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SETinSTONE?

A retrospective impact assessment of human and environmental resource usage in Late Bronze Age Mycenaean monumental architecture, Greece

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Introduction and overall outline of the project[1]

Monumental building projects are universal phenomena, from the stone circle of Göbekli Tepe, Turkey, to the Burj Khalifa in Dubai, and are associated with high levels of constancy and permanence. These qualities can be seen in the durability of the materials employed, in the overall size and visibility of the materials themselves and in the resultant building project. Often such buildings have a celebratory character relating to specific events during which they form the focal point of communal activities and ceremonies. Monumental building projects can materialise in the form of military installations (fortification walls), tomb monuments (pyramids), religious complexes (temples), rulers' seats (palaces) and communal works (irrigation systems). While such constructions are impressive by their sheer physical size, their social impact may be even more pervasive. The 'monumental' as a phenomenon[2] is often understood as the physical expression of rulers or elite members of complex societies, and is materially incorporated within the transformed 'fabric' of the surrounding landscape. The transformation of a space in the landscape into a place of production is defined as a 'task-scape'.[3] Subsequently this 'task-scape' is further developed into a place of use. The full transformation is regularly understood as being instigated and orchestrated by these rulers through mobilizing substantial amounts of human, faunal and material resources. The fact that the Burj Khalifa stands over 828 m tall is awe-inspiring, but the additional knowledge that it took 22 million person-hours to construct makes it truly impressive.[4] Furthermore, monuments carry multiple meanings. They are connected to people, places and symbolic values in multiple ways, and can evoke many identities by being places in use, but *also* as places being constructed.[5] The question of 'making' in any past monumental building project's context and environment is, therefore, a question of human ecology. The latter investigates complex and widely varied interaction processes between past people and their surroundings. Socio-economic, political and psychological factors (e.g. war, natural disasters, people's [lack of] trust in religion and world-views), each played a role in how people and societies overall interacted with each other and their environment, in stable but also in changing conditions.

The influence of monumental construction on its human and material surroundings can be explored excellently in the context of Late Middle and Late Bronze Age (LBA) Mycenaean Greece, which is carried out by the 'SETinSTONE' project.[6] The overall aim of the project is to assess if and how monumental building activities in LBA Greece impacted the political and socio-economic structures of the Mycenaean polities in the period between 1600 and 1100 BC, and how people responded to changes in these structures. SETinSTONE is especially concerned with the processes and practices that created such monumental and public works in the Aegean Late Middle to LBA Argolid. Monumental constructions contemporary with those in the Argive Plain (located in Attica and Achaia) are investigated for comparative purposes (see figure 1).

Logistically demanding building programmes took place especially in the 13th century BC and resulted in the construction of massive citadels, burial monuments, waterworks, roads and bridges. These initiatives must have mobilized substantial labour forces over sustained periods of time. Such intensive and prolonged building efforts required a consistent amount of human and material resources. Since agriculture formed the basis of many pre-modern economies, which was also the case for Bronze Age societies in Greece, these monumental building projects likely affected their local economies profoundly. Some scholars have interpreted the detrimental nature of mobilizing these work forces as a form of resource exhaustion. This would have affected the stability of socio-political structures towards the end of the Late Helladic (LH) IIIB period.[7] The human (over-)use of dwindling resources, climatic changes, natural disasters,

