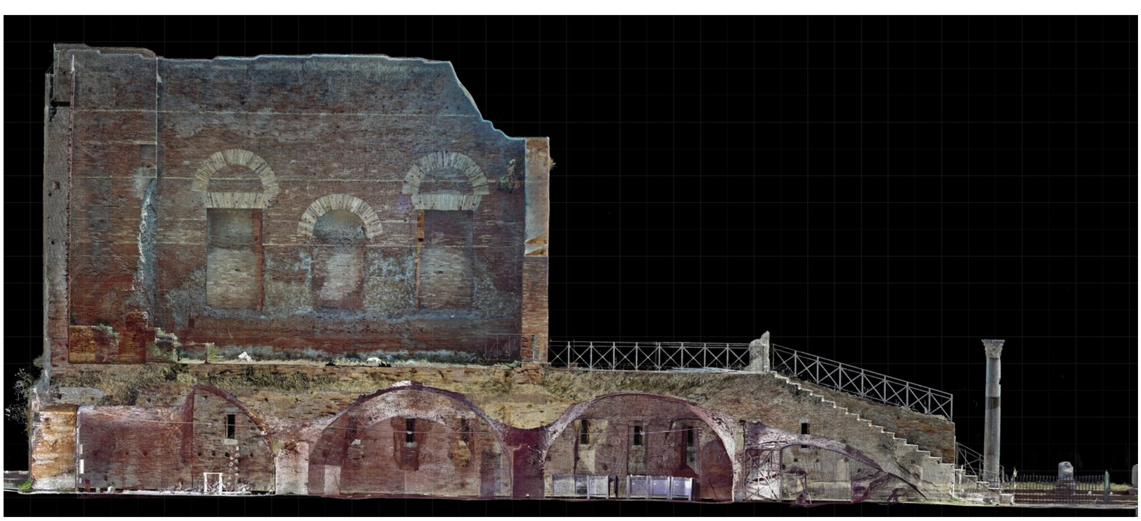

Fig. 1: Ostia, Capitolium, longitudinal section. Laser scan courtesy Yoshiki Hori, Department of Architecture and Engineering, Kyushu University

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	quantity (m³)	**produce** mdle (000s)	**transport** mdle (000s)	**construct and finish** mdle (000s)	**TOTAL** mdle (000s)	**% of total labour**	**% total including transport**
structure	2900	10	15	10	20	**20%**	**10%**
orders	590	8	150	60	70	**60%**	**80%**
veneer	80	2	15	20	20	**20%**	**10%**
TOTAL	**3600**	**20**	**180**	**90**	**270**		
% of total including transport		**5%**	**70%**	**25%**			

Table1: Resource requirements of the Capitolium, Ostia, in man-days of unskilled labour equivalents.

are very general estimates designed to give orders of magnitude, based on minimum figures, for purposes of comparison.

The results are summarised in table 1.[7] Although the main structure accounts for 80% of the total volume of the materials used, it only employs 20% of the total labour, and 10% of the labour plus transport, while the marble orders account for just over 15% of the materials but 80% of the labour plus transport, the remainder being taken up with the marble for veneer. At all stages the orders require the most cost and labour, with transport for the Phrygian column shafts representing the largest single element.

The Capitolium can be compared to the hexastyle Temple to Roma and Augustus at the other end of the forum.[8] Erected probably later in the reign of Augustus with a 32 Roman foot order, it has been calculated to have used 328m³ of Luna marble, with the main structure of concrete.[9] While the linear measurements are roughly three-quarters of those of the Capitolium, the volume of construction is more like a half, and sourcing the marble in Italy should have further reduced the costs.

The near-contemporary Pantheon has a completely different cost profile.[10] Just looking at the work on site without production and transport, construction accounts for 70% of the labour requirements and the orders 30%, while for the Capitolium the construction is only 15% and the orders 85%. This study therefore demonstrates the overwhelming importance of large marble columnar orders in the overall cost of traditional temples, even where the main structure was made of rubble construction. For Ostia, it has reinforced Pensabene's suggestion that the Capitolium, as well as the Temple of Roma and Augustus, required imperial input to provide the high quality marbles for the main orders. For traditional temples, therefore, the orders alone could be used as an indication of the relative cost range of buildings; the Pantheon is quite another story.

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Notes

[1] The analysis is based on Albo 2002. Many thanks to Yoshiki Hori for making available a detailed laser scan of the building (fig. 1).
[2] Pensabene 1996, 198 f.
[3] DeLaine 2002, 65–71.
[4] DeLaine 1997; 2001; 2017; 2018.
[5] Russell 2013, 95–97.
[6] Scheidel – Meeks 2012.
[7] Thanks are due to Mark Griffiths for his invaluable help with the calculations.
[8] Geremia Nucci 2013.
[9] Pensabene 2007, 135–144.
[10] DeLaine 2015.

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Fig. 1: Laser scan courtesy Yoshiki Hori, Department of Architecture and Engineering, Kyushu University. – Table 1: by the author.

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Stone for a Provincial Capital – Procurement and Transport Logistics for the Monumentalization of Roman Tarraco

Anna Gutiérrez Garcia-M.

Tarraco and Its Stones

In early Roman times, Tarraco (a small colony developed from a *praesidium* – or military camp – established in the northeast coast of Spain shortly after 218 BC during the Second Punic War) became the capital town of the largest Roman province in the western Mediterranean.[1] This change of status involved also a significant change of the town landscape and was achieved after an intense building activity that totally modified its architecture and urbanism. This process took place since the late Republican–Augustan period, but was especially important during the following centuries. During the last decades, the understanding of this Roman capital town has leapt forward thanks to the several archaeological excavations and research programs carried out.[2] As a result, we know now that the Julio-Claudian period witnessed the beginning of large-scale works that continued during the 1st century AD, with extensive renovation works at the colonial forum and, most significantly, the construction of a monumental complex, the provincial forum, at the upper part of the town[3] where three enormous spaces were built: a circus, a large terrace with political and administrative functions for the whole province, and a religious area with a temple dedicated to Augustus enclosed by a portico. This building program was finished in Flavian times and saw an important restoration under Emperor Hadrian's reign.

In parallel, the studies undertaken on Tarraco's territory concerning local stone resources allow for a more precise and comprehensive picture of the first steps of the constructive process, and together with those concerning the imported marbles and other ornamental stones found at the town shed light on the mechanisms that enabled to complete the large building ventures that shaped Roman Tarraco's image. These studies are part of a growing research trend in Spain whose results not only have broadened our understanding of local stone exploitation and industry in Roman times, but has also changed the previous conceptions that relegated local ornamental stones of the Iberian Peninsula to mere 'substitutes' of the most prized imported ones.[4]

Unlike other regions of Spain,[5] the area around Tarraco is not especially renowned for its decorative stones. The only two ornamental stones found in the *conventus Tarraconensis* are Santa Tecla stone, a yellow/pinkish well-recrystallised Cretaceous limestone cropping out just about 1 km northeast from the urban center, and the