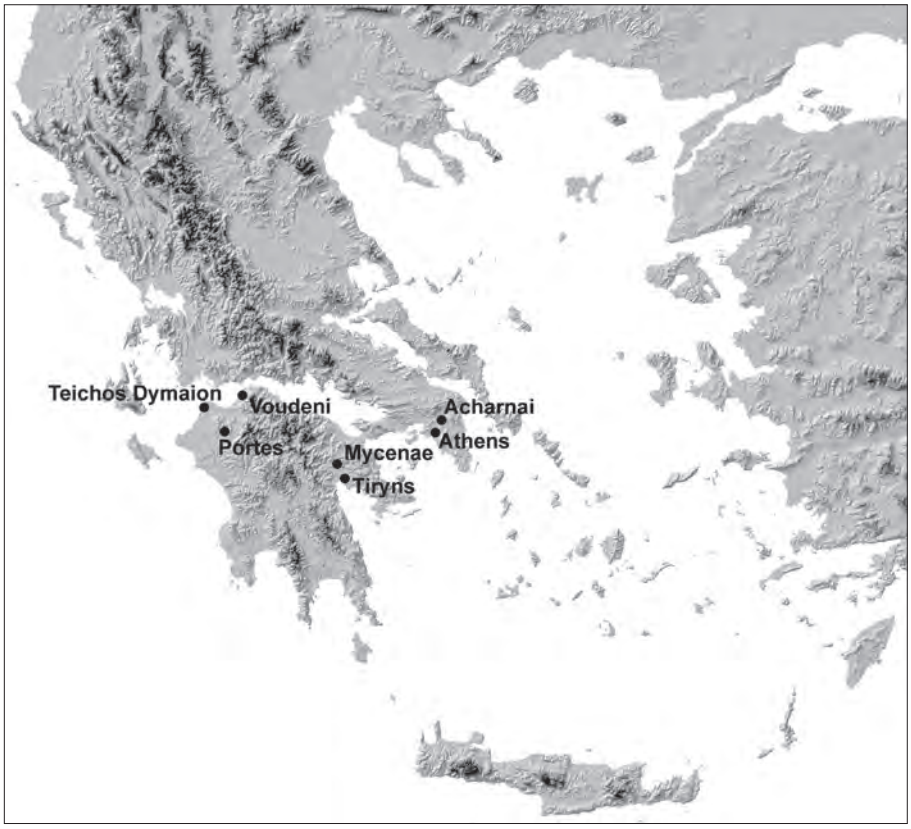

Figure 1. Map of the Aegean showing the sites involved in the SETinSTONE project (image Anavasis/Hans Birk; adapted by Ann Brysbaert).

war, famine, and the breakdown of trade networks have all been seen as contributing factors to the Mycenaean socio-political crises coming to a head around 1200 BC.

Despite many attempts to explain the Mycenaean LBA crises or 'collapse',[8] the complex interaction between the factors causing these societal upheavals is still not fully understood. Equally, whether we can speak of a 'collapse' is itself hotly debated, especially given that this phenomenon was much wider-spread than in the Mycenaean world alone. The Mycenaean polities were part of a Mediterranean LBA system in which multiple regional units interacted and co-depended on each other.[9] Hence, the hypothesis that massive building programmes were detrimental to the LBA Mycenaean societies needs a thorough re-evaluation. This is even more pertinent in view of the likelihood that each region in the contemporary East Mediterranean suffered case-specific internal challenges too.[10]

Due to the complex role(s) that such building programmes may have played in Mycenaean society, SETinSTONE investigates several possible factors of these crises, and in particular, the role of prolonged building activities as one of these potential causes. The project combines a wide range of methodologies that integrate both Landscape Archaeology and Material Culture Studies approaches that investigate the variety of data on three levels:

- Micro-level: the detailed study of the *chaînes opératoires* of constructing with stones, earth masses, and other materials.
- Intermediate-level: investigation of the (finished) building projects themselves and their meaning over time.
- Macro-level: interdisciplinary investigation of the human-landscape interactions of building in the wider region of the Argolid. This combines architectural studies with contributions from studies of subsistence strategies, settlement patterns and networks, mortuary evidence and diet. This level also investigates the needed infrastructure of quarries, roads and transport means, and multiple other resource uses.

The work carried out to date is described below and preliminary results are presented in each section.

Architectural field methods and preliminary results on selected case studies

A detailed recording of monumental buildings is required in order to study their construction and use, with the additional aim of investigating the investment necessary for such buildings. Fieldwork methods for the recording of architectural features follow the methodology described by Pakkanen with slight adjustments for site-specific circumstances.[11] Recording began by mapping a base grid of fixed points using a Leica Differential Global Positioning System with an average location accuracy of 3 cm. Two Leica total stations established a further grid of fixed points that allowed for millimetre accuracy as well as rapid station setup for movement around line-of-sight obstacles.[12] Using the reflectorless setting, daily

measurements averaged 2000-3000 points per station. A coding program converted the total station measurements into line drawings showing the approximate outlines of measured stones or, as in the case of earthworks, point clouds showing the outlines of *dromoi* (tomb access corridors), burial chambers, and tumuli.[13] AutoCAD displays the models from any angle, and the .dxf format of the files can be combined in ArcScene to create a digital reconstruction of entire sites. Agisoft PhotoScan software supplemented the total station data by creating 3D models. The latter are based on photographs taken with a Nikon D7200 digital camera, anchored by photo points that were measured with two total stations (see figure 2). Based on measurements from both the AutoCAD drawings and the photogrammetry models volumes of earth and stone building materials can be calculated, which are further combined with task rates to estimate labour costs.

In the summer of 2016, fieldwork at the Menidhi *tholos* in Acharnes, north of Athens, applied the non-invasive survey techniques outlined above to create a digital documentation of the tomb. The tomb was constructed sometime in the 13th century BC and was last formally investigated during the German Archaeological Institute excavations in the late 1870s. Degraded, highly laminar and relatively thin slabs of limestone comprise much of the stonework for the burial chamber and dromos. The reconstructed section of the upper half of the dromos shows more variation in stone type and size.

Preliminary estimates for the effort involved in the initial stages of construction for the tomb examined the removal of soil and rock to create the outline of the chamber and dromos. Since the volume generated by the survey data represents a sub-minimum of the material removed, current time-cost estimates avoid total cost scenarios in favour of a rough comparative index of effort for the critical first stage.[14] For the dromos (350 m^3) and the burial chamber (including the *stomion* or tomb opening (270 m^3)), an average labour rate (4.2 ph/m^3)[15] results in 2600 person-hours for this stage alone.[16]

As the SETinSTONE project aims to investigate the monumental fortifications of LBA polities, among others, it is most fortunate to work on the well-preserved and well-known walls of Mycenae. In the summer of 2017, a total of eight separate sections of Mycenae's fortification walls were documented. These included: the interior and exterior of the Lion Gate, the interior and exterior of the North Gate, the interior of the North East Extension and the area around the nearby cistern, the inner face of the wall between Grave Circle A and the 'Cult Centre', and three separate sections along the western outer face. The latter sections are spread between the areas just outside the Lion Gate towards the 'Hellenistic Tower'. These sections all focus on the final construction phase of Mycenae's fortification, yet they present a diversity of building styles, functions (walls, gates and a vault) and materials. This range of different sections thus provides a proper reflection of the development of the entire fortification over time. As such, the data from the documented sections can be extrapolated to those sections that were not documented and a complete picture of the site is generated. The volume and subsequently the mass of the blocks used in each section are then calculated. Using the mass, the amount of labour force necessary can be calculated for the individual segments. These numbers can then be extrapolated to similar segments along the fortification of the site. By focusing on representative segments, total labour cost estimation can, therefore, be made for the entire fortification at Mycenae.

The Late Bronze Age (specifically LH IIIB) Athenian Acropolis circuit wall is the second case study examined within the SETinSTONE project's methodology. However, it is not preserved to the same degree as Mycenae's circuit wall.[17] At the Athens Acropolis, Mycenaean period walls

Figure 2. A section of a preliminary photogrammetry model of the Lion Gate at Mycenae (image Yannick Boswinkel).

survived for centuries until they were severely damaged and obliterated by the Persians in 480/479 BC, after which a new circuit wall was built as part of the fifth century BC building programme. Most of the LH IIIB walls were either covered directly by the Classical one (mainly in the north and east legs), or are preserved at a very low level and mostly covered with soil after the great excavation of the Acropolis (1885-1890). This renders them now inaccessible, especially north of the Classical wall's southern leg.[18]

The Mycenaean circuit wall of Athens' Acropolis was around 760 m long and ca. 6 m thick, composed mostly of large and irregularly shaped, native limestone blocks. These were roughly worked on the outer face and with a reconstructed original height of ca. 10 m, at least at the western section. Photogrammetric survey and total station recording will take place at eleven preserved sections (see figure 3), including the bastion in the west, parts of the main wall on the eastern, southern and western legs, as well as a stairway carved into the northern Acropolis for access from the northwest. In the spring of 2017, a survey was conducted on the most impressive surviving stretch at the west side of the Acropolis (section 11, see figure 3, with a length of almost 19 m), and the stretch abutting the Classical Propylaea. Further survey on the other sections will provide the remaining masses and volumes of the different blocks and building materials. The amount of labour force needed for this construction will then be calculated, producing a comprehensive study of all the technical and material particularities of the fortification wall and an overall estimate of the total work force required. Additionally, this combined approach will provide new results concerning the human, natural and material resources needed in order to reconstruct the entire Mycenaean fortification system on the Athenian Acropolis.