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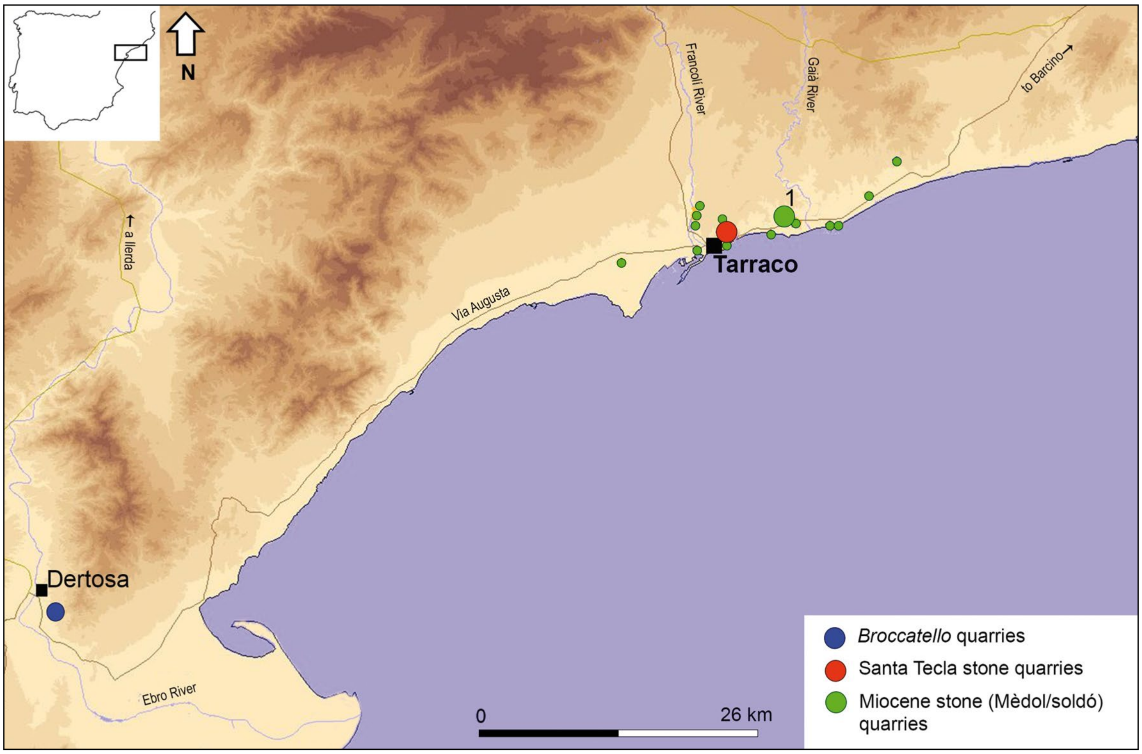

Fig. 1: Map showing the quarries on the territory of Tarraco, grouped according to the type of stone they provide; 1- El Mèdol quarry.

famed *broccatello di Spagna*, a golden/purple shelly limestone from about 80 km south from Tarraco and on the Ebro river banks (fig. 1). The first was extensively used to embellish the major buildings and public spaces of Tarraco, while the second one was used next to the best, most prized *marmora* imported from all corners of the Roman Empire and even had a significant distribution within and outside the Iberian Peninsula.[6] Yet the geological panorama of Tarraco's territory is clearly dominated by a shelly, Miocene limestone outcrop from which different types of stones were obtained. Among them, the most predominant and used were El Mèdol/soldó stone, two varieties of the same stone type (fig. 1).[7] Although they were also supplied as raw material for other types of works (sculpture, epigraphy, sarcophagi production), these local stones were primarily used for building purposes.

The long periods of extensive building activity at Tarraco meant that the economic factors and the dynamics directly related with the construction processes were strongly at play in the town. Large-scale projects obviously involved a massive amount of materials, people, resources and money.[8] Many of them were sourced as close as possible, so they were provided by the town itself or came from its immediate territory.

Building Stone Procurement: Local Stone and the Quarry of El Mèdol

Among the different sorts of building materials needed for any construction project, stone has a key role. Indeed, stone was ubiquitously used in antiquity and at the same time, it is the material most largely preserved in the archaeological record due to its own physical properties. Tarraco is not an exception. Large quantities needed to be located, selected, extracted, transformed and transported from the source to the town to be used in the Colonial and Provincial forums of Tarraco from their creation and throughout all the reform phases. Yet it was also used for non-public buildings both in urban contexts and outside the town walls, as well as for the several infrastructures (water-supply system and road network) implemented for the smooth functioning of the urban life at Tarraco.

Numerous quarries were opened on the Miocene formation outcropping mostly north from the town to obtain the local Miocene shelly limestone, a strong yet easy to cut material, which is perfect for building purposes and became the main source of bulk material.[9] The case of the Roman aqueduct quarries highlights the strong link between some of these quarry sites and specific nearby monuments or villas, as well as the intensive search for stone sources as close as possible. Yet among all the quarry sites of Tarraco's territory El Mèdol quarry stands out. This deep, opencast quarry was, by far, the largest single exploitation in whole northeastern Hispania. It has been recently object of an in-depth study including a field survey of its surroundings, the detailed recording of the fronts, debris heaps and other quarrying-related features as well as some archaeological excavations at particularly interesting points. They consisted in eight test pits, two of which were opened on the eastern sector of the quarry and shed light on the extraction process (fig. 2) and the other six on the central area called El Clot, this area consists on a large, 20 meters deep pit with a monolithic pinnacle standing on its center (fig. 3). The results of all these actions provided, among others:

- a comprehensive, detailed plan of all the quarry sections (including a new small area of extraction unknown until now),
- a substantial increase on the estimated volume of extraction at this site, which was in fact far larger than previously thought (from 66,000 to ca. 150,000 cubic meters, i.e. 350,000 tons of stone), and
- the identification of large debris humps, especially on the western section of the whole quarrying site.

All these observations have increased our knowledge of this site, which is thus confirmed as the first and foremost supplier of the stone for the colonial and provincial forums (as well as, other buildings and infrastructures of Tarraco),[10] as well as the phases of the building of Tarraco.

Indeed, the archaeological excavations provided solid evidence to date the main period of extraction to an earlier era and not in the Flavian period as has been assumed

Fig. 2: Detail of the group of semi-detached blocks located at the test pit 1 in the eastern sector of El Mèdol quarry.

until now. The evidence consists on a Roman denarius found in stratigraphic context and minted under Tiberius (RIC I, 30, dated 36/37 AD) and a C^{14} analysis for a charred wood dating from between the years 27 BC to 19 AD uncovered at the base of the pinnacle during the archaeological excavations of 2013.[11] Indeed, we can assume that the quarry was already supplying stone for the first main construction of the town, the late Republican walls, and that the exploitation continued in full in the Augustan period since the southeastern area of El Clot already reached its full depth of 20 m at the bottom of the pinnacle in the early Imperial period.

Another important aspect is the discovery of what seems to be a point of control of the production at the entrance of the pit; it is located mid-way of the ramp descending towards the lower part of the extraction area and one of the already mentioned coins was found there. Near this spot and right in front of the quarry entrance, a large deposit of discarded blocks existed until very recently.[12] A large collection of ephemeral inscriptions on these abandoned blocks has been discovered and its study, which is still in progress but from which some observations have been presented, provides an extremely interesting insight on the complexity of the organization of the supply.[13]

Fig. 3: View of El Clot area with the central pinnacle, at El Mèdol quarry.