Human-landscape interactions in the Argive Plain

An alternative and interdisciplinary perspective is offered by a study of the human-landscape interactions in one of the core areas of the Mycenaean period, the Argive Plain in the Peloponnese. As such, this sub-project aims to generate an in-depth understanding of the carrying capacity, land use and settlement patterns of the area during the LH III period. Additionally, mortuary evidence is included for the reconstruction of health and diet, and, where possible, life expectancy and mortality rates. The overall outcome will be a better understanding of the living conditions of the local population of the Argive Plain during the period of long-term monumental construction programmes. This forms an essential part of the SETinSTONE project's assessment of the impact of large-scale building projects on both the people and the environment.

Reconstructing the land use of the Argive Plain and its adjacent hinterlands (the fertile valleys of Nemea and Berbati) is based on a data synthesis concerned with known subsistence strategies. It is firmly established that the main subsistence of LBA people in Greece was provided by crop cultivation and animal husbandry.[19] In order to estimate the extent of these agricultural activities in the Argive Plain, their spatial, geomorphological and climatic constrains are studied. Land use is further observed in relation to political circumstances, which impacted agriculture by means of land ownership and surplus production. Related to land use, the settlement distribution of the Argive Plain is also examined in detail. Due to erosion, large-scale sedimentation and the previous research bias towards monumental sites, little is known of rural villages and hamlets which may have dotted the landscape. This study will estimate the potential settlement pattern based on site location preference, the physical landscape, and information from bordering regions.

Evidence utilized for the study of settlement patterns consists of data on the natural landscape (e.g. physical geography, geology, geomorphology), and on the archaeological remains (e.g. results from published extensive surveys and excavations). The data on the natural environment are fairly unproblematic and detailed maps by the Greek Geological Survey (IGME) are available for study. Archaeological data, unfortunately, are scattered amongst various different sources. For botanical, zoo-archaeological and osteological data, as well as studies concerning past climate and Linear B data this project is primarily literature based. Excavation reports of the past 50 years and other resulting publications are thoroughly studied and used in a combined evaluation of Late Bronze Age living conditions.

Although a few scholars have written about the settlement development of the prehistoric Argive Plain,[20] these were based only on extensive surveys and recent small-scale rescue excavations. During this study a re-assessment is made of the known data. To re-evaluate the overall nature of known sites in the research area, the SETinSTONE team visited the 54 sites published by Bintliff[21] and others since then, recording the state of preservation and their environmental context. The sites were recorded thoroughly by conventional photography and were integrated in our comprehensive database that collects all published site information to date (see also figure 4). The variation among the sites was immediately apparent. While some sites consist of large monumental centres covering several hectares of land and capable of harbouring thousands of inhabitants, others are represented only by 'three sherds in a field'. The latter could signify at most the presence of a single, short-lived farmstead. Another observation is that the site distribution is concentrated in a zone between the eroded, steep mountain sides and the colluvium-rich valley bottom (see figure 5), giving rise to the assumption that site distribution patterns are heavily influenced by geomorphological processes.