The huge impact of stone extraction at El Mèdol can be explained by the size of the outcrop, the quality of the stone and its location relatively near the seashore, which was the easiest way to ensure a constant supply of blocks to the town. The discovery of a loading dock on a nearby beach provided the most interesting evidence. This infrastructure is of about 40 m long and 11 m wide and takes advantage of the natural features of the rock, in which it is carved to provide a flat platform acting as a natural breakwater (fig. 4). The sea level has risen here since Roman times, but the presence of square post-holes near the rectilinear channel, together with the location of this dock in relation to the sea currents, strongly point to this being the place from which the blocks were sent to the town by coastal shipping.[14] The effort of cutting this infrastructure means that it was to be intensively used, and the existence of a nearby small Roman site where pottery of the second third of the 1st century AD has surfaced suggests that it was in use when the provincial forum was under construction.

The comprehensive consideration of the quarry and this infrastructure has, thus, shed new light on the extent, chronology and dynamics of the local resource exploitation directly engaged in this phase of great constructive activity and urban renovation.

Decorative Stone Procurement: Local and Distant Materials

On the other hand, the increasing studies on marble and other ornamental stone remains and the advances on Tarraco's harbor's help to understand the various-scale dynamics that provided the decorative stone and sculptures needed to give these public buildings the dignity or *decorum* to befit its status as capital of the largest province of the western

Fig. 4: View of the loading dock (channel and rocky flat platform acting as a natural breakwater) at Roca Plana, near El Mèdol quarry.

Roman Empire (*Provincia Hispania Citerior* or *Tarraconensis*). Marbles and other decorative stones were used in the monumental building programmes of early Roman period as a means to display political authority, economic strength and social prominence, and they played a key role in establishing a self-image of the provincial elites.[15]

The decoration of Tarraco's public buildings and spaces also put in motion an extensive network linking Tarraco with the rest of the province and even more distant territories. They were mostly used at the highly symbolic provincial forum where marbles and other decorative stones from exotic origin were employed. Examples include the numerous columns shafts in Troad granite from Turkey[16] and the decorative elements in marble from Luni, modern Carrara, well-attested in Tarraco's architectural decoration since Julio-Claudian times,[17] but also giallo antico or *marmor Numidicum,* pavonnazzetto or *marmor Docimium*, Africano of *marmor luculleum* and cipollino or *marmor Carystium*[18] and less frequent pieces of other non-Spanish marbles[19] as well as the already mentioned broccatello and vast quantities of the local decorative limestone already mentioned (i.e. Santa Tecla stone). The latter arrived directly from the nearby quarries, but the marbles intended for the provincial forum most likely had a specific arrival point on the nearby area of El Miracle beach, right below the upper part of Tarraco. Not only is it closer to the final destination and mooring there would have avoided disrupting the harbor and the town's traffic, which was indeed a main problem,[20] but it is also attested by

Fig. 5: 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 area as well as the direction of the transport routes towards Tarraco.

the discovery of granite column shafts lying underwater just in front of the Punta del Miracle promontory,[21] nearby the homonymous beach. This more convenient point would probably have been used to offload the stones supplied by El Mèdol quarry for the provincial forum construction site, while the blocks intended for the colonial forum were probably brought to the harbour (fig. 5).

The scattered location of the marble finds and the lack of detailed quantification studies render it difficult to have a global estimate of the use of each type of marble[22] and to determine to which part/phase of the complex they belonged, but is seems nevertheless clear that Carrara marble was extensively used[23] at the provincial forum and the forum's large-scale and position on top of the hill – as sort of an acropolis presided over by the temple of Augustus – ensured an outstanding scenographic effect within Tarraco's urban landscape.

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Notes

[1] The *Provincia Hispania Citerior* at first, and *Hispania Tarraconensis* province after Augustus' administrative reorganisation.

[2] For an overview of the archaeological work until 2015, see Macias – Rodà 2015, and a short, updated summary is provided in Gutiérrez Garcia-M. – Vinci 2018.

[3] Tarraco was founded on a small hill located of up to 80 masl located on the seashore and the Tulcis (modern Francolí) river mouth; the slope between its harbour and lower town, and the upper part is, thus, significant and played a key role in the urban scenography of Tarraco's landscape.

[4] Rodà de Llanza 2012 provides an summary of research undertaken up to 2012, and the later ones have been presented in several scientific forums: see in particular, the Proceedings of the Association for the Study of Marbles and Other Stones (ASMOSIA) Conferences (Schvoever 1999; Herrmann et al. 2002; Lazzarini 2002; Maniatis 2009; Jockey 2011; Gutiérrez Garcia-M. et al. 2012; Pensabene – Gasparini 2015) and the Arqueología de la Construcción meetings (Camporeale et al. 2010; Camporeale et al. 2012; Bonetto et al. 2014). See also, Gutiérrez Garcia-M. 2020.

[5] Such as the south (ancient Baetica and Lusitania provinces) which are rich in high-quality marbles (Àlvarez et al. 2009), or even the NW, where small outcrops of marbles used in Roman times have been located (Gutiérrez Garcia-M. et al. 2016; González Soutelo – Gutiérrez Garcia-M. 2020).

[6] Àlvarez et al. 2009; Àlvarez Pérez et al. 2009; Álvarez i Pérez et al. 2010; Gutiérrez Garcia-M. 2014.

[7] They basically differ on the bioclastic content and can usually be found in one same quarry (Gutiérrez Garcia-M. 2009, 106–108, 112; Gutiérrez Garcia-M. 2011, 325).

[8] See, just to mention one example, the ground-breaking work of J. DeLaine concerning the Baths of Caracalla (DeLaine 1997).

[9] As demonstrated by its continuous use and re-use of already-cut standard-sized dimension stones and ashlars over the following centuries (Menchon – Pastor 2015).

[10] Since El Mèdol stone was also employed for a wide variety of products other than building material, as shown by the several examples of sarcophagi, inscriptions, sculptures and even portraits – some of which still present traces of stucco – found in the town (Gutiérrez Garcia-M. 2009, 112, table 5).

[11] López Vilar – Gutiérrez Garcia-M. 2016, 185, 191.

[12] Located between two main roads, the AP-7 and the A-7 motorways, it was object of a series of

archaeological excavations due to the enlargement of the second one carried out between 2007 and 2009 (Roig Pérez et al. 2011).
[13] Gutiérrez Garcia-M. – Vinci 2018; Vinci 2019.
[14] López Vilar – Gutiérrez Garcia-M. 2017.
[15] See Pensabene 2004 for a summary on the specific case of Hispania.
[16] Rodà de Llanza et al. 2012.
[17] Pensabene 1993; Pensabene – Mar 2004.
[18] 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.
[19] 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 in Lazzarini 2004, 90 f.) and North Africa (Egyptian red porphyry, porfido rosso/*lapis Porphyrites* and greco scritto).
[20] Pensabene – Domingo Magaña 2017.
[21] Pérez 2007.
[22] Most of them were not found in situ and assembled to be reuse/re-cutting in workshops, either probably related to the Hadrianic reform or to later phases (Àlvarez et al. 2012; Arola et al. 2012; Gutiérrez Garcia-M. – López Vilar 2012).
[23] Pensabene 1993; Gutiérrez Garcia-M. – Rodà de Llanza 2012. About 4,000 m^3 are estimated to have been employed only for the temple of Augustus and the upper terrace (Mar – Pensabene 2010, 528–531).

Image Credits

Figs. 1–4: A. Gutiérrez Garcia-M. – Fig. 5: GoogleEarth, with modifications by the author.

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Shipments Great and Small: Moving Building Materials by Sea

Ben Russell

Introduction

Demand for prestige materials, primarily from major imperially-funded projects but also from locally-funded schemes all around the Roman world, put enormous pressure on the producers of raw materials and, especially, transporters. Big buildings demanded big materials and this had an impact on the infrastructure through which these materials were used and the means of transport employed. But the fashion for stone construction more generally also meant that vast quantities of this material were moved overseas throughout the Roman period. As Knoop and Jones have remarked, in a study on stone working in the Middle Ages: 'apart from the selection of suitable stone, probably the most important problem in connection with the supply of building materials was that of carriage.'[1] In this short paper I will consider what the shipwreck evidence reveals about the dynamics of this traffic, focusing on cargoes both big and small, and what they reveal about the commercial mechanisms behind them.

The Shipwrecks: Dataset and Chronology

Our shipwreck record is ever expanding. New wrecks are continually being discovered and old ones re-examined; important recent initiatives, like the publication of Strauss' dataset of wrecks on the Oxford Roman Economy Project's website and McCormick's mapping of sites on the *Digital Atlas of Roman and Medieval Civilisations*, show how our knowledge of the underwater record has increased since Parker's seminal *Ancient Shipwrecks of the Mediterranean and the Roman Provinces.*[2] Although several new stone wrecks have been found in recent years, most of these are yet to be fully published and so for the purposes of this contribution the dataset that I published in 2013, which constitutes 95 wrecks with stone cargoes, will be used.[3] As the distribution map in fig. 1 shows, the known wrecks are spread all around the Mediterranean, though with significant concentrations in French and Italian waters. There are good reasons to think that the density of wrecks in both these areas reflects the original intensity of maritime traffic but it should also be noted that wrecks are primarily found in areas where diving is popular and visibility good; 66% of the wrecks documented by Parker are located in water less than 30 m deep.[4] The empty areas on this distribution map need to be treated with caution, therefore; absence of evidence is not evidence of absence, and there are certainly more unpublished wrecks containing stone cargoes in the Aegean, for instance.

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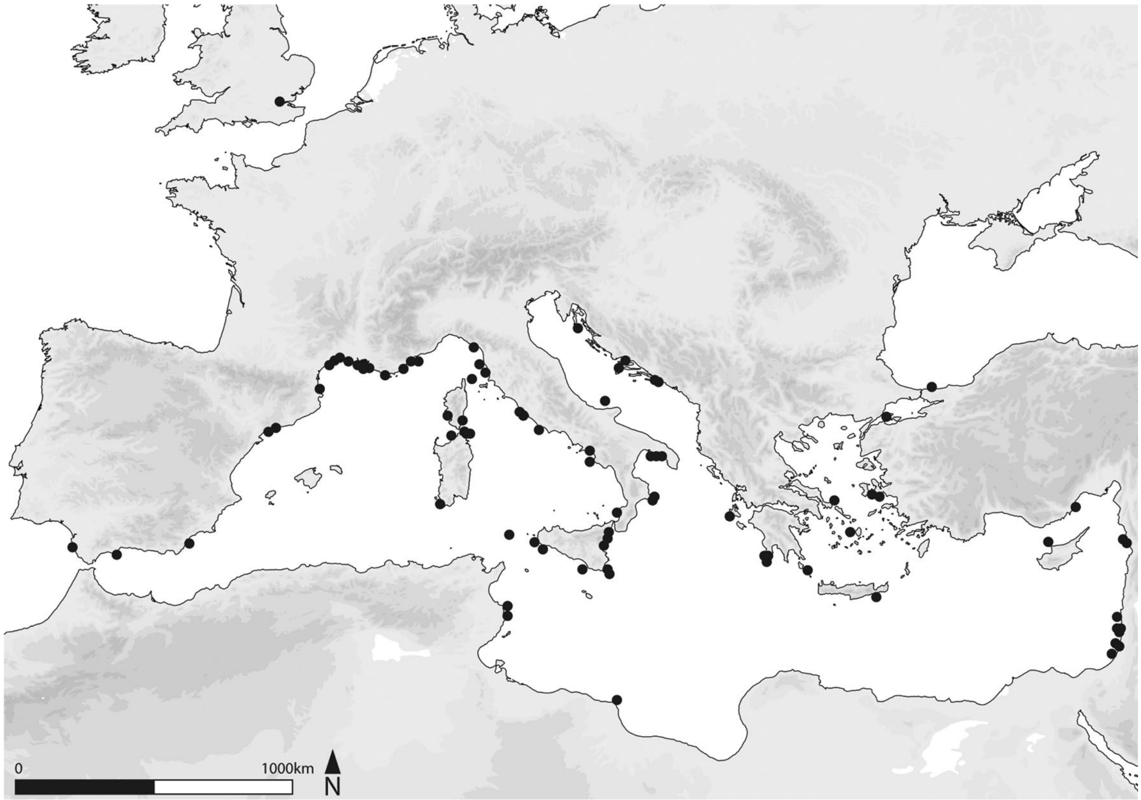

Fig. 1: Distribution of shipwrecks with stone cargoes.

The chronology of these wrecks shows some interesting trends, especially when considered against the background of the overall peak in shipwrecks, located by Parker in the 1st century BC and by Wilson in the 1st century AD.[5] Both those wrecks datable on archaeological, epigraphic, numismatic or other grounds to a specific 100-year period and those dated more generally show a peak in the 3rd century AD (fig. 2). This is particularly striking when one considers the evidence from land-based sites, which would indicate a zenith in the long-distance stone trade somewhere between the late 1st century AD and the late 2nd century AD.

The first thing that should be noted about this dataset, however, is that the wrecks that contribute to this third-century column on the histogram primarily belong in the first half of that century. Equally, this total is inflated by wrecks dated more broadly to either the end of the 2nd or the early 3rd century AD; in other words, much of this activity is Severan in date, an era in which large-scale construction at Rome but also a range of provincial centres boomed.

The second thing to note about the wrecks dated to this period is that a substantial number were carrying sarcophagi rather than architectural elements (fig. 3). In fact, the number of third-century ships carrying stone for building is roughly the same as in the 1st century AD. These sarcophagus wrecks are indicative of demand for imported marble for