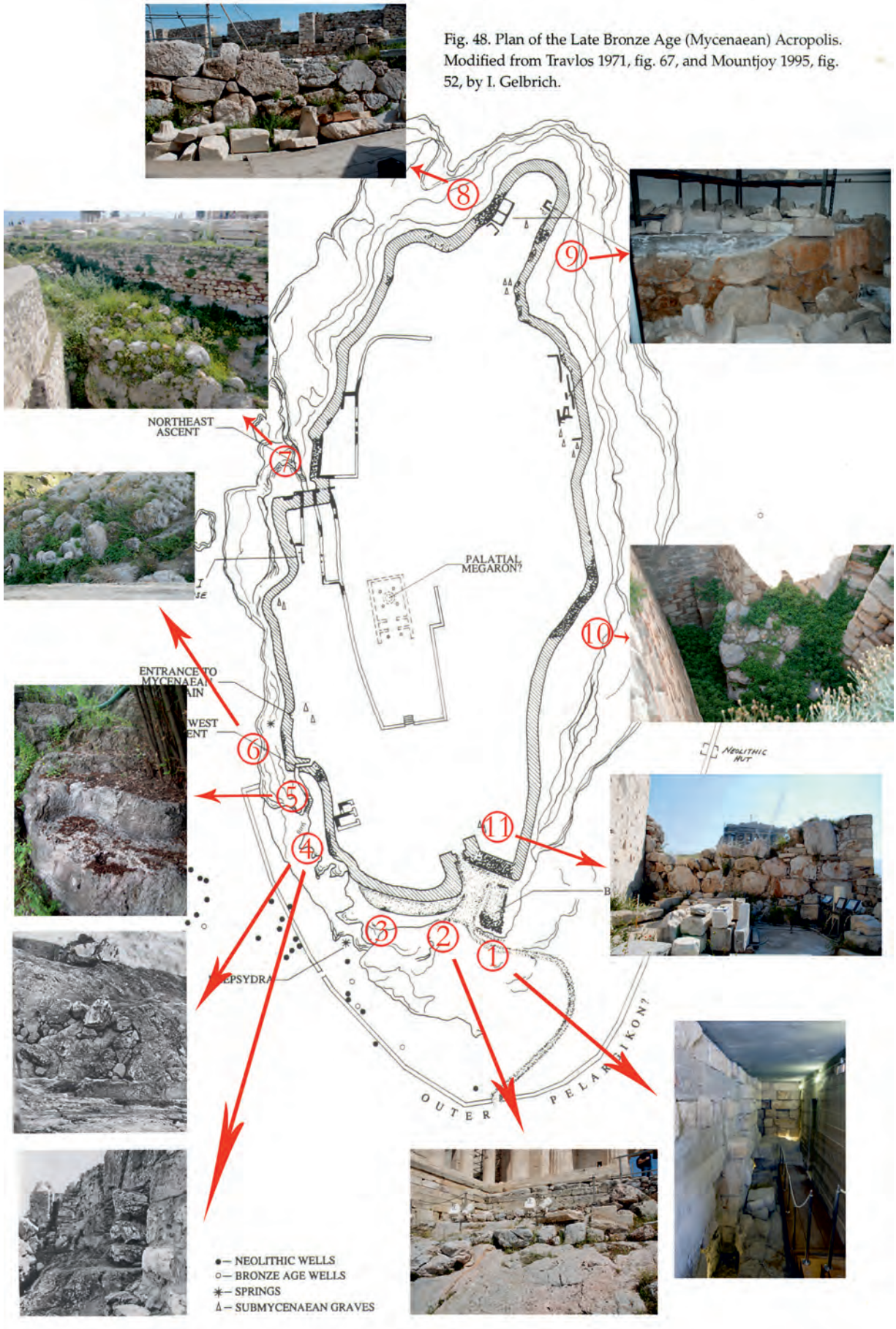

Figure 3. Plan of the Mycenaean Circuit Wall of the Acropolis at Athens with the documented section 11 and the remaining sections to be documented (after Iakovidis 2006, with pictures of the sections by Elisavet P. Sioumpara).

Figure 4. Recording landscape features in the area of Gimno, northwest Argive Plain (photo Victor Klinkenberg).

The preliminary results of the literature study into subsistence strategies have revealed that existing notions about land use practices and environmental constraints in the Argive plain should be re-evaluated. In particular, recent archaeobotanical studies have enriched the knowledge on the versatility of plant species cultivated in LBA Greece.[22] Furthermore, new evidence suggests that the Eastern Mediterranean climate changed towards cooler and more arid conditions during the final years of the Bronze Age.[23] This may have caused dramatic fluctuations in crop production, and eventually could have led to socio-political changes. Clearly, reconstructing LBA land use and subsistence should be approached holistically, incorporating the very recent data received from material evidence and scientific methods. This way it is possible to complete an overall picture of this region at the end of the LBA.

Raw material sources and infrastructure in a constructed landscape

With the material studies on earth and stone architecture contextualized within their local landscape, focus shifts to the physical infrastructure that supported the Mycenaean culture of construction in the Argive Plain. This includes a study of the preserved road network in the region, the availability of resources (mainly quarries), the means of transport, and the proximity between potential points of extraction and construction.

The Mycenaean road system enjoys a longstanding research history. In 1881 Captain Bernhard Steffen systematically surveyed and mapped the area of Mycenae. He identified four highways, radiating from the citadel of Mycenae into the wider territory. His study was concerned with the road network's functions, emphasising defence, agriculture and communication. He also explored a possible inter-regional connection between Mycenae and Corinth.[24] All subsequent studies of the Mycenaean road network are still based on Steffen's survey. In the 1960s, the roads were securely dated to the LBA by pottery sherds found within the road fill.[25] In the late 1990s, Anton Jansen investigated the archaeological remains of Mycenaean roads and stations of Bronze Age Greece. Jansen's work also forms a constituent part of the *Archaeological Atlas of Mycenae*,[26] and the latter dedicates a chapter to the road system. The Atlas discusses and illustrates the remains of the road system mapped by Steffen, while adding information on new stretches and alternative courses of roads, which were identified by the survey team of the Mycenaean Atlas Project.[27] Next to the evidence pertaining to roads, this comprehensive work discusses bridges, culverts, water crossings, terraces and retaining walls (see figure 6).