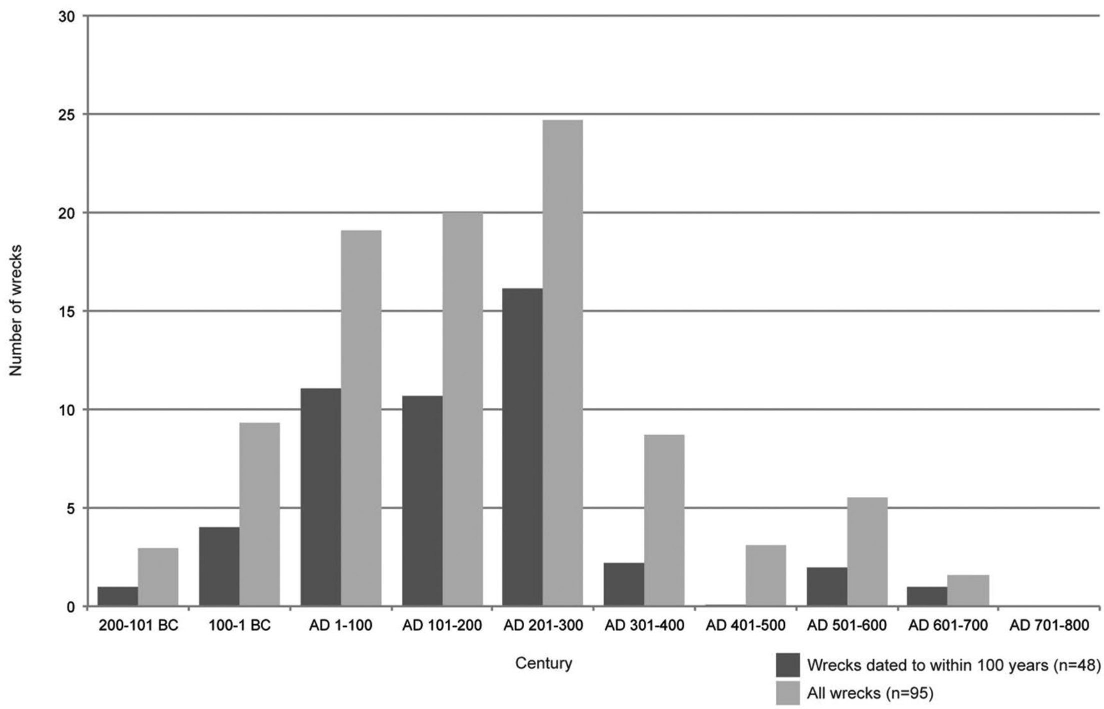

Fig. 2: Histogram of shipwrecks with stone cargoes.

funerary monuments, which in fact continued right through the 3rd and into the 4th century AD, as evidence from the various Adriatic centres, like Aquileia and Ravenna, shows.[6]

The third point to note about the chronology of these shipwrecks is that these later examples are primarily from southern Italian waters. The number of wrecks elsewhere in the western Mediterranean drops off after the 2nd century AD (fig. 4). In contrast, the totals from the eastern Mediterranean stay relatively low throughout the period and are only higher than the western Mediterranean numbers in the 5th to 7th centuries.

Big Ships

Why this concentration of shipwrecks in this relatively late period off southern Italy? These wrecks are focused along the southern coasts of Puglia and Calabria, and along eastern Sicily. All of these vessels were carrying eastern materials – in fact by the 3rd century AD our dataset is heavily dominated by vessels carrying stones from eastern quarries. There is a clear correlation here between the scale and direction of this traffic and the evidence for marble use on land: Luna marble, the main western material identified in shipwreck cargoes (primarily in the Tyrrhenian and off southern France), drops off in use in the mid 2nd century AD and is increasingly replaced by eastern materials (especially Prokonnesian marble), notably at Rome.[7]

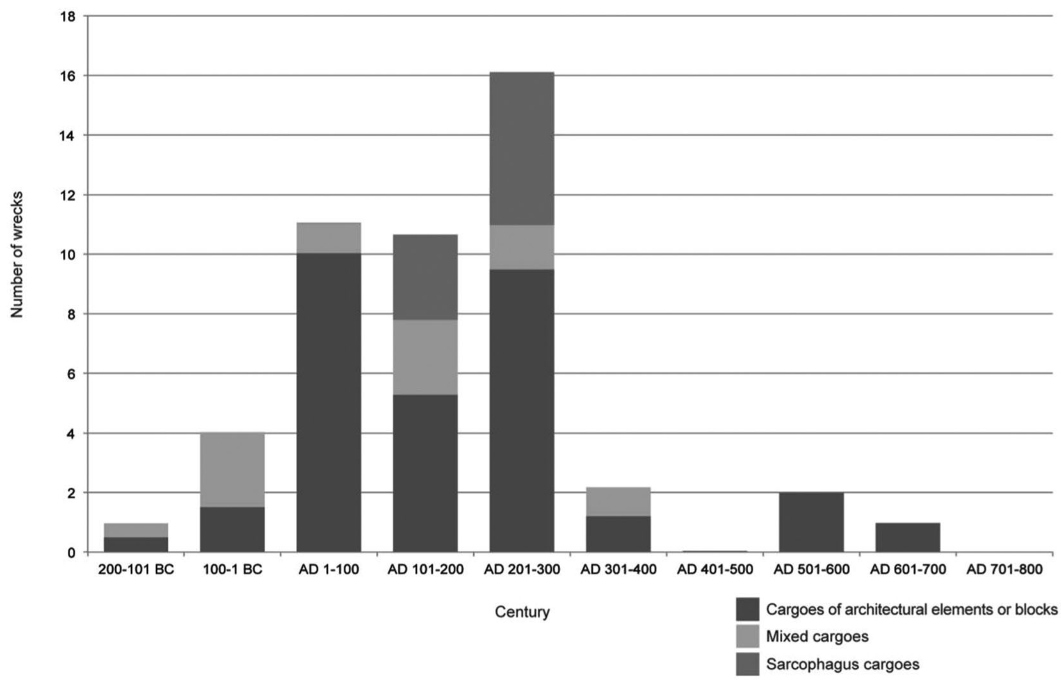

Fig. 3: Histogram of cargo types on shipwrecks datable to a specific 100-year period.

These southern Italian vessels are found on the sea route from the Aegean to Rome and the distance that these ships had to have travelled might explain the number we find wrecked. The trajectories of this traffic can be seen if we map these wrecks based on the likely origin of their cargoes, using the methodology suggested by Parker, which takes account of the divisions of the Mediterranean sailed through rather than the distance traversed (fig. 5).[8] As this map shows, almost all the wrecks in the *Ionium* sea were carrying materials from extremely far away. In the graph form of these data (fig. 6), we can see that western materials were not being moved far – or at least the shipwreck evidence does not give us any insight into those materials that were moved further – while the bulk of the eastern materials that we find in wrecks were being distributed substantial distances. The ships traversing the Ionian sea and rounding southern Italy were travelling considerably further and through far more dangerous seas than those plying the Tyrrhenian and Ligurian seas, for instance. However, the long-distance maritime trade in eastern marbles did not begin in the Severan period; it had, in fact, been going on to varying degrees since the 2nd century BC and highly intensively since the mid to late 1st century AD. Considering this, one might expect more second- rather than third-century wrecks in this area. Distance travelled cannot be the only factor explaining the number of third-century Italian wrecks.

The size of these ships' cargoes suggests another possibility. Many of these Italian ships were carrying cargoes that are among the largest found anywhere. Table 1 lists the smallest (<40 tonnes) and largest (>150 tonnes) recorded stone cargoes. French wrecks,

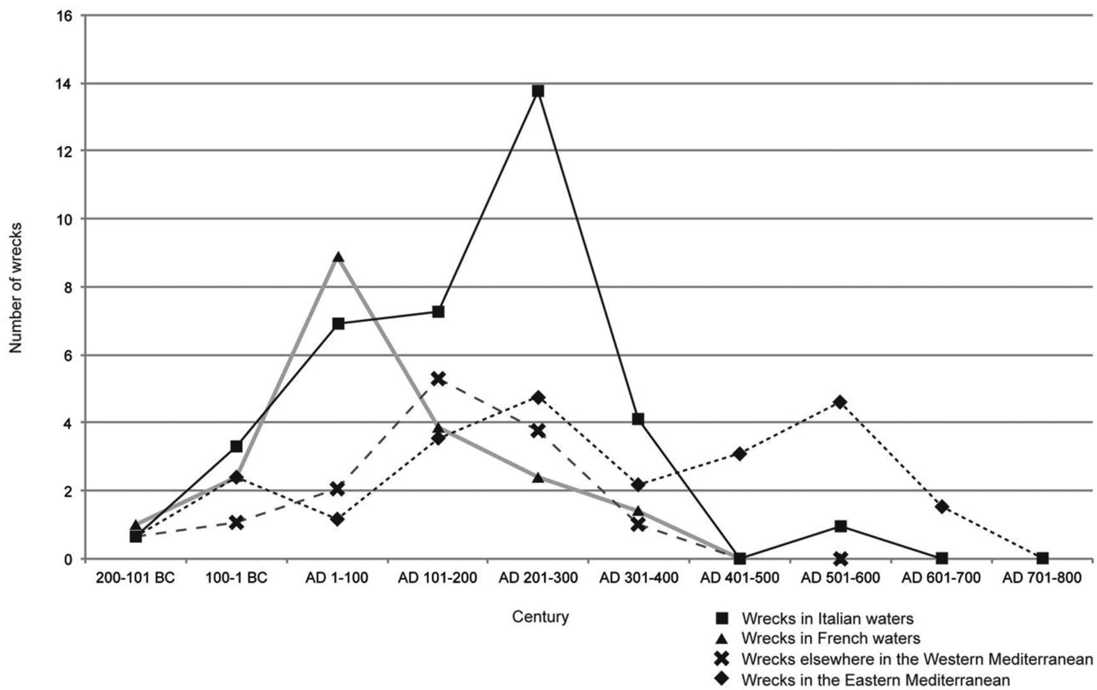

Fig. 4: Graph of the location of shipwrecks by century.

as well as Croatian ones, dominate the list of the smallest ones and southern Italian ones the list of largest ones. The largest three wrecks were all enormous, with stone cargoes in excess of 300 tonnes: Capo Granitola A, Isola delle Correnti, and Punta Scifo B.[9] Individual cargoes did not get larger over time; there is no suggestion of a general trend in cargo or, indeed, ship size. However, there are more large cargoes attested in the 3rd century AD: four are dated securely to that century with another two being dated to the 2nd–3rd and 3rd–4th centuries respectively, compared to one in the 1st century BC and one in the 1st century AD. These cargo weights are not equivalent to the deadweight tonnages of the vessels carrying them, that is the amount of cargo these ships could carry – their capacity. Perishable commodities could have formed an additional component of the cargo and it is also likely that ships carrying cargoes as heavy as stone blocks would have travelled under-capacity: as Throckmorton noted, 'modern practice is never to load a ship with stone beyond about two-thirds of its gross tonnage.'[10] 'Gross tonnage' here refers to the volume of the vessels.

Considering this, two options relating to these vessels present themselves. If the Capo Granitola A, Isola delle Correnti, and Punta Scifo B ships were travelling under-capacity, with just two-thirds of their volume filled by cargo, then their deadweight tonnages – their capacities if full – could have been over 500 tonnes. This would put these three ships among the very largest known from the Roman period: the Madrague de Giens wreck has an estimated deadweight tonnage of ca. 400 tonnes and the Albegna

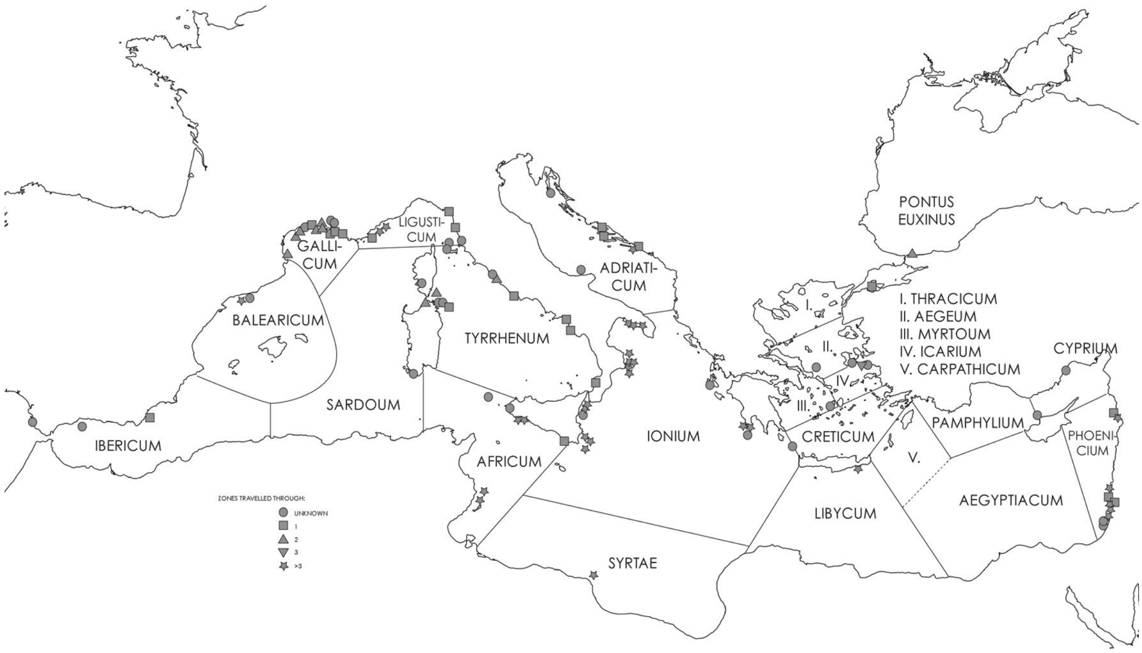

Fig. 5: Map showing the zones through which cargoes have travelled from source.

wreck, the largest known, around 500–600 tonnes; both are dated to the 1st century BC.[11] In the case of the Isola delle Correnti wreck, Kapitän used the hull remains to estimate its length at 40–48 m, its beam at 10–12 m, and its height from keel to deck at 5–6 m.[12] This would make it larger than the Madrague de Giens ship, estimated at 37.5 m in length.[13] In the case of the Capo Granitola A and Punta Scifo B ships not enough remains of the hulls to allow a similar reconstruction. Either they were similarly large or, alternatively, these vessels were not travelling sensibly under-capacity and were in fact dangerously overloaded.

The fact that more large cargoes of stone are attested in the third century than earlier might indicate a certain pressure on transporters. Large building projects were still taking place at Rome but the general number of ships sailing on the Mediterranean, to judge from the shipwreck record, would seem to have dropped in this period. It is possible, therefore, that those large ships that were available were increasingly used for stone transport and, in some cases, even overburdened, in order to cut down the time it took to transport building supplies to major projects. Meijer has also suggested that the imperial system of providing incentives for shippers engaged in the transport of imperial produced might also have a bearing on the later peak in shipwrecks with stone cargoes.[14] As incentives waned in the 2nd century, he argued, the state had fewer ships to pick from. He notes that analysis of the hull remains of the Torre Sgarrata ship, dated to the late 2nd or early 3rd century AD, suggest it was old.[15] More analysis of ships' timbers is required to confirm this overall hypothesis but the limited evidence available at the moment is suggestive.