During the spring of 2017, the SETinSTONE team walked and revisited all the published features in the wider area surrounding the citadel of Mycenae. The aim was twofold: to re-visit the features documented by Jansen and the Atlas team, and to observe their current state of preservation. Moreover, since the surrounding landscape has a varied topography, we also wanted both to understand and to experience the physical and functional relationship between these features and their surrounding landscape. The majority of the features we observed pertain to the road system that sustained transport and communication in the polity of Mycenae during the

Figure 5. Research area for this sub-project. Indicated are the visited sites and geomorphological zones (image authors).

LBA.[28] Additionally, we also revisited several of the published stone quarries and published tombs, some located in the vicinity of potential stone extraction places and along roads. We photographed and described in detail the current state of all features and sites. Our information supplements the already published features, which were entered in our database. These are now grouped in categories and all located accurately on Google Maps to facilitate our analyses of their interrelationship in a 3D landscape, featuring sites, quarry locations and transport remains. Nodal points between areas of supply (agricultural products and building materials) and areas of construction and consumption are of specific interest. Our observations contribute towards a better understanding of how people and materials moved in the landscape for multiple reasons, many of which impacted on each other, while these road trajectories formed social and technical exchange hubs for skills, knowledge and resources.

As a whole SETinSTONE is especially concerned with the processes and practices that created monumental and public works in the Aegean Late Middle to Late Bronze Age in the Argolid and beyond. Each (sub-)project[29] contributes towards our larger aim of assessing if and how monumental building activities in LBA Greece impacted on the political and socio-economic structures of the Mycenaean polities between 1600 and 1100 BC. Exactly how people responded to changes in these structures remains still to be seen as the project progresses in the coming years.

Figure 6. Section of Mycenaean road (highway 1, top left) with water management features of drainage channels (A) and multiple culverts (B) (photos Ann Brysbaert).

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Endnotes

1 This paper is the result of the joint efforts in which all team members took part. The overall coordination of the paper, its introduction and concluding remarks were written by Ann Brysbaert; section 2 on architectural fieldwork by Yannick Boswinkel, Daniel Turner and Elisavet Sioumpara; section 3 on human-landscape interactions by Victor Klinkenberg and

Riia Timonen, and section 4 on raw materials and infrastructure by Hanna Stöger and Ann Brysbaert.

2 For definitions of monument and monumentality, see Osborne 2014.

3 After Ingold 2000 who defined and introduced this concept.

4 For structural details of the Burj Khalifa, see http://www.burjkhalifa.ae/en/the-tower/design.aspx.

5 Brysbaert 2016: p. 3.

6 SETinSTONE: ERC consolidator project, grant agreement nbr 646667, conducted at Leiden University, between 2015-2020. www.setinstone.eu.

7 E.g. Galaty & Parkinson 2007.

8 E.g. Middleton 2010.

9 A recent overview given by Cline 2014.

10 Cline 2014 brings together many regional discussions on the topic. See also Liverani 1987.

11 Pakkanen 2009.

12 Both model T500 and T1000 were used.

13 Developed by the Finnish Institute at Athens.

14 It does not count, for example, the thickness of the stone cladding or removal of material beyond the outline of the completed tomb.

15 ph is person-hours.

16 Turner, in preperation.

17 Iakovidis 2006.

18 Korres 2015.

19 Halstead 1992; Halstead 1999.

20 E.g. Bintliff 1997; Wright 2004.

21 Bintliff 1977.

22 Valamoti et al. 2011.

23 Finné et al. 2011; Drake 2012.

24 Steffen 1884: pp. 8-9.

25 Mylonas 1966: p. 87.

26 Jansen 2002; Archaeological Atlas of Mycenae: Iakovidis et al. 2003.

27 Iakovidis et al. 2003: pp. 28-31.

28 Details of this work will appear in a forthcoming paper.

29 These projects are grouped together in this paper for convenience but form seven separate projects in total.