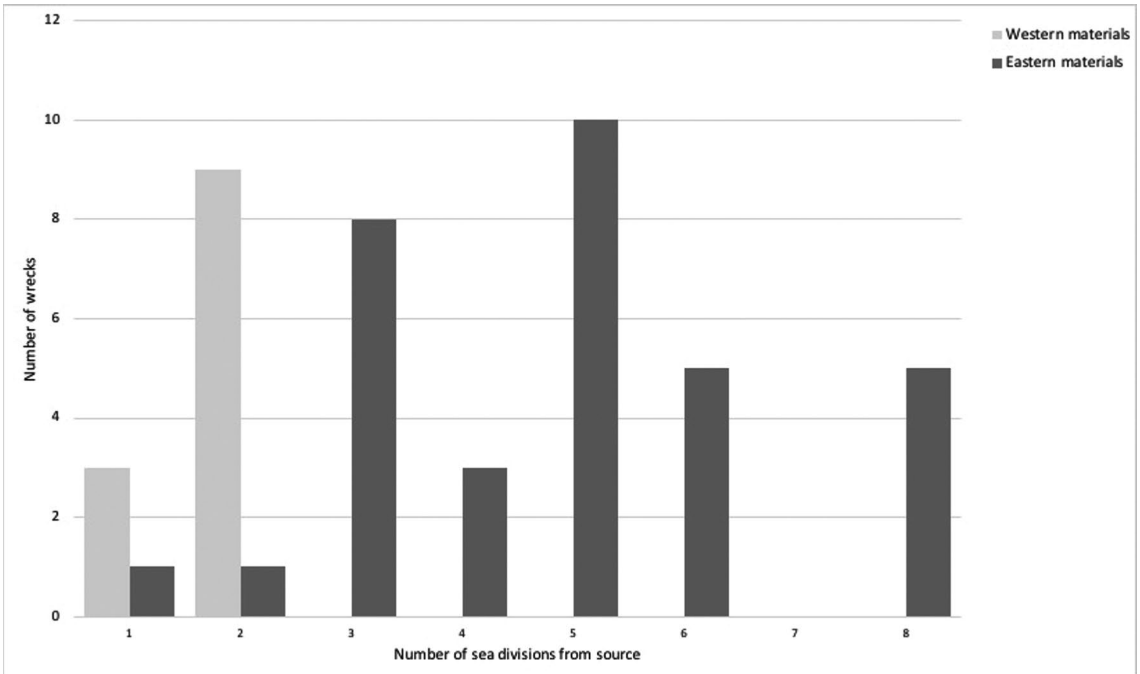

Fig. 6: Graph of the data mapped in fig. 5.

Even if these vessels were sensibly loaded and not travelling at capacity, transporting a material as heavy as stone on a large ship brought with it significant risks. Casson, in fact, when arguing for a specialised variety of ship for stone transport – a *navis lapidaria* – suggested that such a transporter should have been 'shorter and sturdier' than ordinary merchantmen and ideally also reinforced.[16] If a ship the size of the Isola delle Correnti one was fitted out with a reinforced hull this would have added substantially to its displacement (the weight of the cargo and the ship). Considering that the lightweight tonnage (hull and equipment weight) of the shorter Madrague de Giens ship has been estimated as 166 tonnes, the displacement of the full Isola delle Correnti ship would probably have been well over 600 tonnes.[17] This was certainly not a short ship and if it was reinforced it would have been extremely cumbersome; in fact, it is hard to imagine a ship less like Casson's ideal stone carrier.

Small Ships and Local Traffic

Many of the stone-carrying ships wrecked off southern Italy, therefore, were exceptionally large and travelling long distances. Most ships engaged in the movement of building materials were much smaller, typically carrying cargoes of well under 100 tonnes.[18] Some of them, as the distribution map in fig. 5 and graph in fig. 6 show, also moved relatively short distances. Nowhere is this picture of what Parker has called 'low-

Smallest cargoes			Largest cargoes		
Site	**Cargo**	**Weight (tonnes)**	**Site**	**Cargo**	**Weight (tonnes)**
Capo Granitola D	Architectural elements (Prokonnesian)	<10	Capo Granitola A	Architectural elements (Prokonnesian)	c. 350
Jakljan	Sarcophagi	<10	Isola delle Correnti	Blocks (Prokonnesian)	c. 350
La Mirande	Marble slabs	<10	Punta Scifo B	Blocks	c. 350
Les Riches Dunes 5	Block and panels	<10	Sapientza	Blocks	c. 300
Sète	Column drum and block	<10	Punta del Francese	Blocks	c. 265–275
Skerki F	Blocks and columns	c.13	Mahdia	Various	c. 250–300
Les Laurons IX and X	Building stone	c.13 and c.33	Punta Cicala	Architectural elements	c. 250
Dramont I	Blocks	c.23	Saint Tropez A	Architectural elements	c. 200–230
Marseillan	Blocks	c.24	Punta Scifo A	Architectural elements	c. 200
Camarina A	Giallo antico columns	c.20–30	Marzamemi A	Blocks and architectural elements	c. 170–200
Carry-le-Rouet	Building stone	c.25–30	Cavo Doro	Blocks	c. 160
Veli Školj	Sarcophagi	<30	Torre Sgarrata	Sarcophagi	c. 160
Izmetište	Building stone	c.30–40	San Pietro	Sarcophagi	c. 150
Saintes-Maries 18, 21 and 22	Blocks	c.30–40 each	Ekinlik Adasi	Architectural elements (Prokonnesian)	c. 150

Table 1: The smallest and largest attested stone cargoes.

profile local traffic' clearer than off southern France.[19] Here we see what Leidwanger has termed a distinct 'maritime economic neighbourhood'.[20]

Among these French shipwrecks are cargoes of local building stone that were being moved along the coast because land transport was more costly. The Carry-le-Rouet shipwreck, dated to the late 2nd or early 1st century BC, shows that this practice was common in the Hellenistic/Republican period, as well as later.[21] The two ships that sank in the harbour at Anse des Laurons were carrying Ponteau limestone, again for local use.[22]

Not all of these French wrecks were carrying local materials, though. A series of vessels moving Luna marble from northern Italy have been excavated in recent years;

typically their cargoes do not exceed 30–40 tonnes. The three first- or second-century AD ships discovered at Saintes-Maries, each containing six or seven large blocks of Luna marble, are cases in point.[23] Only the Dramont I ship was transporting marble from the eastern Mediterranean and this vessel was probably loaded close to Rome or in some other central Italian harbour.[24] The vessels dealing with imports in this region, therefore, were primarily involved in traffic between the harbour at Luna and the cities of southern France.

Comparable 'maritime neighbourhoods', at least with regard to stone transport, can be recognised in the Adriatic, as well as off the coast of Israel. In the latter case, however, the wrecks identified belong mostly to the late antique period and reflect building activity and the supply of materials to it in a very particular historic context.

Commercial Mechanisms

The distribution and chronology of wrecks carrying stone cargoes reveal a range of patterns and show that there was no single way of transporting this material. What does the composition of their cargoes add to this picture? In an important recent article, Boetto has used a range of shipwrecks containing different types of commodities and cargo compositions to illustrate how different modes of commercial mechanism existed contemporaneously.[25] Her aim is to show how debates about whether Roman maritime trade was primarily either 'direct'/'commissioned' or 'indirect'/'tramping' somewhat miss the point, since within the shipwreck record a whole range of mechanisms can be noted. Boetto highlights five ships in her study: (1) the Madrague de Giens ship, with its homogenous cargo (wine amphorae) loaded simultaneously at a harbour near the place of production and shipped directly to another port; (2) the Cabrera III ship with a heterogenous cargo (various amphorae) loaded simultaneously at a main port (*entrepôt*) and transported directly to another main port; (3) the Culip IV ship with a heterogeneous cargo (various amphorae and finewares) loaded simultaneously at a main port (*entrepôt*) and transported directly to a secondary harbour; (4) the Cavalière ship with a heterogeneous cargo (various amphorae and pork) accumulated and sold via tramping; and (5) the Barthélemy B ship with a homogenous cargo (roof tiles) that is specifically commissioned and transported.

None of the ships that Boetto highlights were carrying stone but some of the same diversity can be noted among the stone shipwrecks. Heterogeneous cargoes existed, for instance, on the Dramont I ship, as already observed, as well as on the Izmetište and Margarina ships; these are comparable in form to the cargoes on the Cabrera III or Culip IV ships in Boetto's typology.[26] On a tiny number of wrecks stone was found in such small quantities that it could have been moved via tramping: on the La Mirande ship, for instance, where five panels of Luna marble accompanied a cargo of amphorae and on the Chrétienne M(3) wreck, where *africano* panels were recovered.[27] In general, however, the known stone cargoes are extremely homogenous; even acknowledging that many of these sites are patchily published and any perishable elements are now lost, it still seems to be the case that stone usually formed the primary component of these cargoes. Most of these wrecks also contain just a single lithotype. The bulk of ships carrying stone identified to date, therefore, are closest in cargo composition to the Madrague de Giens and Barthélemy B types on Boetto's scheme. Many of the most important marble quarries were located close to the coast and had their own harbours nearby – the quarries on Prokonnesos and Thasos are notable examples – and so it is entirely feasible that some of our ships were loaded directly at the quarry.[28] The small number of cargoes containing two or more lithotypes were probably loaded at main ports. The Punta Scifo A ship, with its cargo of Prokonnesian and *pavonazzetto*, and the Giardini Naxos ship, containing Prokonnesian and *cipollino*, have been argued by others, based on the arrangement of the components of their cargo, to have been loaded in one go at a single location.[29] Ephesos or Nicomedia have been proposed for the former, while the Piraeus might make sense for the latter. In the former case, one overseas shipment (of the Prokonnesian blocks) would have to have preceded the final voyage (with the *pavonazzetto* arriving at the port by land), while in the case of the Giardini Naxos cargo, both the *cipollino* blocks and the Prokonnesian ones would have had to have been shipped to Piraeus before being loaded onto a new ship. The picture suggested by these cargoes fits nicely with Nieto's model of redistribution, as well as Arnaud's observation about so-called 'segmented' sailing.[30]

The majority of ships carrying stone cargoes, in sum, were engaged in 'direct' trade and indeed, like the cargo on the Barthélemy B ship, it is probable that these cargoes represent specific commissions. This argument is clearest in the case of the sarcophagus wrecks, especially the San Pietro ship, which contained chests and lids that still had to be separated and paired up.[31] But it is also probable that all of the vessels containing monolithic columns were transporting commissions.

Conclusions

In his description of Roman engineering, Strabo remarks that 'they [the Romans] have so constructed also roads which run throughout the country, by adding both cuts through hills and embankments across valleys, that their wagons can carry boat-loads…'[32] Overland vehicles and even river vessels, of course, would never have been able to carry the sorts of weight the vessels discussed above routinely shipped. Ordinary wagons would rarely have been able to cope with more than a couple of tonnes.[33] On rivers, where large barges were favoured for stone transport, few capable of carrying more than 100 tonnes have been excavated. Strabo's real point here is that roads opened up inland areas and that cuttings and embankments, bridges and other infrastructure helped to control the gradient of these roads and so allow the movement of heavy cargoes. Overland and riverine transport was never as efficient as maritime transport in antiquity, however, and for this reason the long-distance movement of stone in the Roman world was primarily carried out by sea. The shipwreck record is the most useful tool available to us for understanding how this maritime traffic in stone was organised and the diversity of cargoes moved around the ancient Mediterranean. While most stone was probably moved through 'direct' trade – and in response to specific orders from architects, workshops or single commissioners – smaller quantities of stone could have been shipped in other ways. Crucially, in no other period, anywhere, do we find as much evidence for the movement of stone by sea as we do in the Roman Mediterranean.

Notes

[1] Knoop – Jones 1967, 45.

[2] Strauss 2013; Digital Atlas of Roman and Medieval Civilisations: https://darmc.harvard.edu/; Parker 1992.

[3] Russell 2013b.

[4] Parker 1992, 5.

[5] Parker 1992, 8 f.; Wilson 2011.

[6] On northern Italian sarcophagi, see Gabelmann 1973.

[7] Russell 2013a, 186.

[8] Parker 2008, 194; the map is based on that produced in Rougé 1966.

[9] Pensabene 2003; Kapitän 1961, 282–288; Bartoli 2008.

[10] Throckmorton 1972, 76.

[11] For the most recent estimate of their tonnages, see Nantet 2016, 343 f. 355–360.

[12] Kapitän 1961, 286–288.

[13] Nantet 2016, 358.

[14] Meijer 2002, 151 f.

[15] Throckmorton 1969, 300.

[16] Casson 1971, 173.

[17] Nantet 2016, 358 f.

[18] Russell 2013b.

[19] Parker 1996, 100.

[20] Leidwanger 2013, 204.

[21] Kainic 1986.

[22] Ximénès – Moerman 1993.

[23] Long 1999.

[24] On this wreck, Joncheray 1998; on its route, Russell 2013a, 136.

[25] Boetto 2012.
[26] Jurišić 2000, 65. 69.
[27] Descamps 1992; Joncheray – Joncheray 2002.
[28] Russell 2013a, 135.
[29] Pensabene 1978, 112–114; Basile 1988, 138 f.
[30] Nieto 1997; Arnaud 2005.
[31] On this point, see Russell 2013a, 271 f.
[32] Strabo 5.3.8.
[33] Russell 2013a, 97 f.

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This volume contains various studies that range from prehistoric Greek building programmes to building in the Roman period. The economic growth of modern societies has been closely linked with construction industries: investments, transport infrastructures for materials and labour-intensive building programmes all have a large impact on local, regional and even global economies. The end results have shaped the built environment of our everyday lives and have often led to an increased quality of life and affluence, though there are many cases that did the opposite as well. Large-scale building projects in pre-industrial societies required extensive manual labour to be invested from the moment materials were scouted for, over the extraction, transportation, use and the subsequent maintenance. Since most ancient societies were based on subsistence economies, important decision-making was a daily balancing act between building work and agriculture. These decisions often strongly influenced the patterns of land use and may have also resulted in circular economic strategies. The papers presented in this volume emphasise the importance of the socio-economic and political structures and decision-making that resulted in 'Building Big', irrespective of the shape and final size of the projects.

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